National Science Board

SCIENCE AND ENGINEERING INDICATORS

NATIONAL SCIENCE FOUNDATION

National Science Board

National Science Board Committee on Science and Engineering Indicators

SCIENCE AND ENGINEERING INDICATORS 2012

National Science Board

Cover Image

The cover for *Science and Engineering Indicators 2012* was designed and produced by OmniStudio, Inc., Washington, DC.

Recommended Citation

National Science Board. 2012. *Science and Engineering Indicators 2012*. Arlington VA: National Science Foundation (NSB 12-01).

National Science Board

January 13, 2012

MEMORANDUM FROM THE CHAIRMAN OF THE NATIONAL SCIENCE BOARD

TO: The President and Congress of the United States

SUBJECT: *Science and Engineering Indicators 2012*

As Chairman of the National Science Board, it is my honor to transmit on behalf of the Board the twentieth in the series of biennial science indicators reports, *Science and Engineering Indicators 2012*. The Board submits this report as required by 42 U.S.C. § 1863 (j) (1).

The Science Indicators series was designed to provide a broad base of quantitative information about U.S. science, engineering, and technology for use by policymakers, researchers, and the general public. *Science and Engineering Indicators 2012* contains analyses of key aspects of the scope, quality, and vitality of the Nation's science and engineering enterprise in the context of global science and technology.

The report presents information on science, mathematics, and engineering education at all levels; the scientific and engineering workforce; U.S. and international research and development performance; U.S. competitiveness in high technology; and public attitudes and understanding of science and engineering. A chapter on state-level science and engineering presents state comparisons on selected indicators. An Overview chapter distills selected key themes emerging from the report.

The Board hopes that both the Administration and Congress find the new quantitative information and analysis in the report useful and timely for informed thinking and planning on national priorities, policies, and programs in science and technology.

Ray M. Bowen

Ray M. Bowen
Chairman
National Science Board

Acknowledgments

The National Science Board (NSB) extends its appreciation to the staff of the National Science Foundation and to the many others, too numerous to list individually, who contributed to the preparation of this report.

Primary responsibility for the production of the volume was assigned to Rolf Lehming, Director of the Science and Engineering Indicators Program of the National Center for Science and Engineering Statistics (NCSES); Lynda T. Carlson, Director, NCSES; John R. Gawalt, Deputy Director, NCSES; and Myron P. Gutmann, Assistant Director, Directorate for Social, Behavioral and Economic Sciences. The authors of the manuscript were:

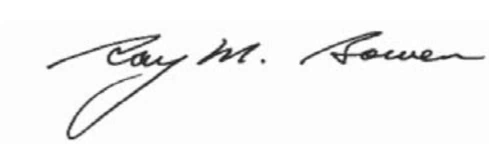
Overview.	Rolf Lehming, NCSES
Chapter 1.	Xianglei Chen, Leslie Hall, Susan Rotermund, Vera Bersudskaya, MPR Associates; Lawrence Burton, NCSES
Chapter 2.	Jaquelina C. Falkenheim, NCSES
Chapter 3.	Robert Bell, Nirmala Kannankutty, Emory P. Morrison, NCSES
Chapter 4.	Mark Boroush, Francisco A. Moris, Raymond M. Wolfe, NCSES
Chapter 5.	Mark Boroush, Lawrence Burton, Mark K. Fiegener, NCSES
Chapter 6.	Derek Hill, NCSES
Chapter 7.	Carolyn L. Funk, SRI International
Chapter 8.	Paula C. Dunnigan, Taratec Corporation; Jeri Mulrow, NCSES

The volume benefited from extensive contributions from NCSES staff. Joan S. Burrelli, Katherine Hale, and Mark C. Regets compiled and analyzed data for the volume. NCSES senior staff and survey managers assured availability of data under often stringent deadlines: Ronda K. Britt, Leslie Christovich, John Finamore, John E. Jankowski, Kelly H. Kang, Lynn Milan, Steven Proudfoot, Emilda B. Rivers, and Michael Yamaner. Jacqueline Durham assisted in acquiring data from outside sources. Stephen Cohen and Jock Black provided advice with statistical or data presentation issues.

In managing production of the volume, Rolf Lehming was assisted by Robert Bell, Nirmala Kannankutty, and Cheryl Roesel. Along with Rolf Lehming, Robert Bell engaged with authors in the development, review, and preparation of chapter content. Nirmala Kannankutty coordinated the schedule for producing the volume. Cheryl Roesel managed the performance of editorial, printing, and publication services. Lynda T. Carlson worked closely with the management team to ensure that the volume was successfully produced.

Robin Pentola was responsible for overall direction and management of the website. Tanya Gore assisted with the final review of the page composition and appendix tables, and Rajinder Raut prepared files for review and provided a technical review of the website. Web design and programming were performed by De Vo, Bridget Tuthill, Jason Shaffer, Moe Than, Makiko Fisher, Micah Horvat, and Richard Ashley of Compuware Corporation. Deborah Collins helped check and review data for Chapter 8 and compiled the list of Acronyms and Abbreviations. Overall editing of the report was performed by David B. Fialkoff and the staff of Lockheed Martin Business Process Solutions. OmniStudio, Inc., Washington D.C., was responsible for design and production of the volume. Many others provided much appreciated advice and assistance and are listed under Contributors and Reviewers.

The National Science Board Office, under the direction of Michael L. Van Woert, provided vital coordination throughout the project. The National Science Board is especially grateful to the S&E Indicators Committee, and Jean M. Pomeroy and Matthew B. Wilson for serving as Liaisons to the Committee. Robert Bell and Rolf Lehming were the Executive Secretaries.



Dr. Ray M. Bowen
Chairman, National Science Board

Dr. José-Marie Griffiths
Chairman, Committee on Science and Engineering Indicators

Contributors and Reviewers

The following persons contributed to the report by reviewing chapters or otherwise assisting in its preparation. Their help is greatly appreciated.

Alice Abreu, International Council for Science
Robert Allen, U.S. Patent and Trademark Office
Nick Allum, University of Essex
Nicole Aspinall, Bloomberg New Energy Finance
Cheikhou Athie, Taratec Corporation
Robert D. Atkinson, Information Technology and Innovation Foundation
Susan L. Aud, National Center for Education Statistics
Samuel F. Barbett, National Center for Education Statistics
Roland Bardon, SRI International
Denise Barnes, National Science Foundation
Kristina Bartsch, Bureau of Labor Statistics
Steven C. Beering, Purdue University
Nathan Bell, Council of Graduate Schools
John Benskin, SRI International
John C. Besley, University of South Carolina
Peter Billington, Higher Education Statistics Agency, Ltd., England
Richard E. Bissell, National Academy of Sciences
Henry Blount, National Science Foundation
Maria Borga, Bureau of Economic Analysis
Nava Brenner, Central Bureau of Statistics, Israel
Prudy Brown, SRI International
David B. Campbell, National Science Foundation
Patricia B. Campbell, Campbell-Kibler Associates, Inc.
Jill Cape, Taratec Corporation
Anthony Carnevale, Georgetown University
Nancy Chan, SRI International
Chiao-Ling Chien, UNESCO Institute for Statistics
Susan Choy, MPR Associates
Patrick Clemins, American Association for the Advancement of Science
Wesley Cohen, Duke University
Daniel Cohen-Vogel, State University System of Florida
Tammy D'Amato, The Patent Board
James J. Duderstadt, University of Michigan
John H. Falk, Oregon State University
Ghislaine Filliatreau, Observatoire des Sciences et des Techniques, Paris
Michael Finn, Oak Ridge Institute for Science and Education
Michael Fix, Migration Policy Institute
Patricia Flynn, Bentley University
John Fraser, The Florida State University
Fred Gault, UNU-MERIT
Donna K. Ginther, University of Kansas
Leonid Gokhberg, Higher School of Economics, Russia
Mary Good, University of Arkansas at Little Rock
Daniel L. Goroff, Alfred P. Sloan Foundation
Kerry Gruber, National Center for Education Statistics
Martin P. Grueber, Battelle
Gary Guenther, Congressional Research Service
Kimberly Hamilton, The Patent Board
Martha Harris, Internal Revenue Service
Robin Henke, MPR Associates
Paul Hitlin, Project for Excellence in Journalism
Ned Howenstine, Bureau of Economic Analysis
Tracy Hunt-White, National Center for Education Statistics
Harold Javitz, SRI International
Mark Jurkowitz, Project for Excellence in Journalism
Scott Keeter, Pew Research Center
Grace Kena, National Center for Education Statistics
Cheryl Kerr, Bureau of Labor Statistics
Beethika Khan, National Science Foundation
Eurry Kim, Internal Revenue Service
Tomoe Kiyosada, SRI International
Kei Koizumi, Office of Science and Technology Policy
Natalia Kovaleva, Higher School of Economics, Russia
Norris Krueger, Entrepreneurship Northwest
J. Steven Landefeld, Bureau of Economic Analysis
Julia Lane, National Science Foundation
Charles F. Larson, Innovation Research International
Bruce V. Lewenstein, Cornell University
Joanna Lewis, Georgetown University
Wendy Li, Bureau of Economic Analysis
James Lightbourne, National Science Foundation
Susan Carol Losh, Florida State University
B. Lindsay Lowell, Georgetown University
Jacques Mairesse, Observatoire des Sciences et des Techniques, Paris
Sunil Mani, Centre for Development Studies, India
Marsha K.McNutt, U.S. Geological Survey
Ram Mudambi, Temple University
Tom Nardone, Bureau of Labor Statistics
Jin Noh, SRI International
Norine E. Noonan, University of South Florida St. Petersburg
Sue Okubo, Bureau of Economic Analysis
Barbara M. Olds, National Science Foundation
Dominic Olivastro, The Patent Board
James C. Palmer, Illinois State University
Jongwon Park, SRI International
Valena Plisko, National Center for Education Statistics
Joshua Powers, Indiana State University
Prem Premakumar, IHS Global Insight
Sean F. Reardon, Stanford University
E.J. Reedy, Kauffman Foundation
Carol Robbins, Bureau of Economic Analysis
Terris Ross, National Center for Education Statistics
Erin Roth, National Center for Education Statistics
Allen Ruby, Institute of Education Sciences, U.S. Department of Education

Mikyung Ryu, American Council on Education
Henry Sauermann, Georgia Institute of Technology
Scott Shane, Case Western Reserve University
Kazuko Shinohara, National Science Foundation, Tokyo Office
Sean Simone, National Center for Education Statistics
Thomas M. Smith, Vanderbilt University
Laurel Smith-Doerr, Boston University
Thomas Snyder, National Center for Education Statistics
Matthew Soldner, National Center for Education Statistics
Dixie Sommers, Bureau of Labor Statistics
Thomas L. Spreen, Bureau of Labor Statistics
George Stamas, Bureau of Labor Statistics
Madeleine Sumption, Migration Policy Institute
Anton Suslov, Higher School of Economics, Russia
Gregory Tassey, National Institute of Standards and Technology
Lori Thurgood, SRI International
Christopher P. Toumey, University of South Carolina
Serge Tran, University of California at Los Angeles
Andrew Tyndall, Tyndall Report
Jo Anne Vasquez, Helios Education Foundation
Thomas Weko, National Center for Education Statistics
Vincent Welch, National Opinion Research Center
John A. White, University of Arkansas
Laura Williams, ICF Macro
Sacha Wunsch-Vincent, World Intellectual Property Organization
Lisa Younger, Small Business Administration
Michael Zastrocky, The Leadership Board for CIO's
Klarka Zeman, Statistics Canada
Ping Zhou, Institute of Scientific and Technical Information of China, Beijing

Contents

Acronyms and Abbreviations

AAAS	American Association for the Advancement of Science
ACA	Angel Capital Association
ACE	American Council on Education
ACS	American Community Survey
ADP	American Diploma Project
AFT	American Federation of Teachers
AID	Agency for International Development
ANBERD	Analytical Business Enterprise R&D
AP	Advanced Placement
APL	Applied Physics Laboratory
ARRA	American Recovery and Reinvestment Act
ATP	advanced technology products
AUTM	Association of University Technology Managers
BEA	Bureau of Economic Analysis
BLS	Bureau of Labor Statistics
BRDIS	Business R&D and Innovation Survey
CCSSI	Common Core State Standards Initiative
CGS	Council of Graduate Schools
CIP	Classification of Instructional Programs
CIS	Community Innovation Survey
CNSTAT	Committee on National Statistics
CPS	Current Population Survey
CRADA	Cooperative research and development agreement
CSEP	Center for the Study of Education Policy, Illinois State University
DHS	Department of Homeland Security
DNA	deoxyribonucleic acid
DOC	Department of Commerce
DOD	Department of Defense
DOE	Department of Energy
DOI	Department of the Interior
DOT	Department of Transportation
EC	European Community
ECLS-K	Early Childhood Longitudinal Study-Kindergarten
ECS	Education Commission of the States
ED	Department of Education
EICC	Interagency Coordinating Committee
EPA	Environmental Protection Agency
EPSCoR	Experimental Program to Stimulate Competitive Research
Esnet	DOE's Energy Sciences Network
EU	European Union
FDA	Food and Drug Administration
FDI	Foreign direct investment
FDIUS	Survey of Foreign Direct Investment in the United States
FFRDC	Federally funded research and development center
FY	Fiscal year
GAO	Government Accountability Office
GBAORD	government budget appropriations or outlays for R&D
GDP	gross domestic product
GED	General Equivalency Diploma
GM	genetically modified
GSS	General Social Survey
GUF	general university fund
HBCU	historically black college or university
HHS	Department of Health and Human Services
HSLS	High School Longitudinal Study
HSTS	High School Transcript Study
HT	high technology
ICE	Immigration and Customs Enforcement
ICT	information and communications technologies
IDeA	Institutional Development Award
IDR	interdisciplinary research
IEA	International Energy Agency
IOF	involuntarily out-of-field
IPO	initial public offering
IRC	Internal Revenue Code
IRI	Industrial Research Institute
IRS	Internal Revenue Service
KEI	Knowledge Economy Index
KI	knowledge intensive
KTI	knowledge- and technology-intensive
LEHD	Longitudinal Employer-Household Dynamics
LEP	limited English proficient
LTT	long-term trend
MEP	Manufacturing Extension Partnership
MER	market exchange rate
MIT	Massachusetts Institute of Technology
MNC	multinational company
MOFA	majority-owned foreign affiliate
NAEP	National Assessment of Educational Progress
NAGB	National Assessment Governing Board
NAICS	North American Industry Classification System
NASA	National Aeronautics and Space Administration
NASF	net assignable square feet
NCES	National Center for Education Statistics
NCLB	The No Child Left Behind Act of 2001
NCRPA	National Cooperative Research and Production Act

NGA	National Governors Association
NIH	National Institutes of Health
NIPA	national income and product accounts
NIST	National Institute for Standards and Technology
NLR	National Lambda Rail
NOAA	National Oceanic and Atmospheric Administration
NORC	National Opinion Research Center
NRC	National Research Council
NS&E	natural sciences and engineering
NSB	National Science Board
NSCG	National Survey of College Graduates
NSF	National Science Foundation
NSRCG	National Survey of Recent College Graduates
OECD	Organisation for Economic Co-operation and Development
OES	Occupational Employment Statistics
OSTP	Office of Science and Technology Policy
PISA	Program for International Student Assessment
PPP	purchasing power parity
PSM	Professional Science Master's
PUMS	Public Use Microdata Sample
R&D	research and development
R&E	research and experimentation
RA	research assistantship
RDD	random direct dialing
RD&D	R&D and demonstration
RDT	research, development, and testing
S&E	science and engineering
S&T	science and technology
SASS	Schools and Staffing Survey
SBIR	Small Business Innovation Research
SCI	Science Citation Index
SDR	Survey of Doctorate Recipients
SEH	science, engineering, and health
SESTAT	Scientists and Engineers Statistical Data System
SLDS	Statewide longitudinal data systems
SOI	Statistics of Income
SSCI	Social Sciences Citation Index
STEM	science, technology, engineering, and mathematics
STTR	Small Business Technology Transfer
TA	teaching assistant
TFA	Teach for America
TIMSS	Trends in International Mathematics and Sciences Study
TIP	Technology Innovation Program
U&C	universities and colleges
UK	United Kingdom
UNESCO	United Nations Educational, Scientific and Cultural Organization
USDA	Department of Agriculture
USDIA	Survey of U.S. Direct Investment Abroad
USGS	U.S. Geological Survey
USPTO	U.S. Patent and Trademark Office
VA	Department of Veterans Affairs
VCU	Virginia Commonwealth University
WebCASPAR	Integrated Science and Engineering Resources Data System

About Science and Engineering Indicators

Science and Engineering Indicators (SEI) is first and foremost a volume of record comprising the major high-quality quantitative data on the U.S. and international science and engineering enterprise. SEI is factual and policy neutral. It does not offer policy options, and it does not make policy recommendations. SEI employs a variety of presentation styles—tables, figures, narrative text, bulleted text, Web-based links, highlights, introductions, conclusions, reference lists—to make the data accessible to readers with different information needs and different information-processing preferences.

The data are "indicators." Indicators are quantitative representations that might reasonably be thought to provide summary information bearing on the scope, quality, and vitality of the science and engineering enterprise. The indicators reported in SEI are intended to contribute to an understanding of the current environment and to inform the development of future policies. SEI does not model the dynamics of the science and engineering enterprise, and it avoids strong claims about the significance of the indicators it reports. SEI is used by readers who hold a variety of views about which indicators are most significant for different purposes.

SEI is prepared by the National Science Foundation's National Center for Science and Engineering Statistics (NCSES) under the guidance of the National Science Board (Board). It is subject to extensive review by outside experts, interested federal agencies, Board members, and NSF internal reviewers for accuracy, coverage, and balance.

SEI includes more information about measurement than many readers unaccustomed to analyzing social and economic data may find easy to absorb. This information is included because readers need a good understanding of what the reported measures mean and how the data were collected in order to use the data appropriately. SEI's data analyses, however, are relatively accessible. The data can be examined in various ways, and SEI generally emphasizes neutral, factual description and avoids unconventional or controversial analysis. As a result, SEI almost exclusively uses simple statistical tools that should be familiar and accessible to a college bound high school graduate. Readers comfortable with numbers and percentages and equipped with a general conceptual understanding of terms such as "statistical significance" and "margin of error" will readily understand the statistical material in SEI. A statistical appendix aids readers' interpretation of the material presented.

SEI's Different Parts

SEI includes an overview, seven chapters that follow a generally consistent pattern, and an eighth chapter, on state indicators, presented in a unique format. The chapter titles are

- Elementary and Secondary Mathematics and Science Education
- Higher Education in Science and Engineering
- Science and Engineering Labor Force
- Research and Development: National Trends and International Comparisons
- Academic Research and Development
- Industry, Technology, and the Global Marketplace
- Science and Technology: Public Attitudes and Understanding
- State Indicators

An appendix volume, available online at http://www.nsf.gov/statistics/indicators/, contains detailed data tables keyed to each of the eight chapters. SEI includes a list of abbreviations/acronyms and an index.

The National Science Board authors one or more companion pieces, which draw upon the data in SEI and offer recommendations on issues of concern for national science and engineering research or education policy, in keeping with the Board's statutory responsibility to bring attention to such issues. In addition, the Board publishes the *Science and Engineering Indicators Digest*, a condensed version of SEI comprising a small selection of important indicators. The digest serves two purposes: (1) to draw attention to important trends and data points from across the chapters of SEI and (2) to introduce readers to the data resources available in the main volume of *SEI 2012* and associated products.

The Overview

The overview is a selective synthesis that brings together patterns and trends that unite data in several of the substantive chapters. The overview helps readers to synthesize the findings in SEI as a whole and draws connections among separately prepared chapters that deal with related topics. It is intended to serve readers with varying levels of expertise. Because the overview relies heavily on figures, it is well adapted for use in developing presentations, and presentation graphics for the figures in the overview are available on the Web. Like the core chapters, the overview strives for a descriptive synthesis and a balanced tone, and it does not take or suggest policy positions.

The Seven Core Chapters

Each chapter consists of contents and lists of sidebars, text tables, and figures; highlights; introduction (chapter overview and chapter organization); a narrative synthesis of data and related contextual information; conclusion; notes; glossary; and references.

Highlights. The highlights provide an outline of major dimensions of a chapter topic. Each highlight starts with a statement that summarizes a key point made in the chapter. Bulleted points supporting the key point follow.

Introduction. The chapter overview provides a brief explanation of the importance of the topic. It situates the topic in the context of major concepts, terms, and developments relevant to the data reported. The introduction includes a brief narrative account of the logical flow of topics within the chapter.

Narrative. The chapter narrative is a descriptive synthesis that brings together significant findings. It is also a balanced presentation of contextual information that is useful for interpreting the findings. As a descriptive synthesis, the narrative aims (1) to enable the reader to assimilate a large amount of information by putting it in an order that facilitates comprehension and retention and (2) to order the material so that major points readily come to the reader's attention. As a balanced presentation, the narrative aims to include appropriate caveats and context information such that (3) a nonexpert reader will understand what uses of the data may or may not be appropriate, and (4) an expert reader will be satisfied that the presentation reflects a good understanding of the policy and fact context in which the data are interpreted by users with a range of science policy views.

Figures. Figures provide visually compelling representations of major findings discussed in the text. Figures also enable readers to test narrative interpretations offered in the text by examining the data themselves.

Text Tables. Text tables help to illustrate and to support points made in the text.

Sidebars. Sidebars discuss interesting recent developments in the field, more speculative information than is presented in the regular chapter text, or other special topics. Sidebars can also present definitions or highlight crosscutting themes.

Appendix Tables. Appendix tables, available online (http://www.nsf.gov/statistics/indicators/), provide the most complete presentation of quantitative data, without contextual information or interpretive aids. According to past surveys of SEI users, even experienced expert readers find it helpful to consult the chapter text in conjunction with the appendix tables.

Conclusion. The conclusion summarizes important findings. It offers a perspective on important trends but stops short of definitive pronouncements about either likely futures or policy implications. Conclusions tend to avoid factual syntheses that suggest distinctive or controversial viewpoints.

Glossary. The glossary defines terms used in the chapter.

References. SEI includes references to data sources cited in the text, stressing national or internationally comparable data. SEI does not attempt to review the analytic literature on a topic or summarize the social science or policy perspectives that might be brought to bear on it. References to that literature are included where they help to explain the basis for statements in the text.

The State Indicators Chapter

This chapter consists of data that can be used by people involved in state-level policy making, including journalists and interested citizens, to assess trends in S&T-related activities in their states. Indicators are drawn from a range of variables, most of which are part of the subject matter of the seven core chapters. The text explains the meaning of each indicator and provides important caveats about how to interpret it. Approximately three to five bullets highlight significant findings. Data for the indicators are graphically displayed in United States maps that color code states into quartiles and in state-by-state tables. A small number of appendix tables for this chapter can be found online.

No interpretive narrative synthesizes overall patterns and trends. SEI includes state-level indicators to call attention to state performance in S&T and to foster consideration of state-level activities in this area.

Presentation

SEI is released in printed and electronic formats. The printed volume provides the full content except for the appendix tables. The complete content of SEI is posted online at http://www.nsf.gov/statistics/indicators/ in html format and PDF, with text tables, appendix tables, and source data for each figure available in spreadsheet (MS Excel) format. In addition, selected figures are also available in presentation-style format as MS PowerPoint and JPEG files.

Overview

List of Figures

Introduction

This overview of the National Science Board's *Science and Engineering Indicators 2012* highlights some major developments in international and U.S. science and technology (S&T). It is not intended to be comprehensive; the reader will find more extensive data in the body of each chapter. Major findings on particular topics appear in the Highlights sections that precede chapters 1–7.

The indicators included in *Science and Engineering Indicators 2012* derive from a variety of national, international, public, and private sources and may not be strictly comparable in a statistical sense. As noted in the text, some data are weak, and the metrics and models relating them to each other and to economic and social outcomes need further development. Thus, the emphasis is on broad trends; individual data points and findings should be interpreted with care.

The overview focuses on the trend in the United States and many other parts of the world toward the development of more knowledge-intensive economies in which research, its commercial exploitation, and other intellectual work are of growing importance. Industry and government play key roles in these changes.

The overview examines how these S&T patterns and trends affect the position of the United States, using broadly comparable data wherever possible for the United States, the European Union (EU[1]), Japan, China, and other selected Asian economies (the Asia-8: India, Indonesia, Malaysia, the Philippines, Singapore, South Korea, Taiwan, and Thailand).

The overview sketches an analytical framework for, and a broad outline of, the main S&T themes, which it then examines through the lens of various indicators. R&D and human resources indicators feature prominently, along with indicators of research outputs and their use in the form of article citations and patents. The overview then describes the growth and structural shifts in international high-technology markets, trade, and relative trade positions.

Some of the data available as of this writing cover all or part of the period of the 2007–09 financial and economic crisis that continues to unsettle the world. The crisis has affected the range of S&T endeavors, from basic research to production and trade of high-technology goods and knowledge-intensive services. The full effects of these events will take years to become apparent, but, to the extent permitted by available data, the overview will comment on recession-induced changes in the major well-established trends.

Major Global Science and Technology Trends

Since the 1990s, a global wave of market liberalization has produced an interconnected world economy, accompanied by unprecedented levels of activity and growth and by ongoing structural changes. Governments in many parts of the developing world, viewing science and technology as integral to economic growth and development, have set out to build more knowledge-intensive economies. They have taken steps to open their markets to trade and foreign investment, develop their S&T infrastructures, stimulate industrial R&D, expand their higher education systems, and build indigenous R&D capabilities. Over time, global S&T capabilities have grown, nowhere more so than in Asia.

As more effective communication and management tools have been developed, multinational corporations (MNCs) seeking to access these new markets have evolved global corporate structures that draw on far-flung, specialized, global supplier networks. In turn, host governments have often attached conditions to market access that, along with technology spillovers, have aided in the development of indigenous S&T capabilities. Western- and Japan-based MNCs are increasingly joined in world S&T markets by newcomers headquartered in developing nations.

In most broad aspects of S&T activities, the United States continues to maintain a position of leadership. But it has experienced a gradual erosion of its position in many specific areas. Two contributing developments to this erosion are the rapid increase in a broad range of Asian S&T capabilities outside of Japan and the effects of EU efforts to boost its relative competitiveness in R&D, innovation, and high technology.

Asia's rapid ascent as a major world S&T center is chiefly driven by developments in China, which on most indicators continues to show long-term growth that would normally be regarded as unsustainable. But several other Asian economies (the Asia-8) have also played a role. All are intent on boosting quality of, and access to, higher education and developing world-class research and S&T infrastructures. The Asia-8 functions like a loosely structured supplier zone for China's high-technology manufacturing export industries. This supplier zone increasingly appears to include Japan. Japan, a preeminent S&T nation, is continuing to lose ground relative to China and the Asia-8 in high-technology manufacturing and trade. India's high gross domestic product (GDP) growth continues to contrast with a fledgling overall S&T performance.

The EU is seeking to hold its own in the face of these worldwide S&T shifts. Its innovation-focused policy initiatives have been supported by the creation of a shared currency and the elimination of internal trade and migration barriers. Much of the EU's high-technology trade is with other EU members. EU research performance is strong and marked by pronounced EU-supported, intra-EU collaboration. The EU is also focused on boosting the quality and international standing of its universities.

Other countries share this heightened focus on S&T as a means of economic growth. Brazil and South Africa show high S&T growth rates, but from low bases. Among the more developed nations, Russia's S&T establishment continues to struggle in both relative and absolute terms, whereas Israel, Canada, and Switzerland are examples of mature, high-performing S&T establishments.

Global Expansion of Research and Development Expenditures

Global R&D expenditures over the past decade have grown faster than global GDP,[2] an indication of widespread efforts to make economies more knowledge and technology intensive. The global total rose from an estimated $522 billion in 1996 to approximately $1.3 trillion in 2009, with the rate of growth slowing in the 2008–09 recession years (figure O-1). Although the specific data points in figure O-1 are imprecise estimates, the steady and strong upward trend illustrates the rapidly growing global focus on innovation through R&D.[3]

R&D investments of Western countries slowed markedly in the face of adverse economic conditions. After 2008, R&D growth stopped and decreased for both the United States and the EU, after accounting for inflation. Growth for the Asian region (China, Japan, and the Asia-8) and the rest of the world slowed somewhat in 2008 and 2009, but from very high rates in earlier years.

The United States remained by far the single largest R&D-performing country, with an R&D expenditure of $400 billion in 2009. For the first time, the Asian region's total of $399 billion[4] matched the U.S. total in 2009 (figure O-2).

China's 2008–09 R&D growth increased by a record 28%—well above its 1997–2007 trendline growth of 22%—and propelled it past Japan into second place. 2010 data released by China's National Bureau of Statistics show a further 22% increase.

R&D expenditures can be viewed as long-term investments in innovation. The R&D/GDP ratio is a convenient indicator of how much of a nation's economic activity is devoted to innovation through R&D. A U.S. goal in the 1950s was to achieve an R&D investment of 1% of GDP by 1957. More recently, many governments have set their sights at 3% of GDP in pursuit of developing knowledge-based economies, a figure the EU has formally made its long-term planning target.[5]

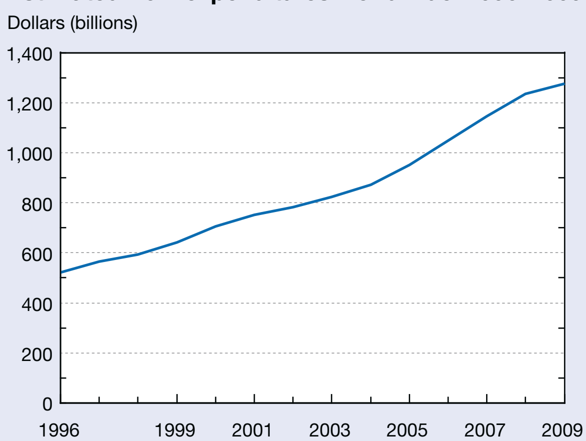
However, decisions affecting the bulk of R&D expenditures are generally made by industry, thus removing achievement of such a target from direct government control. In the United States, industry funds about 62% of all R&D. The EU average is 54%, but with considerable range (e.g., nearly 70% for Germany, but 45% for the United Kingdom). In China, Singapore, and Taiwan, industry funding ranges from 60% upward. Nevertheless, government planners monitor the R&D/GDP ratio as an indicator of innovative capacity, even as few countries reach the 3% mark.

Over the past decade, many developing economies in Asia have exhibited increased R&D/GDP ratios; conversely, the United States and the EU ratios have broadly held steady. Japan's comparatively high R&D/GDP ratio reflects the confluence of contracting GDP and flat R&D.

China's R&D/GDP ratio almost tripled, from 0.6% in 1996 to 1.7% in 2009, a period during which China's GDP grew at 12% annually—an enormous, sustained increase. The gap in China's R&D/GDP ratio relative to those of developed economies suggests that there is room for China's R&D volume to continue to grow rapidly (figure O-3).

The decade-long (1996–2007) R&D growth rates of mature S&T economies were lower than those of developing ones. Growth of R&D expenditures in the United States, the

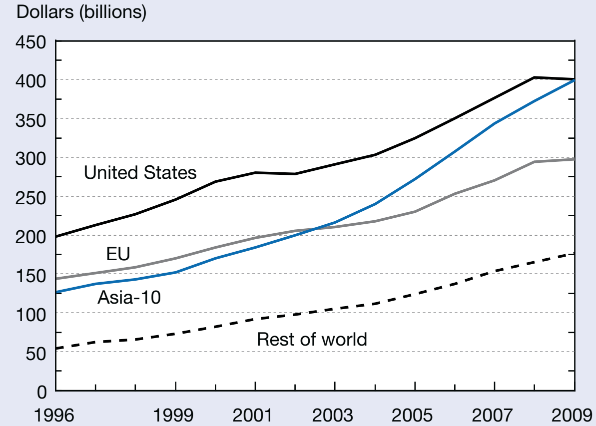
Figure O-1
Estimated R&D expenditures worldwide: 1996–2009



SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators* (2011-1 and previous years) and United Nations Educational, Scientific and Cultural Organization Institute for Statistics, http://stats.uis.unesco.org.

Science and Engineering Indicators 2012

Figure O-2
R&D expenditures for United States, EU, and 10 Asian economies: 1996–2009

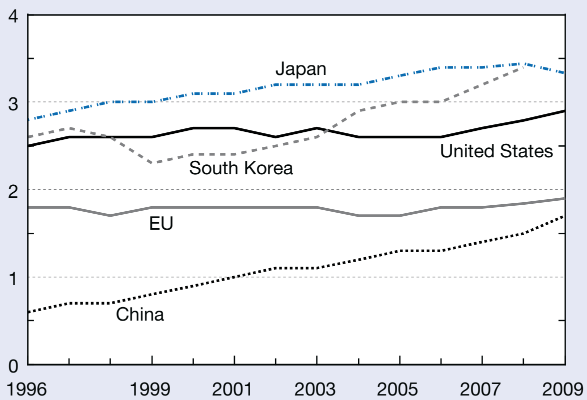


Asia-10 = China, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand; EU = European Union

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators* (2011-1 and previous years) and United Nations Educational, Scientific and Cultural Organization Institute for Statistics, http://stats.uis.unesco.org.

Science and Engineering Indicators 2012

Figure O-3
R&D expenditures as a share of economic output of selected regions/countries: 1996–2009



EU = European Union; GDP = gross domestic product

NOTE: 2009 data unavailable for South Korea.

SOURCE: Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators* (2011-1 and previous years).

Science and Engineering Indicators 2012

EU, and Japan were in the 5.4%–5.8% range while growth ranged from about 9.5%–10.5% for Singapore and Taiwan, to 12% for South Korea.

The effect of the global economic slowdown on R&D expenditures is dramatic—a sharp drop in growth in most locations in 2008–09 that is in stark contrast to a 28% rise in China's R&D spending, its highest growth rate since 2000 (figure O-4).

The relatively greater R&D growth rates of Asian economies (excluding Japan) resulted in changes in the global distribution of estimated R&D expenditures. Compared to 1996, the North America region's (United States, Canada, and Mexico) share of estimated world R&D activity decreased from 40% to 36% by 2009; the EU's share declined from 31% to 24%. The Asia/Pacific region's share increased from 24% to 35%, Japan's low growth notwithstanding (figure O-5).

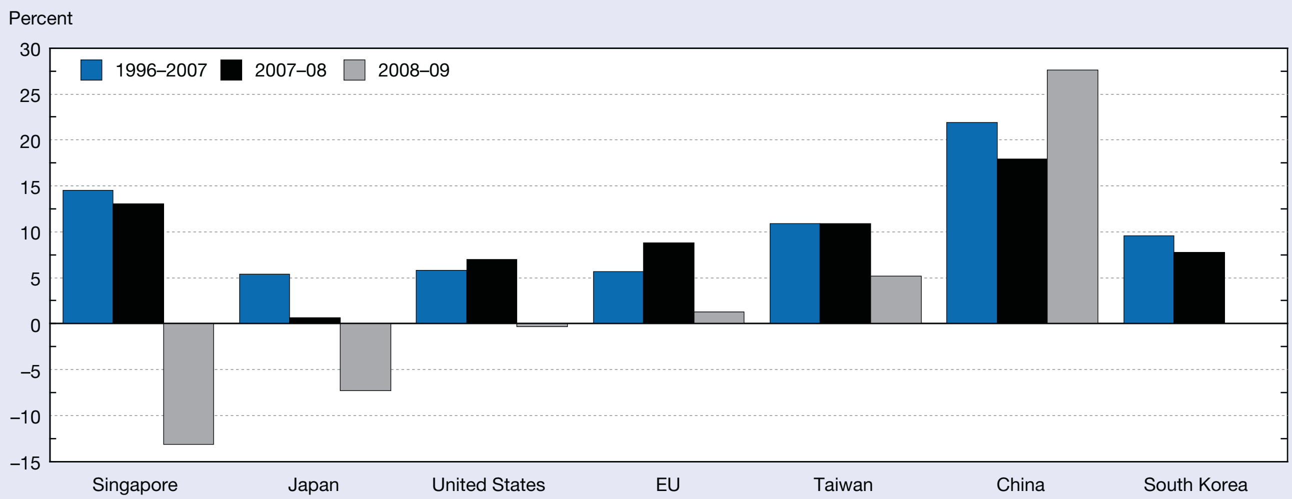
Overseas R&D by Multinational Corporations

The shift toward greater R&D expenditures in Asia is also reflected in R&D flows between MNCs and their overseas affiliates in which they hold majority ownership (figure O-6).

Overseas R&D expenditures of U.S.-based MNCs ($37 billion in 2008) shifted toward Asian markets whose combined share increased from 11% in 1998 to 20% a decade later, with increases in China, South Korea, Taiwan, and Singapore. In 1998, about 83% of all overseas R&D by U.S.-headquartered MNCs took place in Europe and Canada; by 2008, their combined percentage had decreased to 74%.

A crude indicator of the pace of utilization of overseas R&D talent and facilities by U.S. MNCs is the percentage of the MNCs' total R&D that is conducted by their majority-owned overseas affiliates. Over the past decade, this share has gradually risen from about 13% to 16% (figure O-7).

Figure O-4
Average annual growth of R&D expenditures for United States, EU, and selected Asian economies: 1996–2007, 2007–08, and 2008–09



EU = European Union

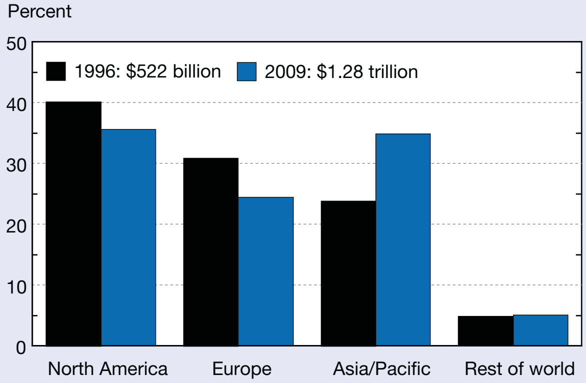
NOTE: 2009 data unavailable for South Korea.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators* (2011-1 and previous years).

Science and Engineering Indicators 2012

Affiliates of foreign-headquartered MNCs in 2008 spent about $40.5 billion on R&D in the United States, virtually unchanged from the preceding year. The companies' share of total U.S. business R&D has fluctuated between 13% and 15% since 2000.

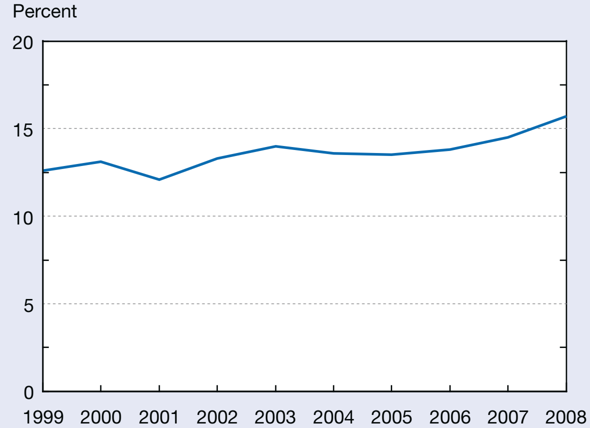
Figure O-5
Location of estimated worldwide R&D expenditures: 1996 and 2009



SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators* (2011-1 and previous years) and United Nations Educational, Scientific and Cultural Organization Institute for Statistics, http://stats.uis.unesco.org.

Science and Engineering Indicators 2012

Figure O-7
U.S. multinational companies' R&D performed abroad: 1999–2008

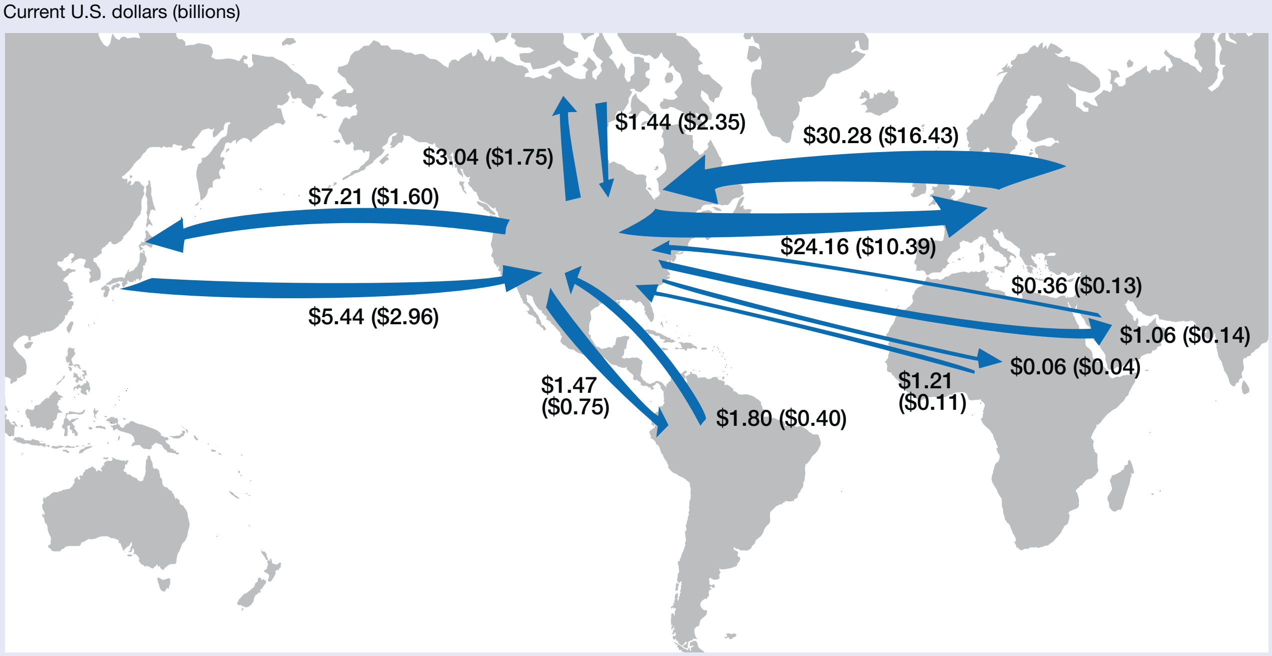


NOTES: Data for majority-owned affiliates. Preliminary estimate for 2008.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of Bureau of Economic Analysis, Survey of U.S. Direct Investment Abroad.

Science and Engineering Indicators 2012

Figure O-6
R&D performed in the United States by U.S. affiliates of foreign companies, by investing region, and R&D performed abroad by foreign affiliates of U.S. multinational corporations, by host region: 1998 and 2008



NOTES: Preliminary estimates for 2008 (1998 data in parentheses).

SOURCES: Bureau of Economic Analysis, Survey of Foreign Direct Investment in the United States (annual series); Survey of U.S. Direct Investment Abroad (annual series).

Science and Engineering Indicators 2012

Global Higher Education and Workforce Trends

No comprehensive measures of the global S&E labor force exist, but fragmentary data indicate rapid growth, concentrated in developing countries, in the number of individuals who pursue education beyond the secondary level. Their number of degrees, especially degrees in the natural sciences and engineering (NS&E), has diminished the advantage that mature countries had in advanced education.[6] The low U.S. share of global engineering degrees in recent years is striking; well above half of all such degrees are awarded in Asia[7] (figure O-8).

Governments in many Western countries and in Japan are concerned about lagging student interest in studying NS&E, fields they believe convey technical skills and knowledge that are essential for knowledge-intensive economies. In the developing world, the number of students earning first university degrees—that are considered broadly comparable to a U.S. baccalaureate—in NS&E is rising.

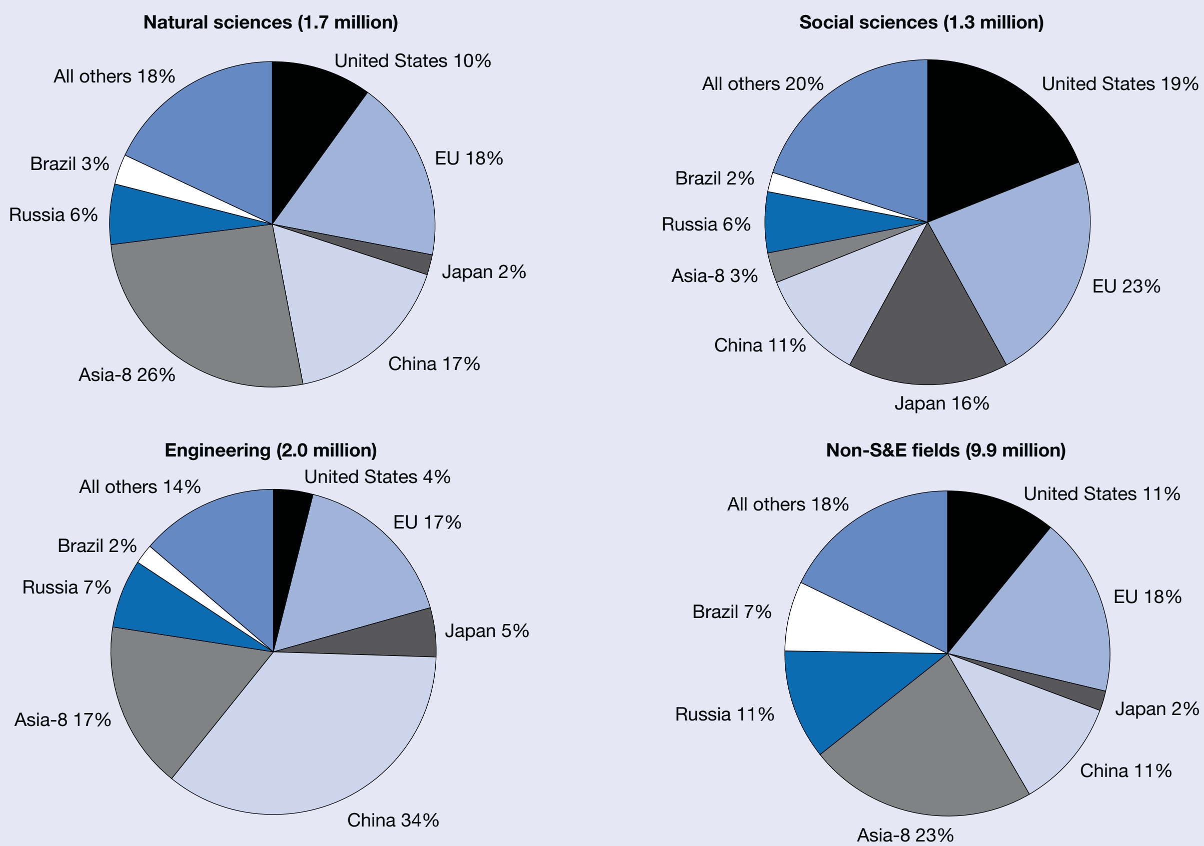
China, especially, has driven the rise of first university NS&E degrees—from about 280,000 in 2000 to 1 million in 2008 (figure O-9). Its degree structure has a pronounced concentration on engineering degrees, which represent about 30% of all first university degrees, 60% of S&E degrees, and 70% of NS&E degrees (the U.S. equivalents are 4%, 14%, and 28%).

South Korea, Taiwan, and Japan show similar field patterns. The combined NS&E degrees earned by their students, about 330,000 in 2008, exceeded the 248,000 earned by U.S. students, even though the U.S. population was considerably larger (300 million versus 200 million).

The expansion of NS&E degrees extends beyond first university degrees to degrees certifying completed advanced study. Since 2000, the number of NS&E doctorates awarded in Japan and India has increased to approximately 7,100 and 8,000, respectively. NS&E doctorate awards from universities in China have more than tripled since 2000, to about 26,000 in 2008, exceeding the comparable number of NS&E doctorates awarded in the United States (figure O-10).

Moreover, unlike in China, in the United States a large proportion of these degrees go to non-U.S. citizens. Most of the post-2000 increase in U.S. NS&E doctorate production reflects degrees awarded to temporary visa holders,

Figure O-8
First university degrees, by selected region/country: 2008 or latest data



Asia-8 = India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand; EU = European Union

SOURCES: Organisation for Economic Co-operation and Development, Education Online database, http://www.oecd.org/education; and national statistical offices.

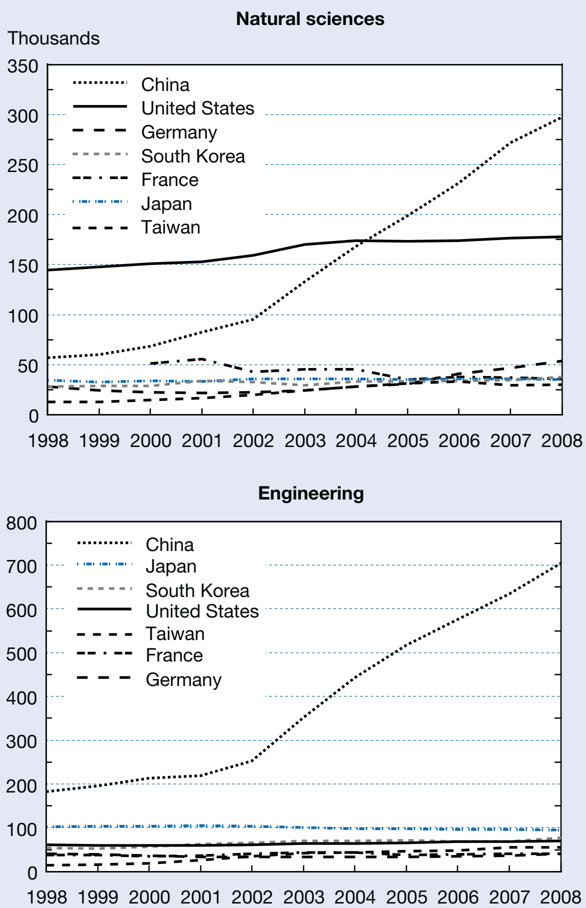
Science and Engineering Indicators 2012

who in 2009 earned about 10,900 of the 24,700 U.S. NS&E doctorates.[8] Temporary visa holders, not counting foreign students with permanent visas, have earned 39% to 48% of U.S. NS&E doctorates since 2000. More than half of these students are from China, India, and South Korea.

For engineering alone, the numbers are considerably more concentrated. Since 2000, the share of U.S. engineering doctorates earned by temporary visa holders has risen from 51% to as high as 63% in 2005–07, before dropping to 57% in 2009. Nearly three-quarters of foreign national recipients of engineering doctorates were from East Asia or India.

Many of these individuals, especially those on temporary visas, will leave the United States after earning their doctorates, but if past trends continue, a large proportion—about 60%—will stay. It appears, though, that graduates from top-rated programs are somewhat less likely than others to stay.[9]

Figure O-9
First university degrees in natural sciences and engineering, by selected country/economy: 1998–2008



NOTE: Natural sciences include physical, biological, environmental, agricultural, and computer sciences, and mathematics.

SOURCES: Organisation for Economic Co-operation and Development, Education Online database, http://www.oecd.org/education; and national statistical offices.

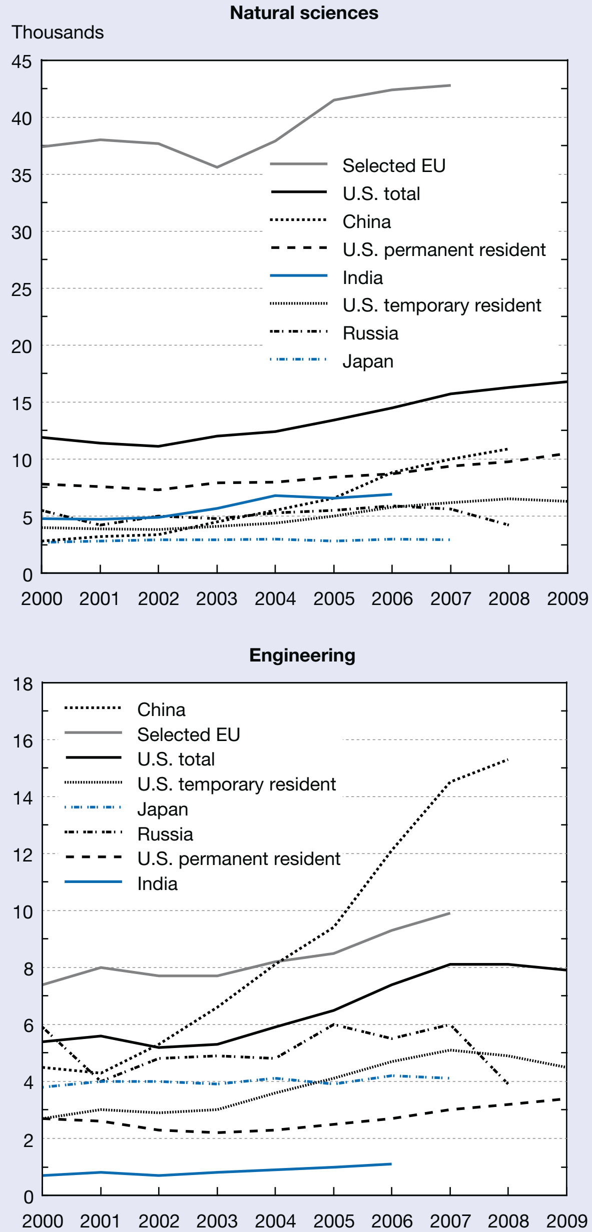
Science and Engineering Indicators 2012

Expanding Global Researcher Pool

Estimates of the number of the world's researchers provide broad support for the trends and shifts suggested by R&D and degree data.

The estimated number of researchers grew from nearly 4 million in 1995 to about 6 million in 2008.[10] The United

Figure O-10
Doctoral degrees in natural sciences and engineering, by selected region/country: 2000 to most recent year



EU = European Union

NOTE: Natural sciences include physical, biological, environmental, agricultural, and computer sciences, and mathematics.

SOURCES: Organisation for Economic Co-operation and Development, Education Online database, http://www.oecd.org/education; and national statistical offices.

Science and Engineering Indicators 2012

States and the 27 EU-member countries accounted for about 1.4 and 1.5 million researchers each—a combined 49% of the total but below the 51% share they had held a decade earlier. China's researchers tripled over the period.

Trends in researcher growth rates vary greatly by country and region (figure O-11). The United States and the EU had moderate annual growth in the 3%–4% range between 1995 and 2002, after which U.S. growth moderated. Comparable rates for Japan fluctuated between ±1%; Russia's researcher numbers kept contracting. Growth in the Asian region outside Japan was generally higher in the 2002–09 period than earlier and averaged 8%–9% for Taiwan, Singapore, and South Korea, capped by China's 12% annual average.

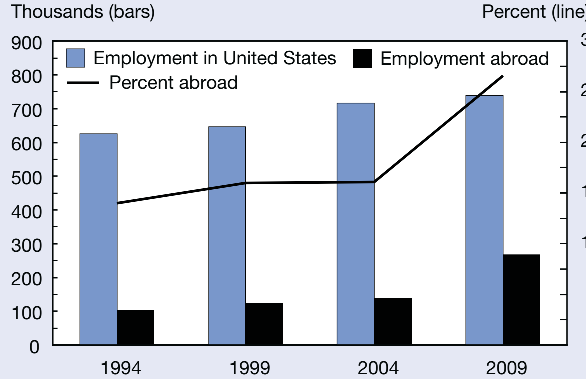
The contribution of multinational corporations to researcher growth in the overseas markets in which they operate is unknown. But preliminary data, available every 5 years, suggest a pronounced expansion of R&D employment by overseas affiliates (majority-owned only) of U.S.-based MNCs in recent years.[11] After gradually increasing from 102,000 in 1994 to 138,000 in 2004, their R&D employment almost doubled to 267,000 in 2009. Over the same 5 years, the MNCs's R&D employment in the United States rose from about 716,000 to about 739,000. This boosted the overseas share of their total R&D employment from 16% to 27% (figure O-12). Not included are researchers in overseas firms in which MNCs hold less than majority ownership or in unaffiliated firms that perform contract research for MNCs.

Data on employment of researchers by foreign-based MNCs in other countries are unavailable, except for those working in the United States. Growth in U.S. employment of researchers working for U.S. affiliates of foreign-based MNCs has been broadly in line with overall U.S. researcher trends.

Research Outputs: Journal Articles and Patents

Research produces new knowledge, products, or processes. Research publications reflect contributions to knowledge, patents indicate useful inventions, and citations on patents to the scientific and technical literature indicate linkages between research and practical application.

Figure O-12
R&D employment of U.S.-based multinational corporations: 1994, 1999, 2004, and 2009

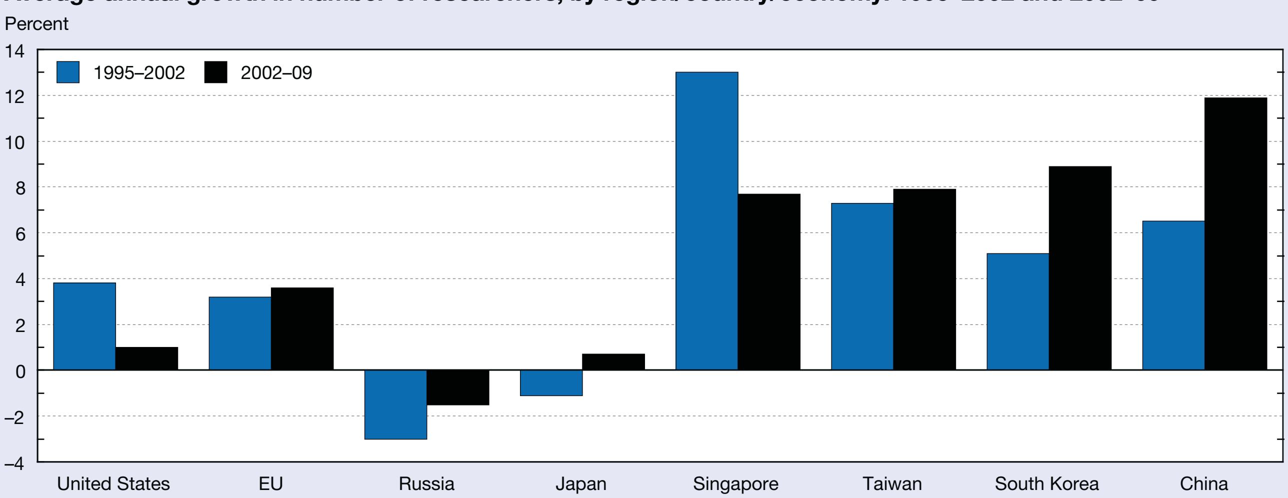


NOTES: Employment abroad limited to majority-owned affiliates. 2009 data are preliminary.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of Bureau of Economic Analysis, International Economic Accounts, U.S. Direct Investment Abroad (2009 and previous years).

Science and Engineering Indicators 2012

Figure O-11
Average annual growth in number of researchers, by region/country/economy: 1995–2002 and 2002–09



EU = European Union

NOTE: Growth rates through last available year in range indicated.

SOURCE: Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators* (2011-1 and previous years).

Science and Engineering Indicators 2012

The number of research articles published in a set of international, peer-reviewed journals has grown from about 460,200 in 1988 to an estimated 788,300 in 2009.[12] The geographical distribution of the authors[13] provides an indication of the size of a country's or region's research enterprise and its production of research results (figure O-13).

Researchers in the EU and the United States have long dominated world article production, but their combined share of published articles decreased steadily from 69% in 1995 to 58% in 2009. In little more than a decade, Asia's world article share expanded from 14% to 24%, driven by China's 16% average annual growth. By 2007, China surpassed Japan's article output and moved into second place behind the United States—up from 14th place in 1995. By 2009, China accounted for about 9% of world article output.

India's output of scientific and technical articles, stagnating through the late 1990s, began to rise after 2000, but India's ranking hardly changed from 12th to 11th place in 2009. Japan's output declined in volume and global share. Russia's article output flattened after 2005, following a decade-long decline that resulted in a drop from 7th to 13th place in global output ranking.

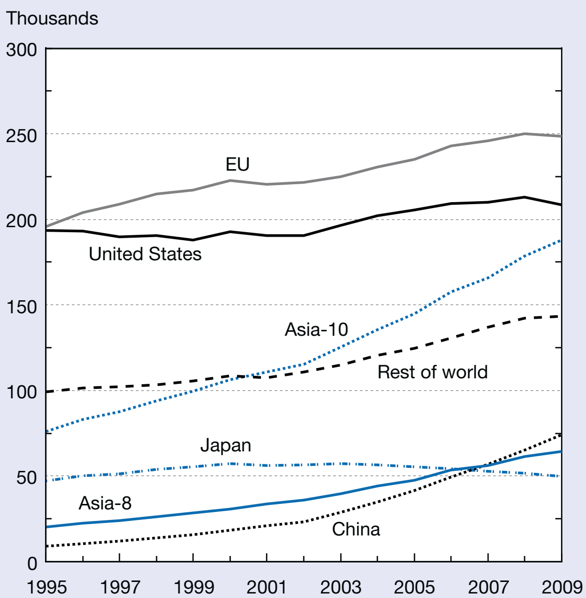
The distribution of a country's research publications across different fields is a broad reflection of its research priorities. A large portion of U.S. articles focused on the biomedical and other life sciences; scientists in Asia and some major European countries published a preponderance of articles in the physical sciences[14] and engineering. Recent shifts in emphasis include China's growing focus on chemistry R&D and South Korea's growing output in biological and medical sciences. These changes reflect government policy choices as China is building up its chemicals industry, and South Korea is trying to develop a world-class reputation in health sciences.

Worldwide, the number of engineering research articles have increased substantially faster than total S&E article production, particularly in Asia outside Japan (figure O-14). Growth in the United States and Japan averaged less than 2%; in the EU, about 4.4%. China's engineering article output grew by close to 16% annually, and the Asia-8 economies expanded their combined output by 10% a year.

Consequently, the production of engineering research articles has shifted away from established S&T nations. In 1995, the U.S. share of engineering articles was 25%, by 2009, 13%. Japan's share declined from 10% to 5% during the same period. The EU's share dipped from 25% to 19%. Asia's share, excluding Japan, increased from 9% to 23%, with China producing nearly half of these articles by 2009.

The relative preponderance of engineering articles in developing Asian economies reflects the region's emphasis on

Figure O-13
S&E journal articles produced, by selected region/country: 1995–2009

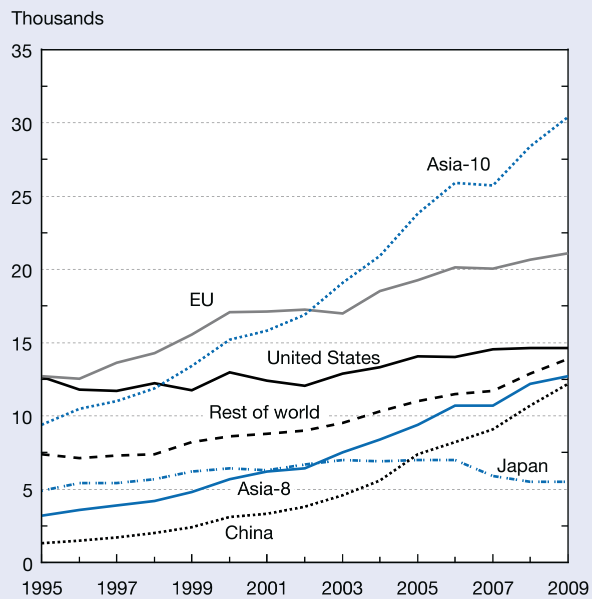


Asia-8 = India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand; Asia-10 = Asia-8 plus China and Japan; EU = European Union

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of Thomson-Reuters, Science and Social Sciences Citation Indexes, http://thomsonreuters.com/products_services/science/, and The Patent Board™.

Science and Engineering Indicators 2012

Figure O-14
Engineering journal articles produced, by selected region/country: 1995–2009



Asia-8 = India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand; Asia-10 = Asia-8 plus China and Japan; EU = European Union

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of Thomson-Reuters, Science and Social Sciences Citation Indexes, http://thomsonreuters.com/products_services/science/, and The Patent Board™.

Science and Engineering Indicators 2012

building high-technology manufacturing capabilities. In the United States and the EU, 7%–8% of all articles are in engineering, in Asia, 11%–20% (figure O-15).

Patents list the prior scientific and technological knowledge on which they are built. Increasingly, U.S. patents have cited scientific articles as one such source. The foreign share of such patent-to-article citations is rising, indicating growing utilization of published research in foreign inventions.

Changing International Research Collaborations

Collaborative research is becoming the norm, and collaboration across national boundaries is generally increasing, as reflected in international coauthorship on research articles. In 1988, only 8% of the world's S&E articles had international coauthors; by 2009, this share had grown to 23%. For the world's major S&T regions, the 2009 rate ranged from about 27% to 42%.

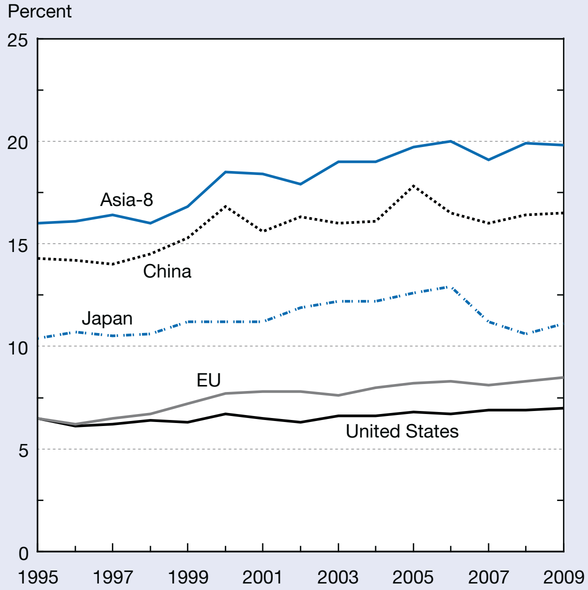
International coauthorship trends for China, South Korea, and Taiwan differ from this pattern. Each location had reached an international coauthorship level of 20%–30% of its total articles by the early 1990s. They broadly maintained the same relative level of international collaboration, indicating that the bulk of their rapid article growth was due to articles with only domestic authors (figure O-16).

As a result of the large volume of both U.S. and EU article outputs, along with EU policies that encourage intra-Union collaboration, U.S.-based authors appeared on 43%, and EU-based authors on 67%, of the world's internationally coauthored articles in 2009. Increasingly, Asia-based authors are participating in international collaborations, signaling maturing of their scientific and engineering capabilities (figure O-17).

Size matters: China, with its rapidly growing research capacity, can support more international collaborations than Singapore. An index of international collaboration corrects for different-sized science establishments and allows comparisons of regional and country coauthorship patterns. On this index, values above "1" indicate higher-than-expected, and values below "1" lower-than-expected, degrees of collaboration with researchers in a particular country.[15]

U.S. international collaborations measured by this index were widespread. Links were strongest with South Korea, Taiwan, Canada, and Israel; collaboration with China, Japan, and India was also above the U.S. average. The pattern of U.S. international collaborations remained mostly steady over the past decade (2000–10), though ties increased with China and weakened somewhat with a number of other Asian economies (figure O-18).

Figure O-15
Engineering journal articles as a share of total S&E journal articles, by selected region/country: 1995–2009

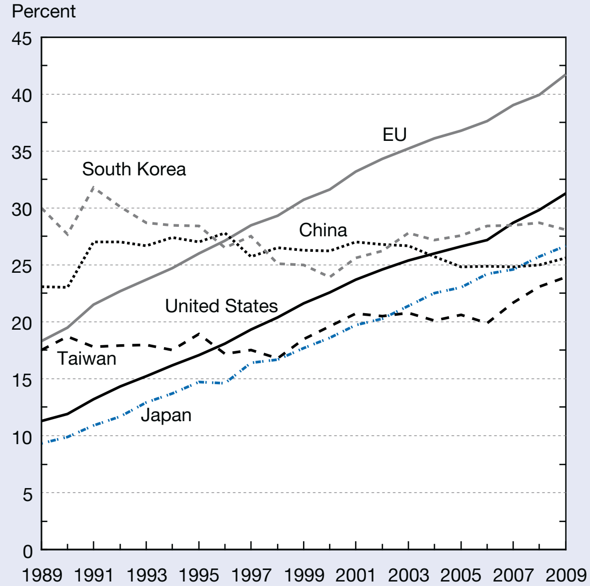


Asia-8 = India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand; EU = European Union

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of Thomson-Reuters, Science and Social Sciences Citation Indexes, http://thomsonreuters.com/products_services/science/, and The Patent Board™.

Science and Engineering Indicators 2012

Figure O-16
Research articles with international coauthors, by selected region/country/economy: 1989–2009



EU = European Union

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of Thomson-Reuters, Science and Social Sciences Citation Indexes, http://thomsonreuters.com/products_services/science/, and The Patent Board™.

Science and Engineering Indicators 2012

EU collaborations were equally widespread and increased measurably over the period, quite likely in response to explicit EU policies. Levels of collaboration with Asia were generally well below the expected level, and the EU collaboration index was lower (and declining) with China than with India (figure O-19).

Collaboration among Asia's growing number of researchers was generally substantially higher than expected, with high levels of collaboration between China and Japan, South Korea, Singapore, and Taiwan. Collaboration between China and India, as measured by this index, diminished noticeably over the decade amid rising Indian collaboration with South Korea and Japan (figure O-20). The underlying index values suggest the genesis of an intra-Asian zone of scientific collaboration that has a counterpart in the region's knowledge- and technology-intensive (KTI) economic activities.

New Research Capacity Reflected in World's Citations Base

Citations to the work of others in the literature are a broad indicator of the usefulness of this work in ongoing research.[16] In most major countries/regions, citations to the international literature have grown at the expense of citing purely domestic work. International citations make up 70% of all references in Japanese articles and 65% of all references in the combined output of the Asia-8. In the United States, the EU, and China, about half of all citations are to articles that include at least one author from another country (figure O-21).

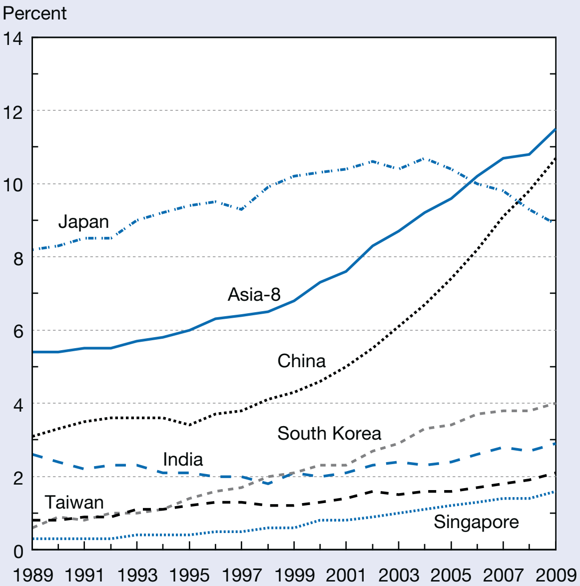
Intra-Asian citation patterns show a distinct reliance by Chinese researchers on the growing domestic literature, and on intra-Asia-8 articles by Asia-8 scientists, accompanied by rising Asia-8-China citations and vice versa. Citations to Japanese science and engineering articles are gradually declining (figure O-22).

Increasingly, high-quality research is being done not only in the United States, the EU, and Japan, but in a broader set of economies. This is illustrated by the declining proportion of citations to U.S. publications in articles originating elsewhere (figure O-23). The same trend appears in the references found in the top 1% of all cited articles.

Inventive Activity Shown by Patents

Government-issued patents protect inventions that are new, not obvious, and useful. The U.S. Patent and Trademark Office (USPTO) grants patents to inventors from all over the world, and the sheer volume of U.S. patents and

Figure O-17
Internationally coauthored articles with authors in Asia, by Asian author location: 1989–2009

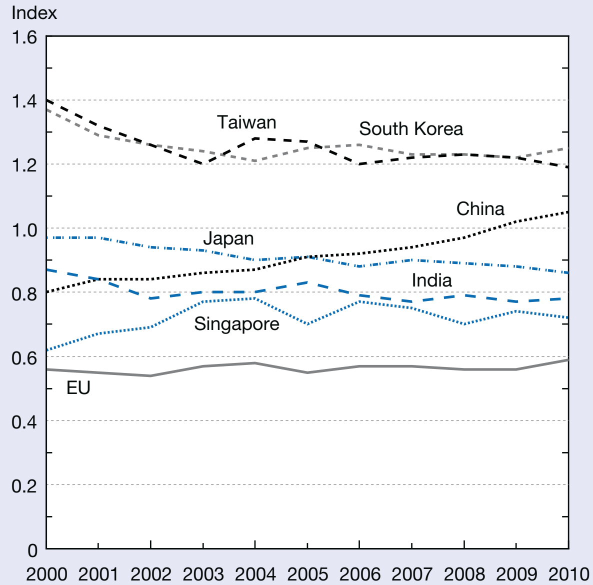


Asia-8 = India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of Thomson-Reuters, Science and Social Sciences Citation Indexes, http://thomsonreuters.com/products_services/science/, and The Patent Board™.

Science and Engineering Indicators 2012

Figure O-18
U.S. research collaborations with EU and selected Asian countries/economies: 2000–10



EU = European Union

NOTE: Index value >1 indicates higher-than-expected degree of collaboration.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of Thomson-Reuters, Science and Social Sciences Citation Indexes, http://thomsonreuters.com/products_services/science/, and The Patent Board™.

Science and Engineering Indicators 2012

the importance of the U.S. market makes them a useful indicator of trends in the geography of inventive activity.

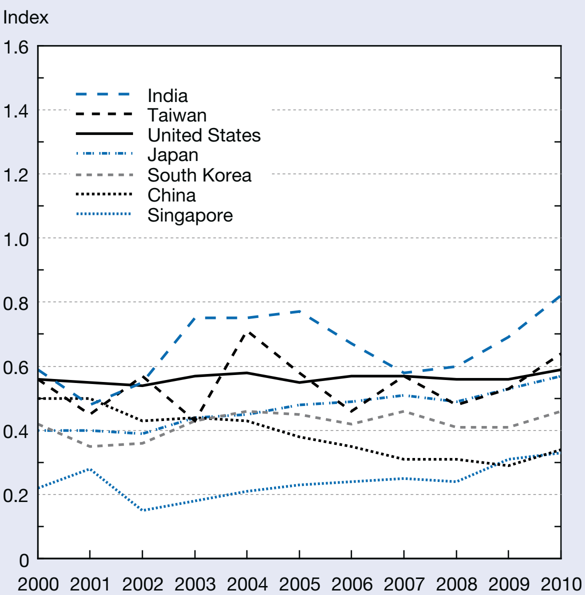
In 1992, about 54% of USPTO patents were granted to U.S.-based inventors; by 2010, this percentage had fallen to 49%, a possible indication of growing inventive activity elsewhere.[17]

Among patents granted to non-U.S. inventors, the shares of EU- and Japan-based individuals have eroded by 9–11 percentage points since 1992. Asia-8's share rose by 15 points over the period, mostly because of activity by South Korea and Taiwan (figure O-24).

The picture of inventive activity drawn by Chinese patents is mixed. Among USPTO awards to non-U.S. inventors, China's share rose from below 0.5% to 3%. By this indicator, broad-based indigenous inventive activity, a focus of Chinese government policy, appears to remain elusive. But patents granted in China to China-based inventors rose from 5,000 in 2001 to 65,000 in 2009, and the Chinese-inventor share of Chinese patent grants increased from 33% to more than 50%.

Not all patents are equal in presumed value. Seeking protection for the same invention in the United States, the EU, and Japan requires substantial resources, suggesting that such patents are considered especially valuable by their owners.

Figure O-19
EU research collaborations with the United States and selected Asian countries/economies: 2000–10



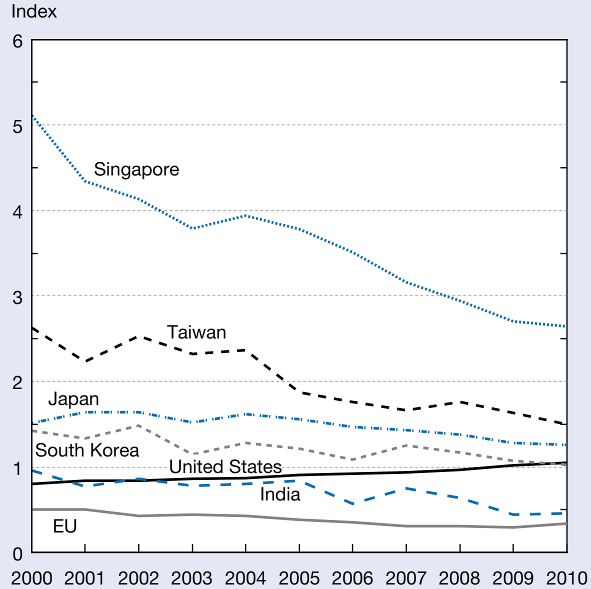
EU = European Union

NOTE: Index value >1 indicates higher-than-expected level of collaboration.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of Thomson-Reuters, Science and Social Sciences Citation Indexes, http://thomsonreuters.com/products_services/science/, and The Patent Board™.

Science and Engineering Indicators 2012

Figure O-20
Chinese research collaborations with the United States, EU, and selected Asian countries/economies: 2000–10



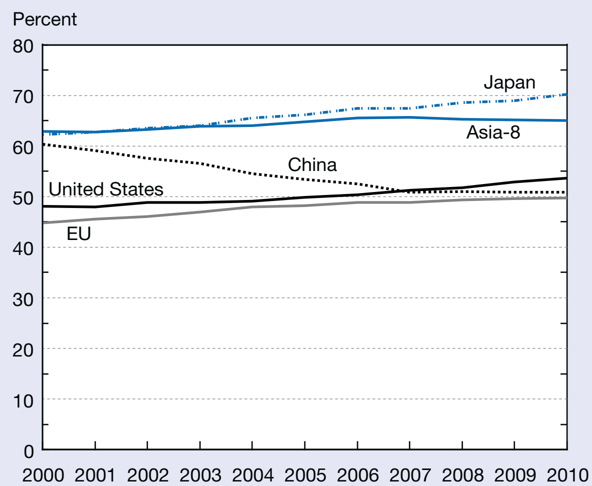
EU = European Union

NOTE: Index value >1 indicates higher-than-expected levels of collaboration.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of Thomson-Reuters, Science and Social Sciences Citation Indexes, http://thomsonreuters.com/products_services/science/, and The Patent Board™.

Science and Engineering Indicators 2012

Figure O-21
Share of selected region's/country's citations to international literature: 2000–10



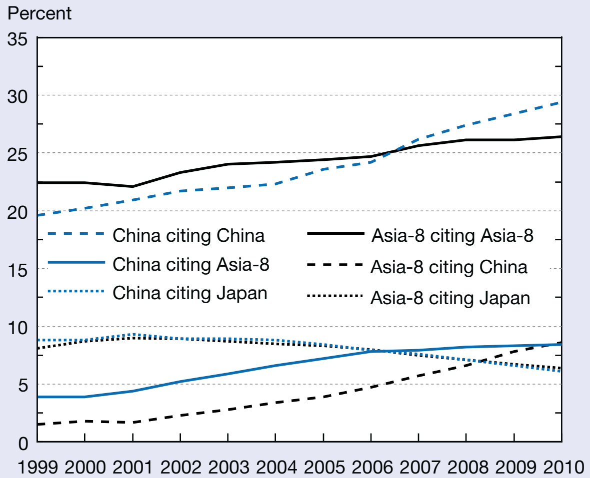
Asia-8 = India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand; EU = European Union

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of Thomson-Reuters, Science and Social Sciences Citation Indexes, http://thomsonreuters.com/products_services/science/, and The Patent Board™.

Science and Engineering Indicators 2012

In 2008, U.S. and EU inventors each accounted for 30% of such high-value patents. Japan's share declined since 2000, while that of the Asia-8 rose, largely on the strength of Korean patenting activity (figure O-25). In contrast, China-based inventors appeared on only 1% of these high-value patents.

Figure O-22
Intra-Asia citation patterns for China, Asia-8, and Japan: 1999–2010

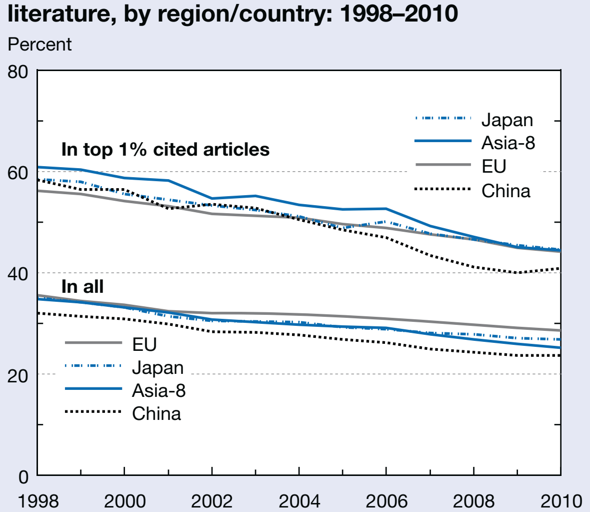


Asia-8 = India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of Thomson-Reuters, Science and Social Sciences Citation Indexes, http://thomsonreuters.com/products_services/science/, and The Patent Board™.

Science and Engineering Indicators 2012

Figure O-23
Citations of U.S. research articles in non-U.S. literature, by region/country: 1998–2010

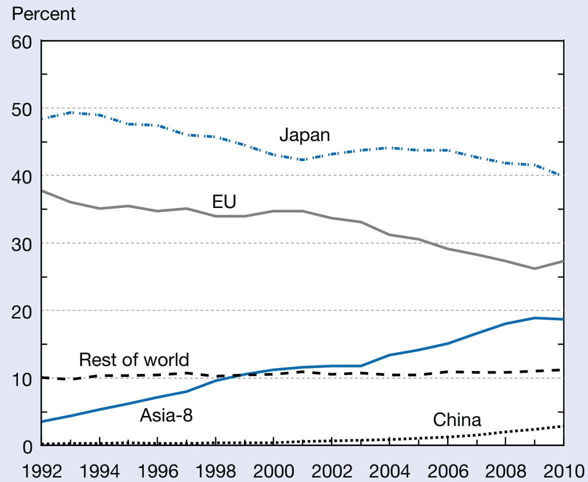


Asia-8 = India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand; EU = European Union

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of Thomson-Reuters, Science and Social Sciences Citation Indexes, http://thomsonreuters.com/products_services/science/, and The Patent Board™.

Science and Engineering Indicators 2012

Figure O-24
Share of U.S. patents granted to non-U.S. inventors, by inventor region/country: 1992–2010

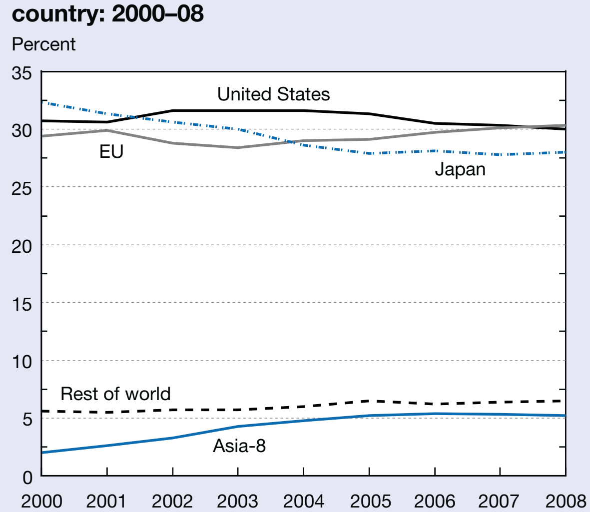


Asia-8 = India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand; EU = European Union

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of U.S. Patent and Trademark Office, Number of Utility Patent Applications Filed in the United States, by Country of Origin: Calendar Years 1965 to Present, http://www.uspto.gov/web/offices/ac/ido/oeip/taf/appl_yr.pdf.

Science and Engineering Indicators 2012

Figure O-25
Global high-value patents, by selected region/ country: 2000–08



Asia-8 = India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand; EU = European Union

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of Organisation for Economic Co-operation and Development, OECD.StatExtracts, patent statistics, http://stats.oecd.org/index.aspx.

Science and Engineering Indicators 2012

Global Output of Knowledge- and Technology-Intensive Firms

Governments in developed countries believe that KTI economies create well-paying jobs, contribute high-value output, and ensure economic competitiveness. Governments in many developing countries believe the same and promote the growth of knowledge-intensive services and high-technology manufacturing industries.[18]

In 2010, these KTI industries contributed a combined \$18.2 trillion to global economic output—about 30% of world GDP, and a growing share of many countries' economic output. Services are by far the largest aggregate, totaling \$16.8 trillion: \$10.9 trillion in tradable services, and \$5.9 trillion in more location-bound health and education services. High-technology manufacturing added \$1.4 trillion (figure O-26).

The effects of the 2007–09 recession on KTI industry output are visibly more severe than were those of the 2001 recession. A slowdown in growth in 2008 was followed by contraction or, in the case of knowledge-intensive services, lack of growth in 2009 and a sharp upswing in 2010. High-technology manufacturing went from 4.9% growth to a 5.7% contraction to 13.5% growth.

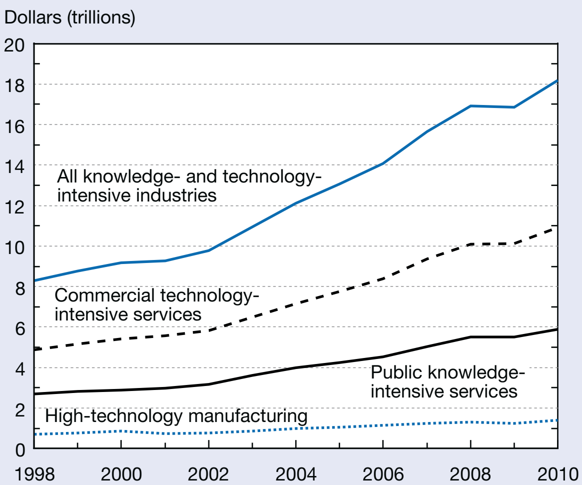
The largest aggregate in the KTI category is commercial knowledge-intensive services, which includes business and financial services and communications. The value of its global output increased from \$4.9 trillion in 1998 to \$9.4 trillion in 2007. As with all KTI industries, it showed recession effects that were more severe for the EU than for the United States (figure O-27). The United States, with \$3.6 trillion in 2010, generated the largest value of these industries, as its output expanded after flat growth in 2008 and 2009.

The EU was particularly hard hit by the recession, resulting in declining output followed by shallow growth. The rest of the world suffered a 1-year slowdown or shallow declines, followed by sometimes vigorous growth. Increased production by China expanded its value-added output of commercial knowledge-intensive services and increased its global share from 3% in 2005 to 7% in 2010.

High-technology manufacturing value-added output suffered a global contraction in 2001 but offered a more varied picture in the 2007–09 recession: Brief but sharp contraction in Asia (excepting China) followed by an equally sizeable rebound in 2010; a sharper drop in the EU, followed by shallow growth; slowing growth followed by strong expansion in the United States; and unimpeded, rapid growth in China. By 2010, China's global share was 19%, up from 3% in 1998 (figure O-28).

The five high-technology manufacturing industries are, in decreasing order of the \$1.4 trillion 2010 global value-added total: communications equipment and semiconductors (\$512 billion), pharmaceuticals (\$346 billion), scientific instruments (\$275 billion), aerospace (\$137 billion), and computers and office machinery (\$127 billion). The United States ranked first overall in aerospace and tied with the EU in pharmaceuticals, but in communications equipment manufacturing it ranked behind Japan and the Asia-8, and in scientific instruments it ranked behind the EU.

Figure O-26
Global value added of knowledge- and technology-intensive industries: 1998–2010

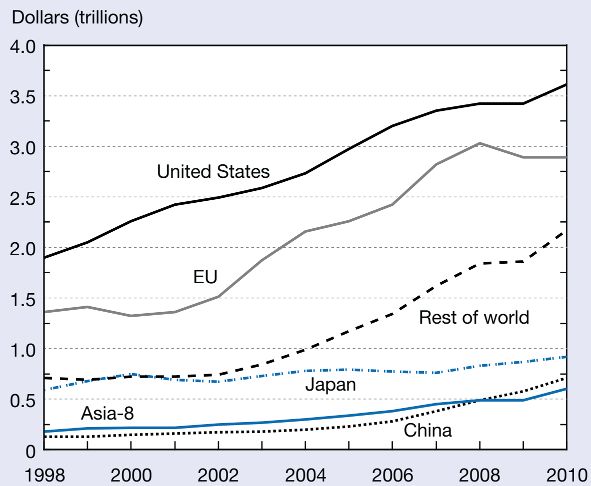


NOTE: Industries defined by Organisation for Economic Co-operation and Development.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of IHS Global Insight, World Industry Service database.

Science and Engineering Indicators 2012

Figure O-27
Value added of commercial knowledge-intensive services, by selected region/country: 1998–2010



Asia-8 = India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand; EU = European Union

NOTE: Industries defined by Organisation for Economic Co-operation and Development.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of IHS Global Insight, World Industry Service database.

Science and Engineering Indicators 2012

China accounts for almost half of the global value of computer and office machinery production. This category saw a particularly rapid shift in relative world positions (figure O-29).

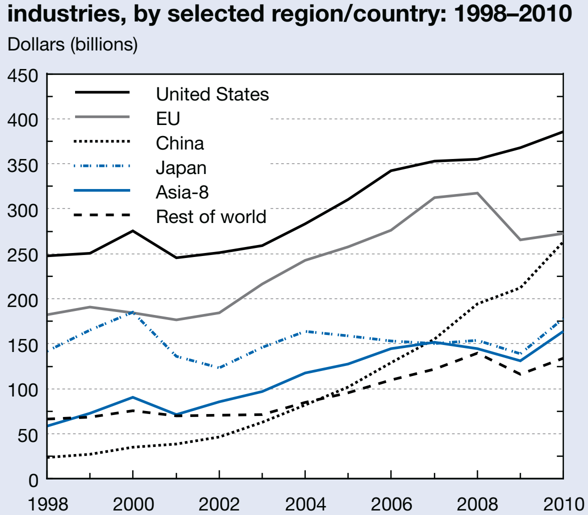
Employment in U.S. High-Technology Manufacturing

The effects of recessions go well beyond their impact on the value of the outputs of production. More far-reaching effects may be felt in the labor markets. Although internationally comparable data on KTI employment are fragmentary, employment data on U.S. high-technology manufacturing are illuminating (figure O-30).

Employment in the five U.S. high-technology manufacturing sectors reached a peak in 2000, just before the 8-month-long recession of 2001. This recession led to job losses in these industries that were substantial and permanent. The 18-month 2007–09 recession further squeezed employment in these industries. The total job loss in high-technology manufacturing over the period was 687,000—a decline of 28% since 2000.

The value of output generated by these industries contracted in 2001 and again slowed in 2007–08. However, over the decade, output per 1,000 employees doubled (unadjusted for inflation) (figure O-31).

Figure O-28
Value added of high-technology manufacturing industries, by selected region/country: 1998–2010



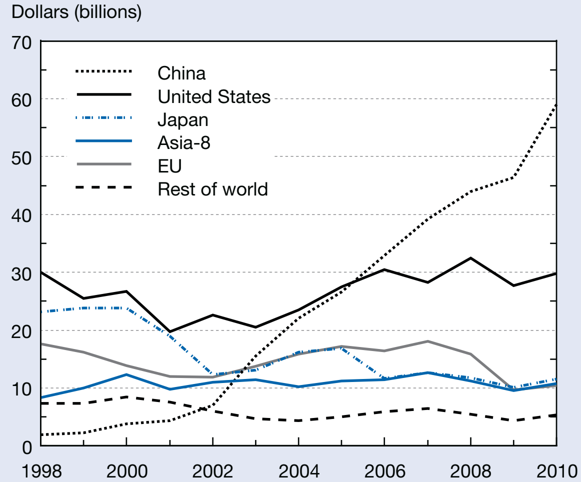
Asia-8 = India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand; EU = European Union

NOTE: Industries defined by Organisation for Economic Co-operation and Development.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of IHS Global Insight, World Industry Service database.

Science and Engineering Indicators 2012

Figure O-29
Value added of computer and office machinery manufacturing, by selected region/country: 1998–2010

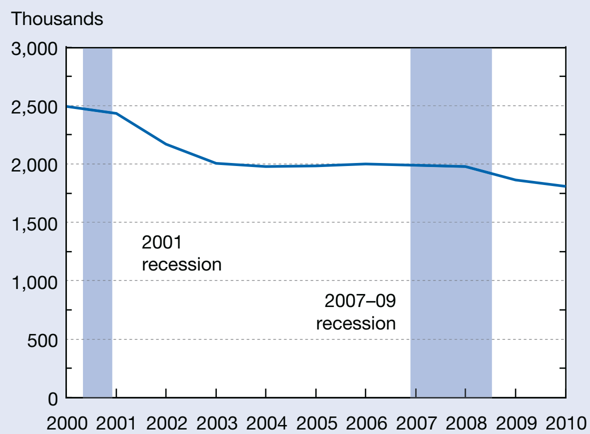


Asia-8 = India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand; EU = European Union

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of IHS Global Insight, World Industry Service database.

Science and Engineering Indicators 2012

Figure O-30
U.S. high-technology manufacturing employment: 2000–10

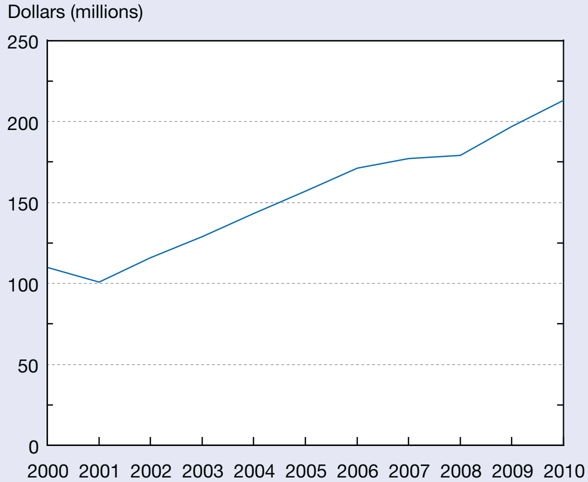


NOTES: Industries defined by Organisation for Economic Co-operation and Development. Bars define recession periods.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of Bureau of Labor Statistics, Current Employment Survey.

Science and Engineering Indicators 2012

Figure O-31
Value of U.S. high-technology manufacturing output per 1,000 employees: 2000–10



NOTE: Industries defined by Organisation for Economic Co-operation and Development.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of IHS Global Insight, World Industry Service database, and Bureau of Labor Statistics, Current Employment Survey.

Science and Engineering Indicators 2012

Global Exports of Commercial Knowledge-Intensive Services

The global value of trade in commercial knowledge-intensive services is gradually increasing but it represents less than 10% of global production of such services. The value of commercial knowledge-intensive services grew from $453 billion in 1998 to $1.46 trillion in 2008 and then contracted to $1.36 trillion in 2009.

The EU is the largest exporter of commercial knowledge-intensive services (excluding intra-EU exports), accounting for about 30% of the world total, followed by the United States with 22% and the Asia-8 with 15% (mostly from India and Singapore). The EU suffered a 10% drop in export volume in 2009, followed by less than 1% growth in 2010; the United States loss was 2%, followed by 6% growth.

Export declines in 2009 by China and the Asia-8 were in the 4%–6% range, after which the Asia-8 rebounded with 16% growth. 2010 data for China are unavailable (figure O-32).

Changing Global High-Technology Trade Patterns

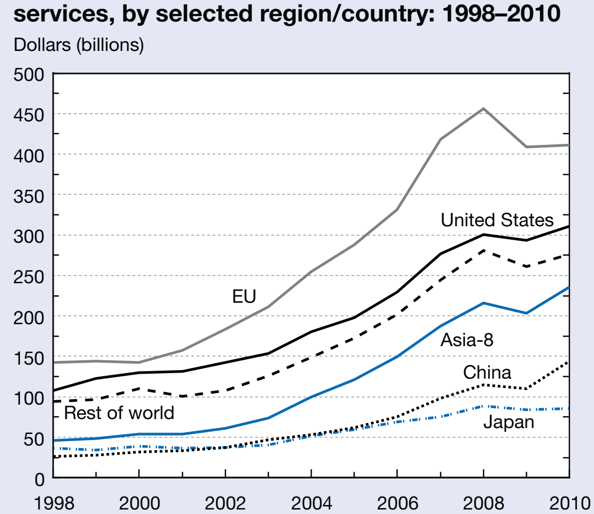
Two global recessions notwithstanding, total export volume of high-technology products increased at an 8% annual rate from 1998 to 2010, not accounting for inflation. This ranged from a low of 2% for Japan to a high of 19% for China, with the United States and EU in the 5%–7% range. The increase reflects a number of developments: growing international capacity for high-technology manufacturing, expansion of multinational companies' overseas production, and growing reliance on specialized and geographically dispersed supplier networks.

China became the largest single high-technology exporter in 2006 and, together with the Asia-8, has since accounted for about half of total world exports in high-technology goods. After relatively prolonged slowdowns following the 2001 global recession, China and Asia-8 high-technology exports accelerated until sharp declines in 2009, which were followed immediately by expansion beyond the 2008 levels. The general patterns were similar for the United States and the EU, but with a less complete recovery for the EU. Japan's high-technology exports have been flat, not accounting for inflation, for a decade or more (figure O-33).

These changes have affected the relative positions of the developed and developing countries. China's share of world high-technology exports increased from 7% in 1998 to 22% in 2010, while the Asia-8 share dropped to 26% in 2009 before easing upward again. Shares of the United States, EU, Japan, and the rest of the world—mostly developing countries—were flat or declined (figure O-34).

An Asian high-technology supplier zone has developed that is largely arrayed around China. The shift in output of high-technology goods toward developing Asian economies has been accompanied by the growth of intraregional supplier relationships that provide intermediate goods, many for further assembly and eventual export. The share of Asia-8 high-technology exports going directly to the United States

Figure O-32
Exports of commercial knowledge-intensive services, by selected region/country: 1998–2010



Asia-8 = India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand; EU = European Union

NOTES: EU excludes internal trade. China includes Hong Kong.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of World Trade Organization, International Trade and Tariff database.

Science and Engineering Indicators 2012

and the EU declined from more than 50% to under 30%, while exports to China rose from 10% to 37% of their total (figure O-35).

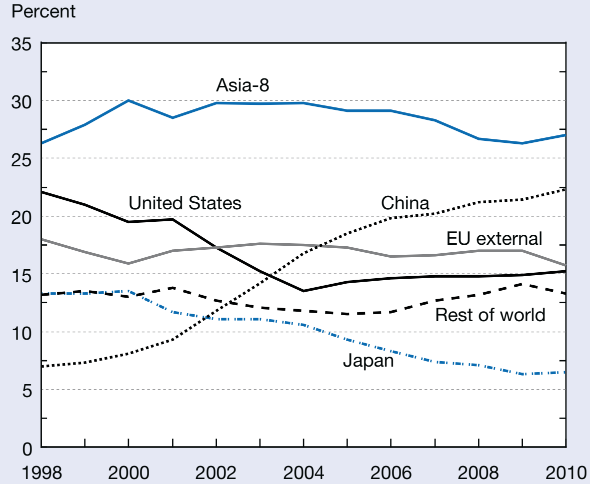
China's high-technology exports withstood the global recession very well. Slowing sharply from double-digit to high single-digit growth in 2007–08, they declined by 9% in 2009 but rose by 22% in 2010. After 2009, China's high-technology exports to the United States jumped from $107 billion to $137 billion. Similarly large increases were evident for other export destinations (figure O-36).

Deficit in Goods Trade, Surplus in Services and Intangibles

In high-technology goods trade, U.S. surpluses through the mid-1990s turned into substantial deficits after 1997 which reached almost $100 billion in 2010 (figure O-37). Major deficit drivers were communications and computer goods, whose production shift to Asia coincided with growing U.S. demand. Pharmaceuticals contributed to the deficit, while aerospace and scientific instruments counteracted it.

The EU's overall high-technology trade deficit was relatively stable, though lower than that of the United States. Its communications and computers deficit, however, was almost identical to that of the U.S., reflecting the same dynamic of rising domestic demand and relocated production.

Figure O-34
Share of global high-technology exports, by selected region/country: 1998–2010



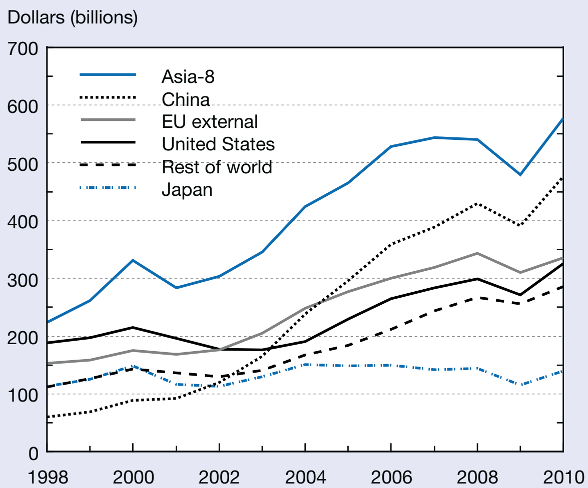
Asia-8 = India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand; EU external = European Union trade excluding intra-EU exports

NOTE: Industries defined by Organisation for Economic Co-operation and Development.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of IHS Global Insight, World Trade Service database.

Science and Engineering Indicators 2012

Figure O-33
High-technology exports, by selected region/country: 1998–2010



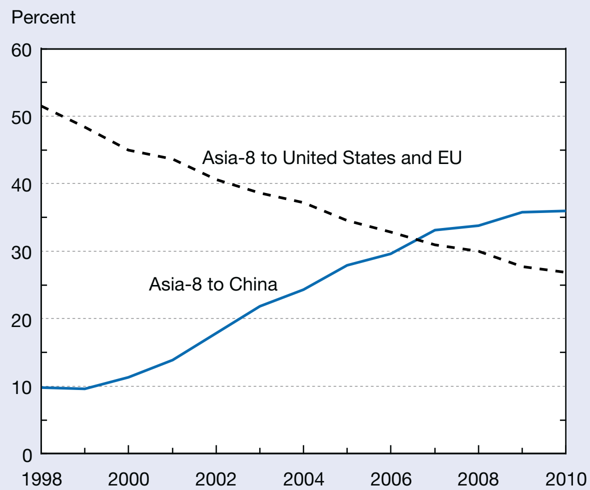
Asia-8 = India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand; EU external = European Union trade excluding intra-EU exports

NOTE: Industries defined by Organisation for Economic Co-operation and Development.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of IHS Global Insight, World Trade Service database.

Science and Engineering Indicators 2012

Figure O-35
Asia-8 global high-technology exports to United States/EU and China: 1998–2010



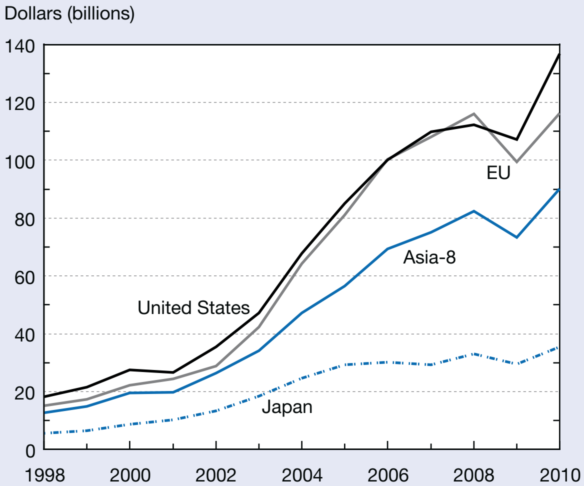
Asia-8 = India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand; EU = European Union

NOTE: Industries defined by Organisation for Economic Co-operation and Development.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of IHS Global Insight, World Trade Service database.

Science and Engineering Indicators 2012

Figure O-36
China's high-technology exports to selected regions/countries: 1998–2010



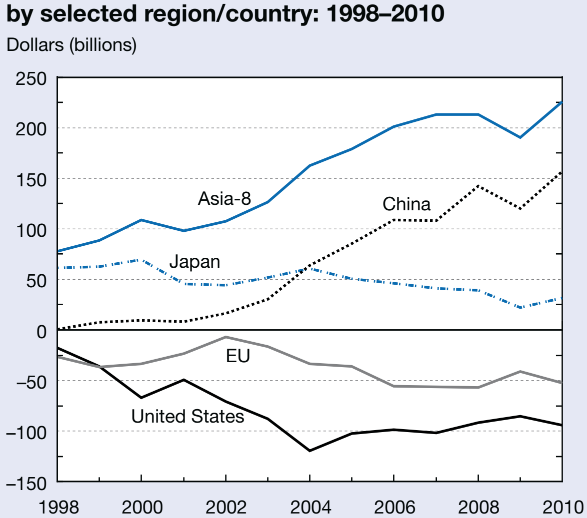
Asia-8 = India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand; EU = European Union

NOTE: Industries defined by Organisation for Economic Co-operation and Development.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of IHS Global Insight, World Trade Service database.

Science and Engineering Indicators 2012

Figure O-37
Trade balance of high-technology goods, by selected region/country: 1998–2010



Asia-8 = India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand; EU = European Union

NOTE: Industries defined by Organisation for Economic Co-operation and Development.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of IHS Global Insight, World Trade Service database.

Science and Engineering Indicators 2012

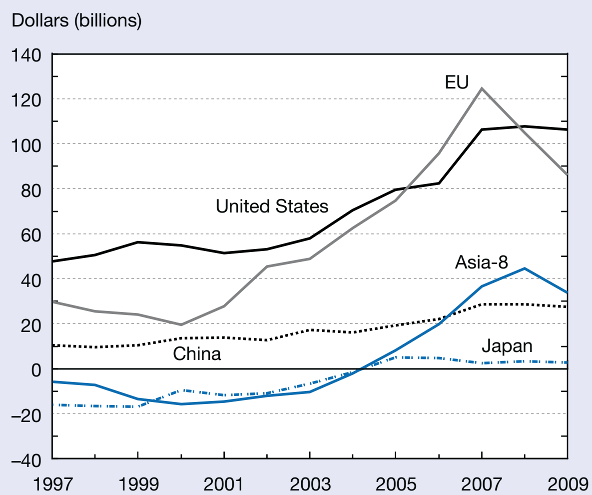
China and the Asia-8 had substantial 2010 high-technology trade surpluses of $157 billion and $226 billion, respectively, indicating that recession-induced reductions in their previous surpluses were likely to prove only temporary.

U.S. trade in commercial knowledge-intensive services and intangible assets—business, financial, and communications services, and payments of royalties and fees—has produced a consistent and growing surplus (figure O-38). It reached a record $108 billion in 2008, sufficient to counterbalance the high-technology goods deficit, and has been flat since then, reflecting the recession's effect. The EU's surplus was sharply off, and that of the Asia-8 fell as well—reflections of the continuing effects of the global recession.

Conclusion

Science and technology are becoming ubiquitous features of many developing countries, as they integrate into the global economy. As a group, developing countries appear to either have been less severely affected by the worldwide financial crisis and recession than the United States, EU, and Japan, or to have recovered more rapidly. Governments in these countries have held firm in building S&T into their development policies, as they vie to make their economies more knowledge- and technology-intensive to ensure their competitiveness. These policies include long-term investments in higher education to develop human talent, infrastructure development, support for research and development,

Figure O-38
Trade balance in knowledge-intensive services and intangible assets, by selected region/country: 1997–2009



Asia-8 = India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand; EU = European Union

NOTE: Industries defined by Organisation for Economic Co-operation and Development.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of World Trade Organization, International Trade and Tariff database.

Science and Engineering Indicators 2012

attraction of foreign direct investment and technologically advanced multinational companies, and the eventual development of indigenous high-technology capabilities.

The resulting developments open the way for widespread international collaboration in science and engineering research.[19] The broad trend in this direction is reflected in increasing numbers of research articles in the world's leading journals with authors in multiple countries. These researchers are increasingly able to draw on high-quality work done outside the traditional S&T locales, and international connections are deepened by globally mobile experts.

Competitive elements, such as the quest for international talent, enter as well. Once largely limited to major Western nations, the quest for international talent is now pursued by many and "brain drain" has evolved into cross-national flows of highly trained specialists. Governments are eager to develop more modern economies that will increase the wealth of their populations. They seek to establish specialty niches and indigenous world-class capacity and to become competitive in international investment, development, and trade.

The globalization of the world economy has brought unprecedented levels of growth to many countries, demonstrating that benefits can accrue to all. These trends continue, but the structural changes that are part and parcel of rapid growth bring with them painful dislocations that are amplified by the continuing changes forced by the recent recession.

Notes

1. Unless otherwise noted, EU refers to the 27 member countries of the European Union.

2. World Bank estimates of global gross national income.

3. These estimates rely on data from the Organisation for Economic Co-operation and Development (OECD) and the United Nations Educational, Scientific and Cultural Organization Institute for Statistics. They are not precise measures. Reported data are converted to dollar totals using purchasing power parities, the local costs of a standard market basket of goods and services. The accuracy of this standard economic conversion may degrade in the case of developing economies. In addition, estimation of some missing data and variable reporting mean that there is uncertainty about any specific point estimate. The reader's focus is directed to the overall trend, which reflects an internally consistent estimate over time.

4. The latest updated 2009 U.S. R&D estimate is $400.5 billion. The overview uses the most recent OECD numbers to allow comparison with other countries' values.

5. European Commission, Barcelona European Council, *Presidency Conclusions* (Barcelona, Spain, March 2002).

6. See Joan Burrelli and Alan Rapoport, *Reasons for International Changes in the Ratio of Natural Science and Engineering Degrees to the College-Age Population,* SRS 09-308 (Arlington, VA: National Science Foundation, January 2009).

7. No data are available for India, making this share estimate an upper bound.

8. Both figures exclude those with unknown citizenship (1,600 in 2007) and those with degrees in medical/other life sciences. Engineering figures exclude about 630 with unknown citizenship. The U.S. figures include individuals with permanent visas.

9. Michael G. Finn, Stay Rates of Foreign Doctorate Recipients From U.S. Universities, 2007 (Oak Ridge, TN: Oak Ridge Institute for Science and Education, January 2010).

10. Both estimates are based on data from a limited number of countries reporting their data, on a full-time equivalent basis, to OECD.

11. Preliminary 2009 data from Bureau of Economic Analysis, International Economic Accounts, U.S. Direct Investment Abroad (2009 and previous years); National Science Foundation tabulation.

12. The database used is the expanding set of journals included in the Thomson Scientific, Science and Social Sciences Citation Indexes; IpIQ, Inc.; and National Science Foundation tabulations.

13. Author location is determined by location of institutional affiliation. For example, an American scientist listed at a Japanese university is considered located in Japan; a Japanese scientist listed at a U.S. university is considered located in the United States.

14. The physical sciences are physics; chemistry; earth, atmospheric, and ocean sciences; and astronomy.

15. Expectation is based on a location's total international collaborations. The index numerator is the percentage of country A's international collaborations with country B; the denominator is country B's percentage of the world's international collaborations. See appendix table 5-41.

16. Citation indicators are subject to a number of distortions: self-citation, citation of failed theories, hypotheses, and approaches; citation of domestic versus foreign articles; language and cultural barriers; etc. However, when aggregated over many articles, citation indicators carry information about the relative use of an accumulated knowledge base in subsequent work.

17. In these data, USPTO patents are assigned to the location of the first-named inventor.

18. These industry groups are defined by OECD and form the basis for databases of economic activity that cover a large number of the world's economies. Knowledge-intensive services industries include the commercially tradable business, financial, and communications services; and education and health services, which are considered more nearly location-bound and closer to government functions. High-technology manufacturing industries include aircraft and spacecraft; pharmaceuticals; office, accounting, and computing machinery; radio, television, and communication equipment; and medical, precision, and optical instruments.

19. See National Science Board, *International Science and Engineering Partnerships: A Priority for U.S. Foreign Policy and Our Nation's Innovation Enterprise,* NSB-08-4 (Arlington, VA: National Science Foundation, 2008).

Glossary

Asia-8: Includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand.

Asia-10: Includes China, Japan, India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand.

European Union: The 27 member states of the European Union since 2007 include Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, and the United Kingdom.

High-technology manufacturing: Includes air- and spacecraft; pharmaceuticals; office, accounting, and computing machinery; radio, television, and communication equipment; and medical, precision, and optical instruments.

Knowledge-intensive services: Includes commercial business, financial, and communication services and largely publicly supported education and health services. Commercial knowledge-intensive services exclude education and health.

Chapter 1
Elementary and Secondary Mathematics and Science Education

List of Sidebars

List of Tables

List of Figures

Highlights

Student Learning in Mathematics and Science

Gains in average mathematics scores on the National Assessment of Educational Progress (NAEP) between 2007 and 2009 leveled off for grade 4 and continued for grade 8. For 12th graders, average mathematics scores improved from 2005 to 2009.

- ♦ From 1990 to 2007, average mathematics scores increased by 27 points for fourth graders. Scores then leveled off in 2009 across almost all demographic groups and performance levels and among students at public and private schools.
- ♦ At grade 8, average mathematics scores steadily gained 20 points from 1990 to 2009, with improvement for most demographic groups, performance levels, and school types.
- ♦ At grade 12, average mathematics scores improved by 3 points from 2005 to 2009, with improvement patterns similar to those of eighth graders.

Score gaps among demographic groups narrowed over time but remained substantial.

- ♦ At grades 4, 8, and 12, white and Asian/Pacific Islander students had significantly higher scores than their black, Hispanic, and American Indian/Alaska Native counterparts. Students from higher income families also performed significantly better than their peers from lower income families. Although boys scored higher than girls, the differences were relatively small.
- ♦ At grade 4, some gaps narrowed over time. Between 1990 and 2009, the score gap between white and black students fell from 32 to 26 points, the score gap between public and private school students dropped from 12 to 7 points, and the score gap between low- and high-performing students narrowed by 9 points.

Few students in ninth grade mastered high level algebra skills in 2009, according to the High School Longitudinal Study assessment.

- ♦ A majority of ninth graders demonstrated proficiency in lower level algebra skills such as algebraic expressions (86%) and multiplicative and proportional thinking (59%).
- ♦ Few students reached proficiency in systems of equations (18%) and linear functions (9%), the two highest algebra skills assessed.

Relatively few students at grades 4, 8, and 12 reached their grade-specific proficiency levels in science on the 2009 NAEP assessment. Science scores varied significantly across student subgroups.

- ♦ At all three grade levels, whites, Asians/Pacific Islanders, and students from higher income families scored significantly higher than their counterparts. Boys also scored higher than girls at all three grade levels, but the difference was substantially smaller.

In both 2006 and 2009, U.S. 15-year-olds scored below those of many other developed countries in the Programme for International Student Assessment, a literacy assessment designed to test mathematics and science. Nonetheless, U.S. scores improved from 2006 to 2009.

- ♦ The average mathematics literacy score of U.S. 15-year-olds declined about 9 points from 2003 to 2006, and then rose about 13 points in 2009, placing the United States below 17 of 33 other members of the Organisation for Economic Co-operation and Development (OECD).
- ♦ The average science literacy score of U.S. 15-year-olds was not measurably different from the 2009 OECD average, though it improved by 3 points from 2006 to 2009. The U.S. score was lower than the score of 12 out of 33 other OECD nations participating in the assessment.

Student Coursetaking in High School Mathematics and Science

High school graduates in 2009 continued an upward trend of earning more credits in mathematics and science, including *advanced* mathematics and science courses.

- ♦ The average number of credits earned in all mathematics courses was 3.9 in 2009, up from 3.2 in 1990. The average number of credits earned in all science courses was 3.5 in 2009, up from 2.8 in 1990.
- ♦ Graduates in 2009 earned an average of 1.7 credits in advanced mathematics and 1.9 credits in advanced science and engineering courses, compared with 0.9 and 1.1 credits, respectively, in 1990.

The percentages of students completing advanced mathematics and science courses increased in all subject areas.

- ♦ In 2009, 76% of all graduates earned a credit for algebra II, compared with 53% of all graduates in 1990.
- ♦ The percentage of students earning a credit in precalculus/analysis more than doubled since 1990, with 35% of graduates completing precalculus/analysis in 2009, compared with 14% in 1990.
- ♦ From 1990 to 2009, the percentage of students earning a credit in advanced chemistry increased from 45% to 70%. Increased rates were also seen in advanced biology (28% to 45%) and physics (24% to 39%).
- ♦ The percentage of students taking algebra I before high school increased. Twenty-six percent of high school graduates took algebra I before high school in 2009, up from 20% in 2005.

Although students in all racial/ethnic groups are earning more advanced mathematics and science credits, differences among these groups have persisted.

- Asian/Pacific Islander students earned the most credits in advanced mathematics, an average of 2.4 credits in 2009. Hispanics and blacks earned the fewest credits in advanced mathematics, approximately 1.4 credits. White students earned more credits (1.8) than black or Hispanic students, but fewer than Asian/Pacific Islander students. Similar patterns were seen in science coursetaking.

Teachers of Mathematics and Science

The percentage of public middle and high school mathematics and science teachers with advanced degrees and full certification has increased since 2003, but school differences persist.

- Fifty-four percent of mathematics teachers and 58% of science teachers had earned a master's or higher degree in 2007, compared with 48% and 52%, respectively, in 2003.
- Eighty-seven percent of mathematics and science teachers held regular or advanced teaching certification in 2007—a significant increase for science teachers from 83% in 2003.
- Degree and certification differences persist among schools with different student populations. For example, 69% of science teachers in low-poverty schools had advanced degrees versus 49% in schools with high poverty rates.
- In 2007, about one in five new mathematics and science teachers was hired through an alternative certification program. Relatively more of these teachers were found in high-poverty or high-minority schools. For example, 26% of mathematics teachers in schools with the highest poverty levels became teachers through alternative certification, compared with 12% of those in schools with the lowest poverty levels. (Some alternative certification programs aim to place teachers in high-poverty schools.)

Novice teachers—those with 3 or fewer years of experience—are more prevalent at high-poverty and high-minority schools.

- In 2007, about 20% of all public middle and high school mathematics and science teachers were novice teachers. Proportionally, more of those in high-minority schools were novices: 22% of mathematics teachers and 25% of science teachers were novices, compared with 13% and 15% in low-minority schools.

Most high school teachers of mathematics and science taught in field (i.e., they had a degree or full credential in the subject matter they taught) in 2007. In-field teaching is less prevalent among middle school teachers but has increased among middle school mathematics teachers since 2003.

- In-field mathematics teachers in public middle schools increased from 53% in 2003 to 64% in 2007. Approximately 70% of middle school science teachers taught in field in both 2003 and 2007.
- Eighty-eight percent of high school mathematics teachers in 2007 taught in field, as did 93% of biology/life science teachers and 82% of physical science teachers.

Participation has increased in new teacher induction programs, which provide professional development and support during early teaching years, and the gap in participation rates between teachers at schools with different demographics has narrowed.

- In 2007, 79% of new mathematics teachers and 73% of new science teachers in public middle and high schools had participated in an induction program. The corresponding rates in 2003 were 71% among mathematics teachers and 68% among science teachers.
- In 2003, 63% of new mathematics teachers in high-minority schools had been in an induction program, 25 percentage points fewer than their counterparts at low-minority schools. In 2007, this gap narrowed to 8 percentage points because of higher participation in high-minority schools.

More than three-quarters of mathematics and science teachers in 2007 said that they had received some professional development in their subject matter. However, few participated for as many hours as research suggests is desirable.

- In 2007, 83% of mathematics teachers and 77% of science teachers in public middle and high schools said they had received professional development in their subject matter during the previous 12 months.
- Among those with professional development in their subject matter, 28% of mathematics teachers and 29% of science teachers received 33 hours or more. Research has suggested that 80 hours or more may be required to affect teacher knowledge and practice.

Teachers' views of their working conditions varied with the characteristics of the student population at their schools, but some differences have narrowed since 2003.

- Half of mathematics and science teachers at high-poverty or high-minority schools viewed student tardiness and class cutting as interfering with teaching. In contrast, a third of their counterparts at low-poverty and low-minority schools expressed this view.
- Some differences have narrowed since 2003. Then, about half of mathematics teachers at high-poverty schools saw student apathy as a serious problem, compared with 12% at low-poverty schools. In 2007, that gap had narrowed by about 20 percentage points, reflecting more positive views of teachers at high-poverty schools. The gap in reported lack of student preparedness for learning also shrank.

Transition to Higher Education

Rates of students graduating within 4 years of entering ninth grade ("on-time" graduation) increased slightly in recent years, but gaps among racial/ethnic groups persist.

- In 2009, 76% of students completed high school on time, up from 73% in 2001.
- The on-time graduation rates of black and Hispanic students increased between 2006 and 2009: from 59% to 64% for black students and from 61% to 66% for Hispanic students. Wide gaps remained between the on-time graduation rates of black and Hispanic students and those of white students, who graduated at a rate of 82% in 2009.

The U.S. high school graduation rate lags behind those of most other developed (OECD) nations.

- The United States ranked 18th out of 25 OECD countries for which graduation rate data were available in 2008.
- According to OECD estimates, the United States had an average graduation rate of 77% compared with the OECD average of 80%.

The majority of U.S. high school graduates enroll in a postsecondary institution immediately after high school completion.

- Seventy percent of 2009 high school graduates had enrolled in a postsecondary institution by the October following high school completion, an increase of 19 percentage points since 1975.
- Relatively more female graduates than male graduates enrolled immediately in postsecondary education in 2009 (74% versus 66%).
- Students from high-income families enrolled at a higher rate (84%) than did students from middle-income (67%) or low-income families (55%).
- The rate for white students was 71%, compared with 63% for black and 62% for Hispanic students.

Introduction

National and state education policies continue to focus on improving learning by U.S. students. Policy goals include increasing student achievement overall, reducing disparities in performance among key subgroups of students, and moving the international ranking of U.S. students from the middle to the top over the next decade (The White House n.d.). STEM fields (science, technology, engineering, and mathematics) have been a strong focus of recent reform efforts, including developing common core standards across states, strengthening curricula, promoting advanced coursetaking, enhancing teacher quality, raising graduation requirements, and expanding technology use in education.

This chapter presents indicators of elementary and secondary mathematics and science education in the United States, drawing mainly on data from the National Center for Education Statistics (NCES) of the U.S. Department of Education. Table 1-1 presents an overview of the topics covered in this chapter and the indicators used to illuminate the topics.

The chapter begins by summarizing the most recent data on student achievement in mathematics and science, focusing on recent trends in student performance, changes in performance gaps, and the relative international standing of U.S. students.[1] It also includes new indicators of mathematics and science performance by students in charter schools, trends in mathematics achievement among very high-scoring students, and the results of an algebra assessment of ninth graders.

The chapter then focuses on mathematics and science coursetaking in high school. This edition includes new data on trends in total and advanced mathematics and science credits earned by high school graduates and enrollment in algebra before high school. It also discusses the "common core standards" effort and state participation in that effort, subjects new to this volume.

The chapter turns next to public school mathematics and science teachers, examining their educational attainment, licensure, experience, professional development, attrition, salaries, and working conditions. All teacher indicators in this chapter use the latest available data, which derive from the 2007–08 Schools and Staffing Survey (SASS).

The chapter closes with indicators of students' transitions from secondary to postsecondary education—the subject of chapter 2 in this volume. Updated indicators include on-time high school graduation rates, immediate college enrollment rates, and international comparisons of high school graduation rates and postsecondary enrollment.

The chapter focuses primarily on overall patterns but also reports variation in access to educational resources by schools' minority concentration and poverty level and in student performance by sex, race/ethnicity, and family and school characteristics. Whenever a difference or change over time is cited in this chapter, it is statistically significant at the 0.05 probability level.[2]

Student Learning in Mathematics and Science

Increasing overall student achievement, especially lifting the performance of low achievers, is a central goal of education reform in the United States. This goal is reflected in the federal No Child Left Behind Act of 2001 (NCLB), which mandates that all students in each state reach the proficient level of achievement by 2014. This goal is also highlighted in the more recent federal Race to the Top program, which calls for states to design systemic and innovative educational reform strategies to improve student achievement and

Table 1-1
Indicators of elementary and secondary school mathematics and science education

Topic	Indicator
Student learning in mathematics and science	• Trends in 4th, 8th, and 12th graders' mathematics performance through 2009 • 4th, 8th, and 12th graders' science performance in 2009 • Ninth graders' algebra performance in 2009 • International comparisons of 15-year-olds' mathematics and science literacy in 2003, 2006, and 2009
Student coursetaking in mathematics and science	• High school graduation requirements and curriculum standards • Trends in mathematics and science course completion by high school graduates from 1990 to 2009
Mathematics and science teachers	• Degrees, certification, and experience of public middle and high school teachers in 2008 • Professional development of teachers in 2008 • Teacher attrition from 1988 to 2008 • Teacher salaries and working conditions in 2008
Student transitions to higher education	• On-time high school graduation rates in 2008 • International comparisons of secondary school graduation rates in 2008 • Immediate college enrollment from 1975 to 2009 • International comparisons of college enrollment rates in 2008

Science and Engineering Indicators 2012

close performance gaps.[3] The federal government also targets funds directly to low-performing schools through the School Improvement Grants program,[4] for example, to support changes needed in the lowest achieving schools across the nation. These and other efforts to improve achievement are ongoing.

How has the performance of U.S. students changed over time? Are achievement gaps narrowing? How do U.S. students compare with their peers in other nations? This section addresses these questions by examining over time a series of indicators of student performance in mathematics and science in the United States. It begins with a review of recent results of mathematics and science assessments of U.S. students in grades 4, 8, and 12, followed by a review of the performance of ninth graders in algebra in 2009. The section ends by placing U.S. student performance in an international context, comparing the mathematics and science literacy of U.S. 15-year-olds with that of their peers in other countries.

Mathematics and Science Performance in Grades 4, 8, and 12

The National Assessment of Educational Progress (NAEP), a congressionally mandated program, has monitored changes in U.S. students' academic performance in mathematics and science since 1969. NAEP has two assessment programs: main NAEP and NAEP Long-Term Trend (LTT).[5] The main NAEP assesses national samples of 4th and 8th grade students at regular intervals and 12th grade students occasionally. These assessments are updated periodically to reflect contemporary curriculum standards in various subjects, including mathematics and science. (In 2014, NAEP will conduct its first nationwide assessment in technology and engineering literacy; see sidebar "Development and Content of NAEP Technology and Engineering Literacy Assessment.")

The NAEP LTT assesses the performance of students ages 9, 13, and 17. Its content framework has remained the same since it was first administered in 1969 in science and in 1973 in mathematics, permitting analyses of trends over more than 3 decades. This section examines recent performance results using main NAEP data only. Findings based on NAEP LTT data have been reported in previous editions of *Science and Engineering Indicators,* and no new data were available from the NAEP LTT for this volume.[6]

Reporting NAEP Results

The main NAEP reports student performance in two ways: scale scores and achievement levels. Scale scores place students along a continuous scale based on their overall performance on the assessment. For mathematics assessments, scales range from 0 to 500 for grades 4 and 8 and from 0 to 300 for grade 12. For science assessments, scales range from 0 to 300 for all grades.

NAEP also reports student results in terms of achievement levels. Developed by the National Assessment Governing Board (NAGB), achievement levels are intended to measure how well students' actual achievement matches the achievement expected of them in different subjects assessed by NAEP. Based on recommendations from educators, policymakers, and the general public, NAGB sets three achievement levels for all subjects assessed by NAEP (NCES 2010, 2011):

- *Basic* denotes partial mastery of materials appropriate for the grade level.
- *Proficient* indicates solid academic performance.
- *Advanced* represents superior academic performance.

Based on their test scores, students' performance can be categorized as *below-basic*, *basic*, *proficient*, and *advanced*.[7] Because achievement levels were developed independently at each grade level, they cannot be compared across grade levels.[8] Although the NAEP achievement levels are useful in understanding student results and have been widely used by national and state officials, there is disagreement about whether these achievement levels are appropriately defined. A study commissioned by the National Academy of Sciences asserted that NAEP achievement levels were "fundamentally flawed" (Pellegrino, Jones, and Mitchell 1999). The National Mathematics Advisory Panel concluded in 2008 that NAEP scores for the two highest achievement categories (proficient and advanced) were set too high (NMAP 2008). Both NCES and NAGB acknowledged this controversy, and NCES, upon review of congressionally mandated evaluations of NAEP, has recommended that achievement levels be used on a trial basis and interpreted with caution (NCES 2011).

The following review of NAEP results reports both average scale scores and achievement levels, focusing on the percentage of students performing at or above the proficient level both overall and among various subgroups of students.

Trends in Mathematics Performance Through 2009

Average Score. For grade 4, the average mathematics score increased by 27 points from 1990 to 2007 and leveled off from 2007 to 2009 (figure 1-1). This overall trend was repeated in almost all demographic subgroups, across students at all performance levels (i.e., 10th to 90th percentiles[9]), and among students at both public and private schools (table 1-2).

For grade 8, the average mathematics score increased steadily from 1990 to 2009 with a total gain of 20 points over the period, including a statistically significant 2-point gain from 2007 to 2009 (figure 1-1). Rising scores were widespread, occurring among both male and female students; almost all racial/ethnic groups; students from families that were financially disadvantaged and advantaged; students in the low-middle, middle, and high ranges of performance (i.e., 25th to 90th percentiles); and students attending public schools (table 1-2) (see sidebar "Mathematics and Science Achievement in Charter Schools"). The score at the 10th percentile, however, was unchanged from 2007 to 2009, indicating that mathematics performance did not improve significantly among very low-performing students during this period.

Development and Content of NAEP Technology and Engineering Literacy Assessment

Beginning in 2014, the National Assessment of Educational Progress (NAEP) will administer the first nationwide student assessment in technology and engineering literacy. The framework defines key terms such as *technology* and *engineering literacy,* determines the content to be assessed, specifies the types of assessment questions to be asked, and guides the development of the assessment instrument (WestEd 2010).

Although the federal No Child Left Behind Act of 2001 requires that every student be "technologically literate by the time the student finishes the eighth grade," the law itself is vague in defining what technological literacy is, leaving states to determine what it means and how it should be assessed. Some states require engineering/technology education for students in at least some grades, but few have adopted formal assessments in this area (Metiri Group 2009). Technology- and engineering-related courses are typically offered in middle and high schools as electives or are embedded in other subject areas, such as science or social studies (WestEd 2010). Overall, coursetaking in these subjects is not widespread: in 2009, about 3% of high school graduates had taken an engineering course and 6% an engineering/science technology course (Nord et al. 2011). Currently, there are no national standards for K−12 engineering or technology education. Implementing such standards is difficult given limited experience with engineering/technology education at the K−12 level and insufficient numbers of teachers qualified to deliver instruction in this area (National Academy of Engineering 2010).

Definitions of Technology and Engineering Literacy. For the purpose of developing national assessments in this area, the NAEP framework defines technology, engineering, and technology and engineering literacy as follows (WestEd 2010, pp. 1–4):

- *Technology* is any modification of the natural or designed world done to fulfill human needs or desires.
- *Engineering* is a systematic and often iterative approach to designing objects, processes, and systems to meet human needs and wants.
- *Technology and engineering literacy* is the capacity to use, understand, and evaluate technology as well as to understand technological principles and strategies needed to develop solutions and achieve goals.

Areas To Be Assessed. The 2014 NAEP assessment of technology and engineering literacy will test students in the following three areas:

- *Technology and Society* covers the interaction of technology and people; effects of technology on society and the natural world; and questions of ethics, equity, and responsibility that arise from those effects.
- *Design and Systems* includes the nature of technology; the engineering design process by which technologies are developed; and basic principles of dealing with everyday technologies, including maintenance and troubleshooting.
- *Information and Communication Technology* involves computers and software learning tools; networking systems and protocols; and the selection and use of hand-held digital devices and other technologies for accessing, creating, and communicating information and for facilitating creative expression.

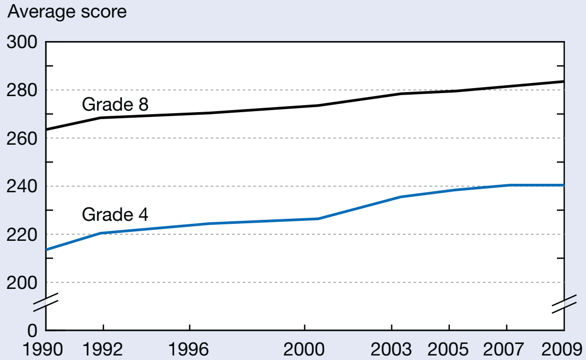
For examples of questions, see http://www.nagb.org/publications/frameworks/prepub_naep_tel_framework_2014.pdf (in chapters 3 and 4). Note that the grade level for these sample questions has not yet been determined.

For grade 12, only 2005 and 2009 results are examined here; substantial revisions of the mathematics framework for the 2005 assessment made comparison with earlier assessments impossible.[10] Between 2005 and 2009, the average mathematics score for students in grade 12 increased by 3 points (appendix table 1-1). Improvement occurred across the board: for both sexes, across all racial/ethnic subgroups, for all performance levels, and among public school students (table 1-2).[11] The gains in average scores were about 3−5 points for many subgroups, with the exception of Asian/Pacific Islander and American Indian/Alaska Native students, who posted gains of 12 and 10 points, respectively, from 2005 to 2009.

Achievement Level. Trends in the percentages of students in grades 4, 8, and 12 reaching the proficient level parallel the scale score trends. The percentage of fourth grade students performing at or above the proficient level increased steadily through 2007 but remained unchanged in 2009. Eighth grade students, on the other hand, showed continuous improvement from 1990 to 2009. Among 12th grade students, the percentage of proficient students increased from 2005 to 2009 (appendix table 1-2).

Despite these gains, the percentage of students reaching the proficient level remains low. In 2009, the percentage of students performing at or above proficient was 39% for 4th graders, 34% for 8th graders, and 26% for 12th graders.

Figure 1-1
Average NAEP mathematics scores of students in grades 4 and 8: Selected years, 1990–2009



NAEP = National Assessment of Educational Progress

NOTES: NAEP mathematics assessment scores range from 0 to 500 for grades 4 and 8. From 1996 on, data shown are for students allowed to use testing accommodations.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2010) of NAEP 1990, 1992, 1996, 2000, 2003, 2005, 2007, and 2009 mathematics assessments, National Center for Education Statistics. See appendix table 1-1.

Science and Engineering Indicators 2012

Trends in Mathematics Performance of Top Students

Although increasing student achievement is the central goal of educational reform in the United States, policies and reform efforts are aimed mainly at improving the achievement of low-achieving students (Hanushek, Peterson, and Woessmann 2010; Loveless 2008; NSB 2010a). Little nationally representative research has been conducted on high-achieving students.

Advances in STEM, however, often depend on originality and leadership from exceptionally capable individuals. Although such individuals are not easily identified, data on students who score unusually well on standardized assessments provide some indication of performance trends among highly capable students. The following analysis uses NAEP assessment data to focus on students who score in the top 1% of mathematics performance in grades 4 and 8.

In 2009, the 37,000–38,000 fourth and eighth grade students who performed at or above the 99th percentile on the NAEP mathematics assessment resembled higher performing students in the general population.[12] However, compared with fourth and eighth graders nationwide, these top performers were more likely to be male, to be white or

Table 1-2
Changes in NAEP mathematics scores of students in grades 4, 8, and 12, by student and school characteristics: Selected years, 1990–2009

	Grade 4		Grade 8		Grade 12[a]
Student and school characteristic	1990–2009	2007–09	1990–2009	2007–09	2005–09
All students	↑	≈	↑	↑	↑
Sex					
Male	↑	≈	↑	↑	↑
Female	↑	≈	↑	↑	↑
Race/ethnicity					
White	↑	≈	↑	↑	↑
Black	↑	≈	↑	↑	↑
Hispanic	↑	≈	↑	↑	↑
Asian/Pacific Islander	↑	≈	↑	↑	↑
American Indian/Alaska Native	S	↓	S	≈	↑
Free/reduced-price lunch[b]					
Eligible	↑	≈	↑	↑	↑
Not eligible	↑	≈	↑	↑	↑
Score in percentile					
10th	↑	≈	↑	≈	↑
25th	↑	≈	↑	↑	↑
50th	↑	≈	↑	↑	↑
75th	↑	≈	↑	↑	↑
90th	↑	≈	↑	↑	↑
School type					
Public	↑	≈	↑	↑	↑
Private	↑	≈	↑	≈	NA

↑ = increase; ≈ = no change; ↓ = decrease; S = suppressed; NA = not available

NAEP = National Assessment of Educational Progress

[a]Changes in mathematics scores for grade 12 presented only for 2005 to 2009 because prior assessments were not comparable with those in or after 2005, and there was no grade 12 mathematics assessment in 2007.
[b]Information on student eligibility for subsidized lunch program, a measure of family poverty, first collected in 1996; comparisons in 1990–2009 columns cover 1996 to 2009.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of NAEP 1990, 1996, 2005, 2007, and 2009 mathematics assessments, National Center for Education Statistics. See appendix table 1-1.

Science and Engineering Indicators 2012

Mathematics and Science Achievement in Charter Schools

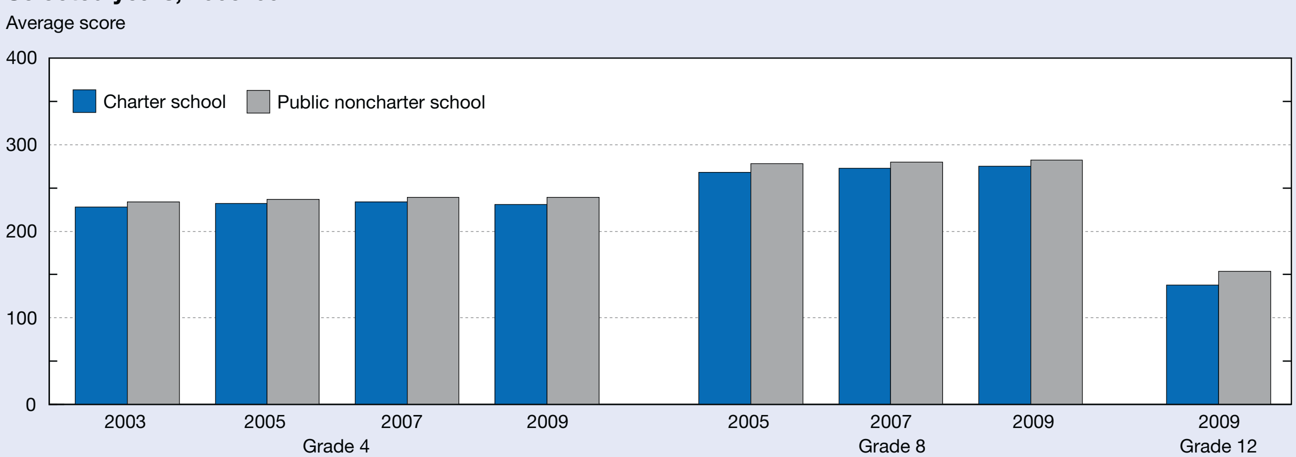
Charter schools are public schools that provide elementary or secondary education to students under a specific charter granted by the state legislature or other appropriate authority (Hoffman 2008). These schools are independent of direct control by local school districts and operate free of many regulations applicable to traditional public schools. Data from the National Alliance for Public Charter Schools (http://www.publiccharters.org/dashboard/home) show that between 2000 and 2010, the number of charter schools more than tripled and the number of students attending these schools increased almost fivefold. In 2009–10, there were about 5,000 charter schools in 40 states and the District of Columbia with a total of 1.6 million students (3.4% of all U.S. public school students).

Comparison of student performance in charter versus traditional public schools is difficult because students in charter schools are self-selected (Garcia 2008; Grady and Bielick 2010). Some parents may enroll their children in charter schools because their children are struggling academically. Other parents may desire greater parent involvement or control. Still others may choose charter schools because they are dissatisfied with some aspect of local public schools. These selection factors may result in student populations in charter schools that are different from those in traditional public schools.

The data from the National Assessment of Educational Progress show that although average mathematics performance of fourth and eighth graders in charter schools improved from 2000 to 2009, charter school students overall had consistently lower scores than their counterparts in traditional public schools, and the gaps persisted over time (figure 1-A). In 2009, the average mathematics score of 12th graders in charter schools was also lower than that of their counterparts in traditional public schools. No measurable difference in average science scores, however, was found between students in charter and noncharter public schools (special NSF tabulations).

To mitigate the effects of selection factors, researchers have employed various research designs to control for different student characteristics in charter and noncharter schools (Abdulkadiroglu et al. 2009; Berends et al. 2010; Braun, Jenkins, and Grigg 2006; CREDO 2009; Hoxby, Murarka, and Kang 2009; Lubienski and Lubienski 2006; Zimmer et al. 2009). These studies produced mixed results on the effectiveness of charter schools, with impacts ranging from small (either positive or negative) to statistically insignificant (Betts and Tang 2008). There is wider variation in performance among charter schools than among public noncharter schools (Braun, Jenkins, and Grigg 2006). This may be due in part to wide variation in charter schools' operation and organizational structure (Buddin and Zimmer 2005; Zimmer et al. 2003).

Figure 1-A
Average NAEP mathematics scores of public school students in grades 4, 8, and 12, by charter school status: Selected years, 2003–09



NAEP = National Assessment of Educational Progress

NOTES: NAEP mathematics assessment scores range from 0 to 500 for grades 4 and 8 and from 0 to 300 for grade 12. Charter schools not identified prior to 2003 for grade 4, 2006 for grade 8, and 2009 for grade 12.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2010) of NAEP 2003, 2005, 2007, and 2009 mathematics assessments, National Center for Education Statistics. See appendix table 1-1.

Science and Engineering Indicators 2012

Asian/Pacific Islander, and to come from higher income families (table 1-3).[13] Top performers in grade 8 were more likely than eighth graders overall to have parents with a college degree.[14]

Average mathematics scores for fourth grade students in this top 1% were not only much higher than those for the average fourth grader (304 versus 240 in 2009), they also exceeded the eighth grade average (304 versus 283 in 2009)[15] (table 1-4). Average mathematics scores for this top group rose steadily from 2000 to 2005 and then remained flat after 2005. Between 2000 and 2009, the scores for the top 1% of fourth graders increased by 9 points, compared with a 14-point increase in scores for all fourth graders.

Like fourth graders, the top 1% of eighth graders had much higher mathematics scores than average (e.g., 366 versus 283 in 2009). However, their trend pattern differed from that of their fourth grade counterparts: average mathematics scores for top eighth graders remained essentially unchanged between 2000 and 2003 and then increased steadily after 2003. The average scores for all eighth graders also increased (appendix table 1-1) so that the improvements overall and among the top 1% were not measurably different.

Table 1-4

Average NAEP mathematics scores of all students in grades 4 and 8 and students in the top 1%: Selected years, 2000–09

Grade	2000	2003	2005	2007	2009
Grade 4					
All students	226	235	238	240	240
Top 1%	295	298	303	303	304
Grade 8					
All students	273	278	279	281	283
Top 1%	358	359	362	364	366

NAEP = National Assessment of Educational Progress

NOTES: NAEP mathematics assessment scores range from 0 to 500 for grades 4 and 8. Top 1% of students are those with NAEP mathematics scores ≥ the 99th percentile for their grade level.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of NAEP 2000, 2003, 2005, 2007, and 2009 mathematics assessments, National Center for Education Statistics.

Science and Engineering Indicators 2012

Table 1-3

Distribution of all students in grades 4 and 8 and students in the top 1% taking the NAEP mathematics assessments, by student characteristic: 2009

(Percent distribution)

	Grade 4		Grade 8	
Student characteristic	All students	Students in top 1%	All students	Students in top 1%
All students	100.0	100.0	100.0	100.0
Sex				
Male	50.8	62.4	50.3	57.9
Female	49.2	37.7	49.7	42.1
Race/ethnicity				
White, non-Hispanic	56.5	69.7	58.5	75.4
Black, non-Hispanic	16.1	1.0	15.2	0.6
Hispanic	21.2	1.5	19.9	1.4
Asian/Pacific Islander	5.0	27.5	5.2	22.2
American Indian/Alaska Native	1.2	0.3	1.1	0.3
Free/reduced-price lunch				
Not eligible	52.4	94.7	57.7	95.0
Eligible	47.7	5.3	42.3	5.0
Highest level of parental education				
High school or less	NA	NA	27.1	1.9
Some college	NA	NA	18.2	4.4
College degree or above	NA	NA	54.8	93.7

NA = not available

NAEP = National Assessment of Educational Progress

NOTES: Students in the top 1% are those with NAEP mathematics scores ≥ 99th percentile for their grade level. Percentages may not add to 100 because of rounding.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of NAEP 2009 mathematics assessments, National Center for Education Statistics.

Science and Engineering Indicators 2012

Changes in Performance Gaps in Mathematics

Despite improvement in recent decades, gaps in mathematics performance persisted among many student subgroups (appendix table 1-1). In general, boys performed slightly better than girls.[16] Gaps between students of different racial/ethnic backgrounds or family income remained large, with white and Asian/Pacific Islander students and those from higher income families posting significantly higher scores than their counterparts who were black, Hispanic, or American Indian/Alaska Native students or who were from lower income families. Large gaps were also observed by school type, with private school students scoring significantly higher than their peers in public schools.[17]

Some reductions in these gaps were observed among fourth grade students (table 1-5). For example, the white-black gap in mathematics performance among fourth grade students narrowed from 32 to 26 scale points between 1990 and 2009 because of larger gains by black students[18] (appendix table 1-1). The gap between public and private school fourth grade students also narrowed during the same period because of greater gains by public school students. Finally, fourth graders' score at the 10th percentile rose faster than that at the 90th percentile, reducing the gap between low- and high-performing students in grade 4. No similar gap reductions between 1990 and 2009 were observed at grades 8 or 12.

Science Performance in 2009

The framework for the NAEP science assessment was updated in 2009 to reflect advances in science, curriculum standards, assessments, and research on science learning (NCES 2011). The new assessment placed a greater emphasis on what students can do with science knowledge. Because the framework changed significantly, the results from the 2009 assessment cannot be compared with earlier ones (NAGB 2008). This section, therefore, discusses only the 2009 assessment results, which will serve as a baseline for measuring students' progress on future science assessments. For earlier results on NAEP science assessments, see *Science and Engineering Indicators 2008*, pp. 1-13 and 1-14 (NSB 2008).

As in mathematics, science performance varies significantly by student demographics and by school type. At grade 4, the average score for boys was slightly higher than that for girls (151 versus 149) (figure 1-2). Differences by racial/ethnic background and family income were larger: scores for white and Asian/Pacific Islander students were at least 28 points higher than those for black, Hispanic, and American Indian/Alaska Native students, and the score for students from higher income families was 29 points higher than that for students from lower income families. Students from private schools outperformed their peers in public schools by 14 points. Similar performance gaps based on sex, race/ethnicity, and family income were observed among students in grades 8 and 12 (appendix table 1-3).

Most students failed to reach the proficient level on the science assessment. In 2009, 34% of 4th graders, 30% of 8th graders, and 21% of 12th graders performed at or above the proficient level in science (appendix table 1-4). At grade 12, only 4% of black students, 8% of Hispanic students, and 8% of low-income students reached the proficient level.

Algebra Performance of Ninth Graders in 2009

The first year of algebra is a prerequisite for higher level mathematics courses in high school (NMAP 2008), opening doors to more advanced mathematics and a college

Table 1-5
Changes in NAEP mathematics score gaps between selected groups of students, by grade level: Selected years, 1990–2009

	Change in score gap		
	Grade 4	Grade 8	Grade 12
Score gap between selected groups of students	1990–2009	1990–2009	2005–09[a]
Males and females	≈	≈	≈
Whites and blacks	↓	≈	≈
Whites and Hispanics	≈	≈	≈
Students from low-income families and those from other families[b]	≈	≈	≈
Low-performing students and high-performing students[c]	↓	≈	≈
Public school students and private school students	↓	≈	NA

≈ = no change; ↓ = decrease; NA = not available

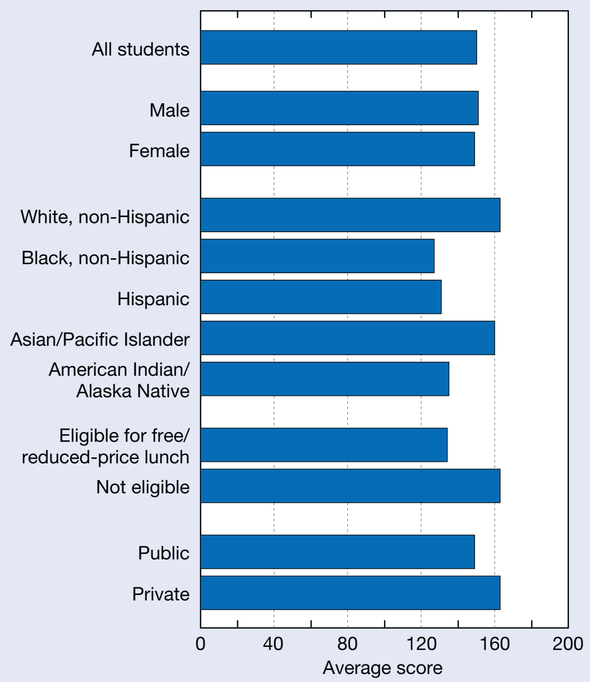
NAEP = National Assessment of Educational Progress

[a]Changes in gaps for grade 12 presented only for 2005 to 2009 because prior assessments were not comparable with those in or after 2005.
[b]Information on student eligibility for subsidized lunch program, a measure of family poverty, first collected in 1996; comparisons in 1990–2009 columns cover 1996 to 2009.
[c]Gap between scores at the 10th and 90th percentiles.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of NAEP 1990, 1996, 2005, and 2009 mathematics assessments, National Center for Education Statistics. See appendix table 1-1.

Science and Engineering Indicators 2012

Figure 1-2
Average NAEP science scores of students in grade 4, by student and school characteristics: 2009



NAEP = National Assessment of Educational Progress

NOTE: NAEP science assessment scores range from 0 to 300 for grade 4.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2010) of NAEP 2009 science assessment, National Center for Education Statistics. See appendix table 1-3.

Science and Engineering Indicators 2012

preparatory curriculum. These, in turn, are associated with higher college attendance rates, higher college graduation rates, greater job readiness, and higher earnings once students have entered the workforce (Achieve, Inc. 2008; Adelman 2006; Allensworth and Nomi 2009; Bozick and Lauff 2007; Gamoran and Hannigan 2000; Ma and Wilkins 2007; Nord et al. 2011). The following section draws on the High School Longitudinal Study of 2009 (HSLS:09) to examine mathematics performance in algebra among a cohort of ninth graders in 2009.

HSLS:09, a nationally representative longitudinal study of more than 21,000 ninth graders in 944 schools, is following a sample of students who were ninth graders in 2009 through secondary and postsecondary education, providing insight into students' learning experiences from the beginning of high school into postsecondary education and work. The base year data collection of HSLS included an algebra assessment that provides indicators of ninth graders' proficiency in five specific algebraic skill areas (Ingels et al. 2011). These skill areas are arranged in a hierarchy such that proficiency at a higher level implies proficiency at all levels below it. In order of increasing difficulty, these five skill areas are as follows:

- Level 1, Algebraic expressions: Understands algebraic basics including evaluating simple algebraic expressions and translating between verbal and symbolic representations of expressions.
- Level 2, Multiplicative and proportional thinking: Understands proportions and multiplicative situations and can solve proportional situation word problems, find the percent of a number, and identify equivalent algebraic expressions for multiplicative situations.
- Level 3, Algebraic equivalents: Understands algebraic equivalents and can link equivalent tabular and symbolic representations of linear equations, identify equivalent lines, and find the sum of variable expressions.
- Level 4, Systems of equations: Understands systems of linear equations and can solve such systems algebraically and graphically and characterize the lines (parallel, intersecting, collinear) represented by a system of linear equations.
- Level 5, Linear functions: Understands linear functions and can find and use slopes and intercepts of lines and functional notation.

In 2009, a majority of ninth graders were proficient in lower level algebra skills such as algebraic expressions (86%) and multiplicative and proportional thinking (59%) (figure 1-3). Proportions demonstrating proficiency in more advanced algebra skills were lower and decreased as the difficulty level increased. Only 9% of ninth graders reached proficiency in linear functions, the highest algebra skill level assessed by HSLS.

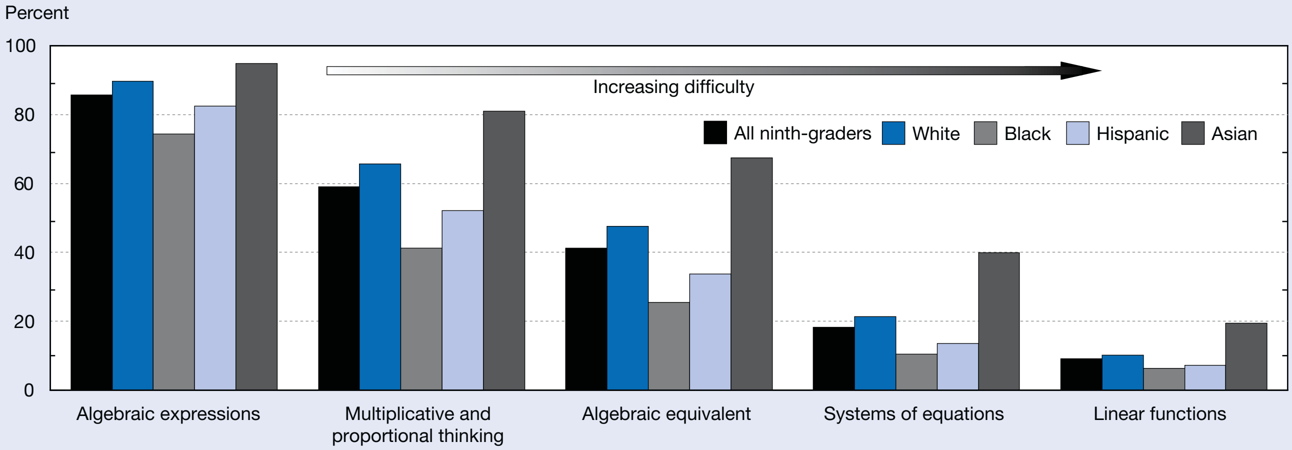
Though there were no gender differences in algebra performance (appendix table 1-5), considerable differences were found among racial/ethnic subgroups (figure 1-3). In each skill area, Asian and white students demonstrated proficiency at higher rates than did black and Hispanic students. For example, 20% of Asians and 10% of whites were proficient in linear functions, compared with 6–7% of blacks and Hispanics.

Differences by parents' education were also considerable (appendix table 1-5). In every skill area assessed, proportionally more students whose parents had a bachelor's or advanced degree achieved proficiency than those whose parents had a high school education or less. For example, 35% of students whose parents had an advanced degree mastered systems of equations and 16% mastered linear functions; the corresponding percentages for students whose parents had not completed high school were 10% and 6%, respectively.

International Comparisons of Mathematics and Science Performance

This section examines the relative international standing of U.S. students in mathematics and science using assessment data from the Programme for International Student

Figure 1-3
Ninth-graders proficient in various algebra skill areas, by race/ethnicity: 2009



NOTES: Skill areas are arranged in a hierarchy such that proficiency in a given area assumes proficiency in all lower areas. "All ninth-graders" bars also include students in other racial/ethnic categories that are not shown separately.

SOURCE: Ingels SJ, Dalton B, Holder TE, Lauff E, Burns, LJ, *High School Longitudinal Study of 2009 (HSLS:09): A First Look at Fall 2009 Ninth-Graders*, NCES 2011-327 (2011). See appendix table 1-5.

Science and Engineering Indicators 2012

Assessment (PISA).[19] Sponsored by the Organisation for Economic Co-operation and Development (OECD) and initially implemented in 2000,[20] PISA assesses the performance of 15-year-olds in mathematics and science literacy every 3 years. Most countries participating in PISA are OECD members, although the number of participating non-OECD nations or regions has been increasing. Most OECD countries are economically advanced nations.

PISA is a literacy assessment, not a curriculum-based assessment; it measures how well students apply their knowledge and understanding to real-world situations.[21] The term "literacy" indicates its focus on the application of knowledge learned in and out of school. In the PISA mathematics assessment, for example, students are asked to estimate an area, compare the best price for buying a product, or interpret the statistics in a news report or government document. In the PISA science assessment, students are asked to discuss acid rain, interpret erosion at the Grand Canyon, or predict the results of a controlled experiment (see sidebar "Sample Items from PISA").

Mathematics Literacy Among U.S. 15-Year-Olds

Despite recent improvement, U.S. PISA scores in mathematics remain consistently below the OECD average and also below those of many non-OECD countries (figure 1-4). On the most recent PISA test in 2009, the U.S. average score of 487 fell below the OECD average of 496 and was lower than the scores of 17 of 33 other OECD nations, including Republic of Korea (546), Finland (541), Switzerland (534), Japan (529), Canada (527), and the Netherlands (526) (appendix table 1-6). The U.S. score was also lower than scores in several non-OECD regions/countries/economies, such as Shanghai-China (600), Singapore (562), and Hong Kong (555). In 2009, U.S. students demonstrated higher mathematical literacy than students in only 5 out of 34 OECD countries (Greece, Israel, Turkey, Chile, and Mexico).

The top mathematics performers in the United States trailed behind their peers in many other nations as well. In 2009, the U.S. score at the 90th percentile in mathematics was 607, lower than the corresponding score in 12 of 33 other OECD nations (620–659) (OECD 2010b).

Science Literacy Among U.S. 15-Year-Olds

U.S. students performed relatively better in the PISA science assessment. The average science literacy score of U.S. 15-year-olds improved by 3 points from 2006 to 2009 (figure 1-4). Whereas U.S. students scored lower than the OECD average in 2006 (489 versus 498), this gap was not evident in 2009 (502 versus 501). The U.S. gains in science since 2006 were mainly driven by improvements at the bottom of the performance distribution; performance at the top remained unchanged (OECD 2010b).

Despite improvement, the 2009 U.S. score (502) was below that of 12 OECD nations (512–554) (appendix table 1-6). For example, U.S. students scored lower than students in 5 top-performing OECD nations (Finland, Japan, Republic of Korea, New Zealand, and Canada) by 27–52 points. U.S. students also lagged behind their peers in (non-OECD) Shanghai-China, Hong Kong, and Singapore (by 40–73 points), The U.S. 90th percentile score in scientific literacy was 629, below the corresponding scores in 7 of 33 other OECD nations (642–667) (OECD 2010b). Thus, U.S. top performers in science did better relative to other countries than did U.S. students on average.

Sample Items from PISA

Sample Items for Mathematics

1) *A result of global warming is that the ice of some glaciers is melting. Twelve years after the ice disappears, tiny plants, called lichen, start to grow on the rocks. Each lichen grows approximately in the shape of a circle. The relationship between the diameter of this circle and the age of the lichen can be approximated with the formula:*

$$d = 7.0 \times \sqrt{(t-12)} \quad \text{for } t \geq 12$$

where d represents the diameter of the lichen in millimeters, and t represents the number of years after the ice has disappeared. Using the formula, calculate the diameter of the lichen, 16 years after the ice disappeared.

Correct answer: 14 mm.

Difficulty level: Correct answer corresponding to 484 score points on the PISA mathematics scale ranging from 1 to 1,000.

2) *In Mei Lin's school, her science teacher gives tests that are marked out of 100. Mei Lin has an average of 60 marks on her first four Science tests. On the fifth test she got 80 marks.*

What is the average of Mei Lin's marks in Science after all five tests?

Correct answer: 64.

Difficulty level: Correct answer corresponding to 556 score points on the PISA mathematics scale ranging from 1 to 1,000

Sample Items for Science

1) *Mary Montagu was a beautiful woman. She survived an attack of smallpox in 1715 but she was left covered with scars. While living in Turkey in 1717, she observed a method called inoculation that was commonly used there. This treatment involved scratching a weak type of smallpox virus into the skin of healthy young people who then became sick, but in most cases only with a mild form of the disease. Mary Montagu was so convinced of the safety of these inoculations that she allowed her son and daughter to be inoculated. In 1796, Edward Jenner used inoculations of a related disease, cowpox, to produce antibodies against smallpox. Compared with the inoculation of smallpox, this treatment had less side effects and the treated person could not infect others. The treatment became known as vaccination.*

What kinds of diseases can people be vaccinated against?

A. Inherited diseases like haemophilia.

B. Diseases that are caused by viruses, like polio.

C. Diseases from the malfunctioning of the body, like diabetes.

D. Any sort of disease that has no cure.

Correct answer: B. Diseases that are caused by viruses, like polio.

Difficulty level: Correct answer corresponding to 436 score points on the PISA science scale ranging from 1 to 1,000.

2) *Regular but moderate physical exercise is good for our health.*

Is this an advantage of regular physical exercise:

Physical exercise helps prevent heart and circulation illnesses. Yes / No

Physical exercise leads to a healthy diet. Yes / No

Physical exercise helps to avoid becoming overweight. Yes / No

Correct answer: Yes, No, Yes in that order.

Difficulty level: Correct answer corresponding to 545 score points on the PISA science scale ranging from 1 to 1,000.

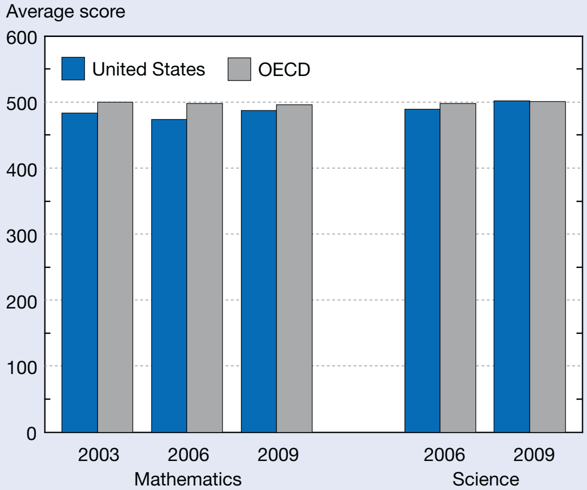
For additional sample questions, see http://www.pisa.oecd.org/dataoecd/47/23/41943106.pdf.

Student Coursetaking in High School Mathematics and Science

Increasing mathematics and science coursetaking is one goal of current education reform efforts.[22] Policymakers are calling for high school students to take more courses in mathematics and science, particularly at the advanced level, to ensure they are adequately prepared for college and careers and to keep the United States competitive in the global marketplace (NSB 2010a; President's Council of Advisors on Science and Technology 2010). Strategies to increase mathematics and science coursetaking have focused on raising high school graduation requirements to include more mathematics and science courses, creating core academic standards to ensure that these courses are sufficiently rigorous, and encouraging students to take more rigorous mathematics and science courses.

This section provides indicators of mathematics and science coursetaking in the United States. The section begins with contextual information about programmatic efforts to increase

Figure 1-4
Average PISA mathematics and science literacy scores of 15-year-old students in the United States and OECD countries: 2003, 2006, and 2009



OECD = Organisation for Economic Co-operation and Development; PISA = Programme for International Student Assessment

NOTE: The average scores for OECD countries cannot be compared across years because the number of OECD countries participating in PISA assessments changed over time.

SOURCES: Lemke M, Sen A, Pahlke E, Partelow L, Miller D, Williams T, Kastberg D, Jocelyn L, *International Outcomes of Learning in Mathematics Literacy and Problem Solving: PISA 2003 Results From the U.S. Perspective,* National Center for Education Statistics (NCES), 2005-003 (2004); Baldi S, Jin Y, Skemer M, Green PJ, Herget D, *Highlights From PISA 2006: Performance of U.S. 15-Year-Old Students in Science and Mathematics Literacy in an International Context,* National Center for Education Statistics, NCES 2008-016 (2007); Fleischman HL, Hopstock PJ, Pelczar MP, Shelley BE, *Highlights From PISA 2009: Performance of U.S. 15-Year-Old Students in Reading, Mathematics, and Science Literacy in an International Context,* National Center for Education Statistics, NCES 2011-004 (2010).

Science and Engineering Indicators 2012

mathematics and science coursetaking and to standardize the quality of these courses. The section next examines various indicators of mathematics and science coursetaking by recent high school graduates in the United States, including trends in *overall* mathematics and science credits completed by high school graduates, the extent to which students take *advanced* mathematics and science courses, enrollment in algebra I before high school, and differences in these indicators among various demographic groups.

The primary data source for this section is the NAEP High School Transcript Study (HSTS). Conducted every 4 to 6 years since 1990, HSTS analyzes transcripts from a nationally representative sample of U.S. high school graduates. Results from the 2009 NAEP HSTS are compared to the results from the 2005, 2000, and 1990 studies. Because the HSTS has been conducted periodically for more than two decades, the data illuminate trends in coursetaking. In addition to course credits earned, HSTS collects student information such as gender and race/ethnicity, allowing comparisons of coursetaking, credits earned, and achievement across demographic groups.

High School Graduation Requirements and Curriculum Standards

The American Diploma Project (ADP) Network includes government and education leaders from 35 states. It seeks to improve student achievement by aligning high school academic content standards with the demands of college and careers and by requiring all graduating students to have completed a college-and-career-ready curriculum (Achieve, Inc. 2011). ADP also encourages states and school districts to adopt graduation benchmarks that align high school coursework with the expectations of colleges and employers. These benchmarks specify that students should take at least 3 years of science and 4 years of mathematics to earn a high school diploma and that some of these courses should be at the advanced level. For example, the benchmarks specify that students must complete mathematics courses at least through the level of precalculus and that science courses must include biology, chemistry, and physics. Currently, 20 states and the District of Columbia have adopted these graduation requirements (Achieve, Inc. 2011).

The Council of Chief State School Officers has documented the nationwide trend of rising mathematics and science coursework requirements to earn a high school diploma (table 1-6). In the mid-1980s, the predominant graduation requirement for mathematics and science coursetaking was 2 years in each subject. No state in 1987, for example, required 4 years of mathematics to graduate; by 2006, 6 states required 4 years of mathematics, and that number doubled to 12 states in 2008. The number of states requiring 4 years of science to graduate jumped from 0 in 1987 to 1 in 2006 and 4 in 2008. More than half of states (27) required 3 years of science to graduate in 2008, a substantial increase from the 3 states with that requirement in 1987.

While graduation requirements for mathematics and science coursetaking show an upward trend, a recent ACT report (2010) found that nearly half of high school seniors planning to attend college had not completed the advanced courses necessary to enroll in credit-bearing college courses. Thus, ADP continues its efforts not only to increase the *number* of mathematics and science courses required to graduate, but also to have states specify that some of these courses be at an *advanced* level.

A complementary reform effort, the Common Core State Standards Initiative, focuses on the content of the courses that students take rather than the number or level of courses. Its goal is to ensure that academic standards across states are similar and that they include the rigorous content and higher order skills necessary to prepare all students for college and careers (see sidebar "Common Core State Standards").

Table 1-6
State graduation requirements for mathematics and science, by number of years required: Selected years, 1987–2008
(Number of states)

State/local standard	Mathematics 1987	Mathematics 1996	Mathematics 2006	Mathematics 2008	Science 1987	Science 1996	Science 2006	Science 2008
Local decision[a]	6	7	6	6	6	7	6	6
1–2 years[b]	33	26	12	6	40	33	16	13
3 years	10	15	26	25	3	8	27	27
4 years	0	2	6	12	0	2	1	4

[a]Local decision means that graduation requirements are set by local districts and may vary within a state.
[b]In 2008, all states with statewide requirements required ≥2 years of mathematics courses; only one state (Illinois) required 1 year of science.

NOTES: Data include Washington, DC. Column totals do not add to 51 because certain states did not participate in Council of Chief State School Officers (CCSSO) survey that year or used a different credit reporting system.

SOURCES: CCSSO, *Key State Education Policies on PK-12 Education: 2008* (2009); Snyder TD, *Digest of Education Statistics 1988,* NCES 88-600 (1988); and Snyder TD, *Digest of Education Statistics 1998,* NCES 1999-036 (1999).

Science and Engineering Indicators 2012

Common Core State Standards

To ensure that students graduate from high school adequately prepared for college and employment, a group of 48 states, led by the National Governors Association's Center for Best Practices and the Council of Chief State School Officers, has developed the Common Core State Standards Initiative (CCSSI) (NGA 2009). The standards outline a body of knowledge and skills students must master at each grade level to graduate from high school ready for college and career in the 21st century. The standards clarify what students are expected to learn in each grade, permit cross-state comparisons, and seek to improve student achievement by increasing the rigor of courses required to meet the standards (Fine 2010).

To date, CCSSI has sponsored development of standards for English language arts (ELA) and mathematics for grades K−12. (Detailed information on the ELA and mathematics standards is available on the CCSSI website at http://www.corestandards.org/the-standards.) The National Research Council is currently working on a framework for new national science standards for grades K−12 that states will have the opportunity to include in their common core standards when the standards become available in 2012 (Achieve, Inc. 2011).

Of the 48 states participating in CCSSI (Texas and Alaska do not participate), 44 states and the District of Columbia had adopted the standards by the end of 2010 (Gewertz 2010). States adopted the standards for a variety of reasons, including their rigor, the opportunity for cross-state comparisons, and increased chances of securing Race to the Top funds (EdSource 2010; Kober and Rentner 2011; The Opportunity Equation 2011). According to a recent survey, a majority of the states adopting the standards plan to develop new assessments, curriculum materials, instructional practices, teacher induction and professional development programs, and teacher evaluation systems based on the standards (Kober and Rentner 2011).

Mathematics and Science Coursetaking in High School

HSTS distinguishes between two levels of mathematics and science courses: general and advanced.[23] General-level courses include introductory content needed for more advanced courses. General mathematics includes courses such as basic mathematics, prealgebra, algebra I, and geometry. General science courses include science survey, introduction to physics, and biology 1.

Advanced courses include higher level content and are sometimes the second-year courses in a subject.[24] For example, advanced mathematics courses include algebra II, precalculus/analysis, trigonometry, statistics and probability, and calculus. Advanced science courses include advanced biology, chemistry, and physics. (Engineering is considered an advanced course and often is grouped with advanced science courses for analysis, as it is in this section.)

Researchers and policymakers suggest that it is not enough simply to require students to earn more credits in mathematics and science; students also need to earn credits in *advanced* courses if goals for improved mathematics and science education and outcomes are to be met. Advanced mathematics and science coursetaking is a strong predictor of students' educational success. For example, students who take advanced mathematics and science courses in high school are more likely to earn higher scores on academic assessments, enroll in college, pursue mathematics and science majors in college, and complete a bachelor's degree (Bozick and Lauff 2007; Chen 2009; NCES 2010, 2011; Nord et al. 2011).

Trends in Total Science and Mathematics Credits Earned

Data from HSTS show that the graduating class of 2009 continued the upward trend of having earned more *total* credits in mathematics and science.[25] The average number of credits earned for all mathematics courses was 3.9 in 2009, up from 3.2 in 1990 (figure 1-5) The average number of credits earned for all science courses was 3.5 in 2009, up from 2.8 in 1990.

Trends in Advanced Science and Mathematics Credits Earned

HSTS data also show that U.S. high school students are taking increasing numbers of *advanced* mathematics and science courses. The average number of credits earned by high school graduates in advanced mathematics courses increased from 0.9 in 1990 to 1.7 in 2009 (figure 1-5). Graduates in 1990 earned an average of 1.1 credits in advanced science and engineering courses, compared with 1.9 credits in 2009.

Credits earned for advanced mathematics courses. From 1990 to 2009, the percentages of students taking advanced mathematics courses increased substantially (figure 1-6). For example, 76% of all graduates earned a credit for algebra II in 2009 compared to 53% of all graduates in 1990. The percentage of students taking and completing precalculus/analysis has more than doubled since 1990: 35% in 2009 compared to 14% in 1990.[26] The overall percentage of students earning credits in calculus (17%) and AP/IB mathematics courses (15%) in 2009 has increased since 1990, when 7% of students took calculus and 4% took an AP/IB course.

One reason students have been able to increase the number of advanced mathematics courses taken in high school is that in recent years more of them have been taking algebra I before high school (Nord et al. 2011) (see sidebar "Taking Algebra I Before High School").

Credits earned for advanced science courses. Many more students took advanced science courses in 2009 as well (figure 1-7).[27] The percentage who earned an advanced chemistry credit increased from 45% in 1990 to 70% in 2009, and comparable increases for advanced biology (from 28% to 45%) and physics (from 24% to 39%) were also large. The percentage of students taking advanced environmental/earth science and AP/IB science courses showed similar upward trends, though fewer students took these courses. Fourteen percent of students took an AP/IB science course in 2009, compared to 11% in 2005.[28]

Compared with advanced mathematics and science, fewer students earned credits in engineering: 3% of 2009 graduates had taken engineering in high school, up from 1.5% in 2005.

Taking Algebra I Before High School

Algebra I is considered a "gateway" course leading to more advanced coursetaking in mathematics and science and to higher levels of achievement (Loveless 2008). An increasing number of educators and researchers are calling for more students to take algebra I before high school (Ma and Wilkins 2007; Matthews and Farmer 2008; National Mathematics Advisory Panel 2008).

High school transcripts indicate credits earned for high school courses taken before ninth grade. According to HSTS data, 26% of high school graduates took algebra I before high school in 2009, up from 20% in 2005 (table 1-A). Percentages of both male and female graduates taking algebra before high school increased, though females (27%) slightly outpaced males (25%) in 2009. Upward trends occurred in all racial/ethnic groups as well, with black, Hispanic, and white graduates posting increases of 4, 7, and 6 percentage points, respectively. Asian/Pacific Islander students outpaced their peers by increasing their rates of completing algebra 1 before high school from 30% in 2005 to 48% in 2009.

HSTS identifies three curriculum levels based on the types of courses students take: standard, midlevel, and rigorous. A rigorous curriculum includes 4 years of mathematics including up to at least precalculus and 3 years of science, which must include biology, chemistry, and physics. HSTS data show that nearly two-thirds of graduates who completed a rigorous high school curriculum took algebra I before high school (Nord et al. 2011).

Table 1-A
High school graduates completing first-year algebra before high school, by student characteristic: 2005 and 2009
(Percent)

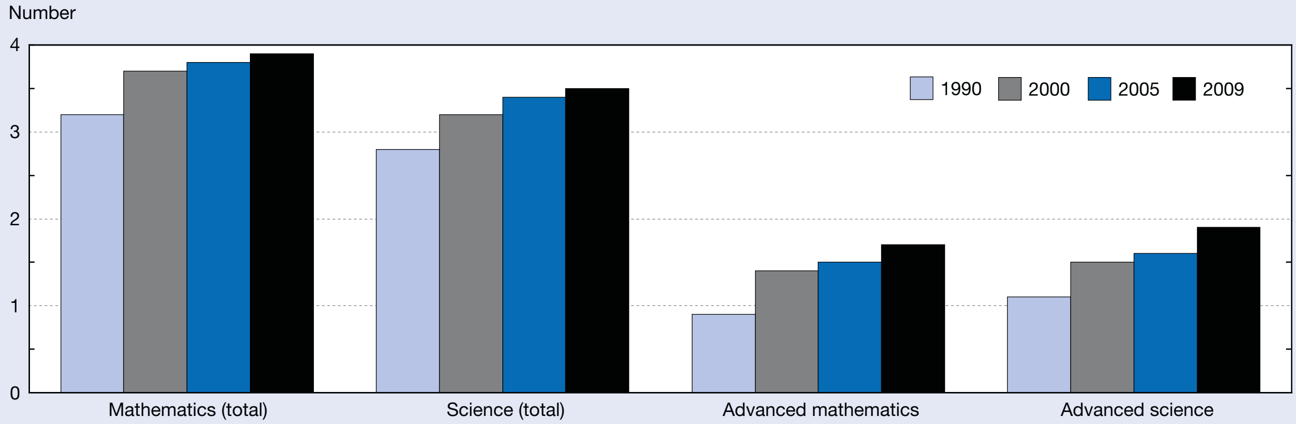
Student characteristic	2005	2009
All students	20	26
Sex		
Male	20	25
Female	20	27
Race/ethnicity		
White, non-Hispanic	23	29
Black, non-Hispanic	8	12
Hispanic	10	17
Asian/Pacific Islander	30	48

NOTE: American Indian/Alaska Native students are included in "all students" but are not shown separately due to small sample sizes.

SOURCE: Nord C, Roey S, Perkins R, Lyons M, Lemanski N, Brown J, Schuknecht J, America's *High School Graduates: Results of the 2009 NAEP High School Transcript Study,* NCES 2011-462 (2011).

Science and Engineering Indicators 2012

Figure 1-5
Average total and advanced mathematics and science credits earned by high school graduates: Selected years, 1990–2009



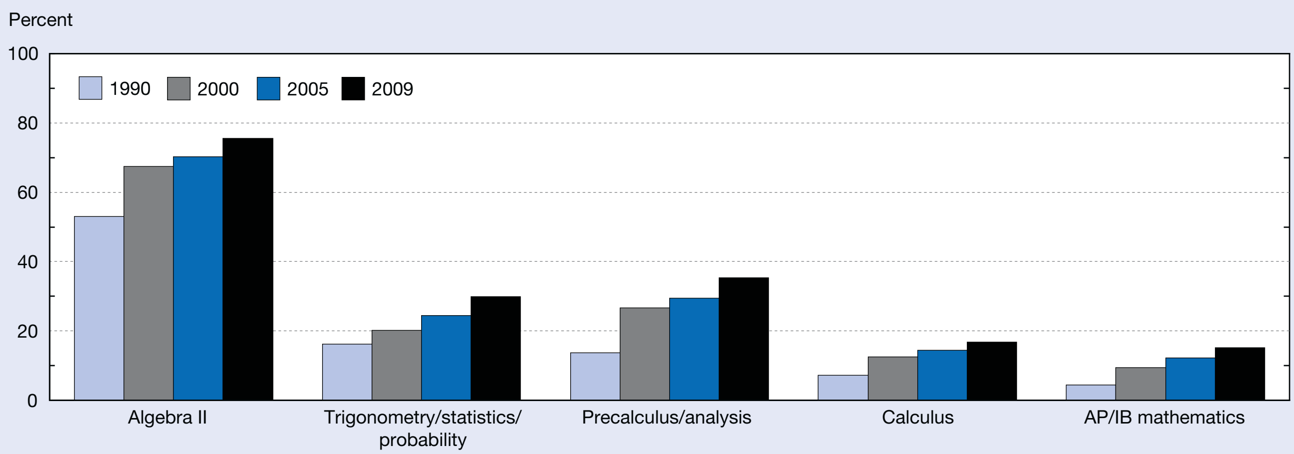
AP = Advanced Placement; IB = International Baccalaureate

NOTES: "Advanced mathematics" courses include algebra II, trigonometry, statistics/probability, precalculus/analysis, calculus, and any AP/IB mathematics courses. "Advanced science" courses include advanced biology, chemistry, physics, advanced environmental/earth science, engineering, and any AP/IB science courses.

SOURCES: Nord C, Roey S, Perkins R, Lyons M, Lemanski N, Brown J, Schuknecht J, *America's High School Graduates: Results of the 2009 NAEP High School Transcript Study,* NCES 2011-462 (2011); National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of National Assessment of Educational Progress 1990, 2000, 2005, and 2009 High School Transcript Studies, National Center for Education Statistics. See appendix table 1-7.

Science and Engineering Indicators 2012

Figure 1-6
High school graduates completing various advanced mathematics courses, by subject: Selected years, 1990–2009



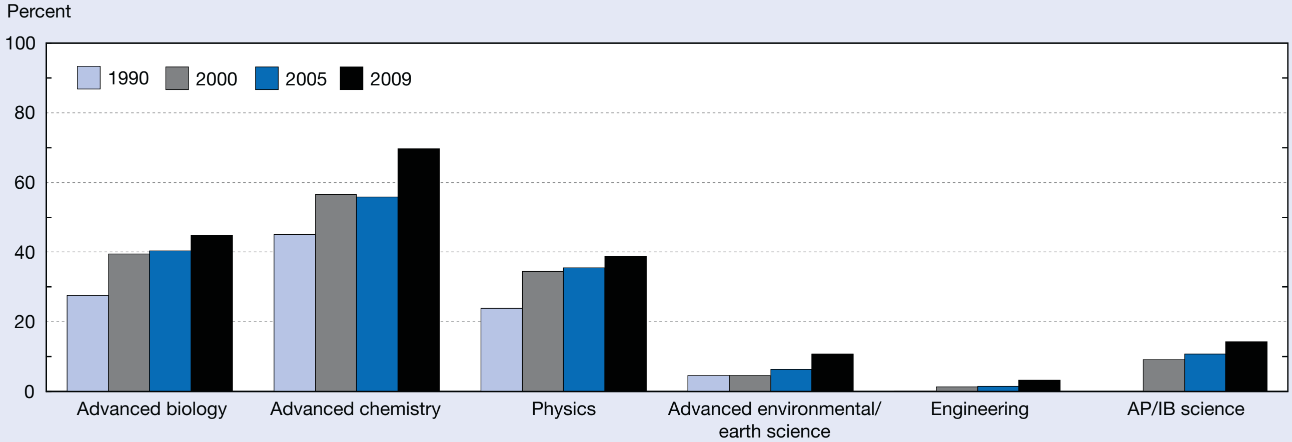
AP = Advanced Placement; IB = International Baccalaureate

NOTE: AP/IB courses are shown separately here but also could be included in other bars. For example, calculus includes any calculus course, including AP calculus.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of National Assessment of Educational Progress 1990, 2000, 2005, and 2009 High School Transcript Studies, National Center for Education Statistics. See appendix table 1-8.

Science and Engineering Indicators 2012

Figure 1-7
High school graduates completing various advanced science and engineering courses, by subject: Selected years, 1990–2009



AP = Advanced Placement; IB = International Baccalaureate

NOTES: "Advanced biology" includes AP/IB biology, physiology, anatomy, and genetics. "Advanced environmental and earth sciences" includes AP/IB environmental sciences, college preparatory earth science, and various geology courses. AP/IB courses are shown separately here but also included in other bars. For example, "Physics" includes any advanced physics course, including AP physics, and "Chemistry" includes any advanced chemistry course, including AP chemistry.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of National Assessment of Educational Progress 1990, 2000, 2005, and 2009 High School Transcript Studies, National Center for Education Statistics. See appendix table 1-9.

Science and Engineering Indicators 2012

Demographic Differences in Advanced Mathematics and Science Credits Earned

Although mathematics and science coursetaking has increased for all demographic groups, differences among these groups have persisted. White students are more likely to earn advanced credits than black or Hispanic students. Asian/Pacific Islander students outpace other groups of students in terms of credits earned and percentages taking advanced courses.

Credits earned in advanced courses. In 2009, females and males earned approximately equal credits in advanced mathematics—an average of 1.7 credits (appendix table 1-7). Among racial/ethnic groups, Asian/Pacific Islander students earned the most credits in advanced mathematics, an average of 2.4 credits in 2009. Hispanics (1.3) and blacks (1.4) earned the fewest credits in advanced mathematics. White students earned substantially more credits (1.8) than black or Hispanic students, but significantly fewer than Asian/Pacific Islander students.

In 2009, females earned an average of 1.9 advanced science and engineering credits, compared to 1.8 credits for males. Among major racial/ethnic groups, Asian/Pacific Islander students earned the highest number of credits in advanced science and engineering (2.8). Hispanic and black students earned 1.5 and 1.6 credits, respectively, in these subjects. White students earned more credits (2.0 credits in advanced science and engineering) than black or Hispanic students, but fewer than Asian/Pacific Islanders.

Percentage taking advanced courses. The percentage of females taking precalculus/analysis (37%) was higher than that of males (34%), as was the percentage of females taking algebra II (78% compared to 74%) (appendix table 1-8). An equal percentage of males and females (17%) took calculus. Asian/Pacific Islander students outpaced all other groups in taking advanced mathematics in 2009. The most striking disparities occurred in AP/IB mathematics coursetaking, with Asian/Pacific Islander students (42%) taking these courses at rates approximately 6 times that of black students (7%), 4 times that of Hispanic students (9%), and 2.5 times that of white students (16%).

Gender differences in advanced science coursetaking varied by subject (appendix table 1-9). Whereas more females than males took advanced biology (50% versus 39%), males took physics at higher rates than females (42% versus 36%). Males were 6 times more likely to have taken engineering (6% versus 1%). Asian/Pacific Islander students took advanced science and engineering courses at rates higher than those of other ethnic groups.

Teachers of Mathematics and Science

Among the many factors that influence student learning, teacher quality is crucial. To ensure that all classrooms are led by high-quality teachers, NCLB mandated that schools and districts hire only highly qualified teachers, defining "highly qualified" as having state certification, a minimum of a bachelor's degree, and demonstrated subject area competence. Teaching quality has remained in the national spotlight. The Race to the Top program, a component of the American Recovery and Reinvestment Act of 2009, called for applications from states to compete for more than $4 billion for education innovation and reform, including recruitment, professional development, compensation, and retention of effective teachers.[29] Salaries, working conditions, and opportunities for professional development contribute to keeping teachers in the profession and the best teachers in the classroom (Berry, Smylie, and Fuller 2008; Brill and McCartney 2008; Hanushek and Rivkin 2007; Ingersoll and May 2010).

This section presents indicators of public school mathematics and science teachers' preparation, experience, professional development, salaries, and working conditions. It focuses on middle and high school teachers, as mathematics and science teachers are more common and more easily identified at these levels than at the elementary level.[30] The primary data source is the 2007–08 SASS; comparable data from earlier SASS collections are also used to examine changes over time. The section refers to 2007 and 2003 to indicate the academic years 2007–08 and 2003–04. When possible, measures are analyzed separately for schools with differing concentrations of minority and low-income students.[31]

To provide context, U.S. public school teachers numbered about 3.4 million in 2007 (appendix table 1-10), a 14% increase over the approximately 3.0 million teachers employed in 1999 (Gruber et al. 2002). Approximately 419,000 taught mathematics or science at public middle and high schools, accounting for 12% of the public school teaching force nationwide.

Characteristics of High-Quality Teachers

The effects of good teachers on student achievement have been well documented (Boyd et al. 2008; Clotfelter, Ladd, and Vigdor 2007; Goe 2008; Guarino, Santibanez, and Daley 2006; Harris and Sass 2007), but the specific teacher characteristics that contribute to student success are less clear (see sidebar "Measuring Teaching Quality"). Some studies have cast doubt on whether commonly measured indicators, such as teachers' licensure scores or the selectivity of their undergraduate institutions, are related to teaching effectiveness (Boyd et al. 2006; Buddin and Zamarro 2009a, 2009b; Hanushek and Rivkin 2006). This section reports on indicators such as public school mathematics and science teachers' educational attainment, professional certification, participation in practice teaching, self-assessment of preparation, and years of experience. Although these are not the only characteristics that contribute to teacher effectiveness, they are more easily measured than such other characteristics as teachers' abilities to motivate students, manage the classroom, maximize instruction time, and diagnose and overcome students' learning difficulties.

Highest Degree Attained

Virtually all mathematics and science teachers at public middle and high schools held at least a bachelor's degree in 2007, and more than half had earned an advanced degree (e.g., master's degree, education specialist, certificate of advanced graduate studies, doctorate, professional degree) (appendix table 1-11). The proportion of mathematics and science teachers with a master's or higher degree has increased since 2003 (from 48% to 54% for mathematics teachers and from 52% to 58% for science teachers).

Teachers with advanced degrees are not evenly distributed across schools, however. Proportionately more mathematics and science teachers in low-poverty and low-minority schools held master's degrees than did their peers in high-poverty and high-minority schools.[32] For example, in 2007–08, 61% of science teachers in low-poverty schools had earned a master's degree, compared with 41% of those in high-poverty schools.

Certification and Entry into the Profession

The traditional path to becoming a teacher begins in an undergraduate education program, where future teachers earn a bachelor's or master's degree and full teaching certification prior to beginning to teach. In recent years, a growing proportion of new teachers have entered the profession through an alternative pathway, usually a program that recruits college graduates from other fields or mid-career professionals in non-teaching careers. These teachers often begin to teach with probationary or temporary certification while they work toward regular certification during the first few years of their teaching careers.[33] Regardless of their pathway into the profession, all public school teachers must have some type of state certification to teach.

State Certification. Teacher certification refers to a license required by the state of all practicing teachers; requirements vary by state but typically include completing a bachelor's degree, completing a period of practice teaching, and passing a formal test[34] (Editorial Projects in Education Research Center 2010). Most states require high school teachers of mathematics and science to have a degree or certificate in their subject area. At the middle school level, some states allow general education preparation and others require subject area preparation for mathematics and science teachers (Greenberg and Walsh 2008). Differences in state standards and requirements for certification complicate measurement of the impact of teachers' credentials on student outcomes; nevertheless, some studies suggest that holding a regular or advanced certification is associated with student achievement (Clotfelter, Ladd, and Vigdor 2007; Easton-Brooks and Davis 2009; Klecker 2008; Subedi, Swan, and Hynes 2010).

In 2007, 87% of public middle and high school mathematics and science teachers were fully certified (i.e., held regular or advanced state certification) (table 1-7). The percentage of science teachers with full certification has increased by 4

Measuring Teaching Quality

No research has conclusively identified the most effective teachers or the factors that contribute to their success, but efforts to improve measures of teaching quality have proliferated in recent years. For example, 21 states and over 100 teacher preparation programs have joined the Teacher Performance Assessment Consortium (TPAC) to develop a teacher evaluation instrument. The evaluation will be based on assessments embedded in teachers' preparatory coursework and on documentation of teaching and learning during multi-day lessons.

Another effort has focused on establishing a composite indicator for effective teaching by measuring student gains on test scores, quality of teaching practice, teachers' pedagogical content knowledge, student perceptions of the classroom environment, and teachers' perceptions of working conditions and instructional support at their schools (Measures of Effective Teaching 2010). Through the Measures of Effective Teaching project, researchers have analyzed data in large school districts nationwide to identify effective teachers and teaching practices. Data collection began in the 2009−10 academic year and continued in 2010−11.

A similar effort focused on mathematics teaching quality is underway at the National Center for Teacher Effectiveness, which seeks to identify practices and characteristics that distinguish effective mathematics teachers and to develop practical instruments and training tools for school districts. The center's core project, Developing Measures of Effective Mathematics Teaching, will combine measures of teacher characteristics, practice, and content knowledge and measures of student engagement and learning to build a composite measure of teaching effectiveness in mathematics. Data collection in approximately 50 schools and 200 classrooms began in 2010 and will continue through 2013.

These projects are among the largest efforts to incorporate gains in student test scores into the measurement of quality, but they are not the first. Several researchers have sought to develop so called "value-added" models that link teacher effectiveness to student gains in achievement test scores (Hanushek and Rivkin 2010; Hanushek et al. 2005). These models do not directly measure variation in teaching practices; rather, they compare test score gains of students with similar background characteristics and initial scores within the same school and attribute students' differences in progress to their teachers (Baker et al. 2010). Although some studies have validated the value-added approach (Jacob and Lefgren 2008; Kane et al. 2010; Kane and Staiger 2008), researchers have raised concerns about nonrandom assignment of students to teachers within a school; the use of standardized tests that do not adequately measure students' knowledge, skills, and progress; and family support or other factors outside of school that contribute to students' achievement (Baker et al. 2010; Hanushek and Rivkin 2010; Rothstein 2008).

Despite these concerns, there seems to be consensus that these models can contribute to current efforts to evaluate teaching when used along with other observable measures. However, researchers have not yet arrived at a comprehensive model for measuring teaching quality.

More information on the Teacher Performance Assessment Consortium is available at http://aacte.org/index.php?/Programs/Teacher-Performance-Assessment-Consortium-TPAC/teacher-performance-assessment-consortium.html. More information about the Measures of Effective Teaching project is available at http://www.metproject.org/. More information about the Developing Measures of Effective Mathematics Teaching project is available at http://www.gse.harvard.edu/ncte/projects/project1/default.php.

Table 1-7
Public middle and high school teachers with regular or advanced certification, by teaching field: Academic years 2003–04 and 2007–08
(Percent)

Teaching field	Academic year 2003–04	Academic year 2007–08
Mathematics	85.1	87.0
Science	82.8	87.3
Other	86.6	88.1

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of 2003–04 and 2007–08 Schools and Staffing Survey, National Center for Education Statistics. See appendix table 1-12.

Science and Engineering Indicators 2012

percentage points since 2003 (from 83% to 87%), and has increased at a faster pace at low-minority schools (from 86% to 93%) (appendix table 1-12).

Fully certified mathematics and science teachers were more prevalent in low-minority schools (92% of mathematics and 93% of science teachers) than in high-minority schools (84% of mathematics and 83% of science teachers) (appendix table 1-12). Fully certified science teachers were also more prevalent in low-poverty schools (89%) than in high-poverty schools (81%). The percentage of fully certified mathematics and science teachers at high-minority and both high- and low-poverty schools has not changed significantly since 2003.

Alternative Entry into the Teaching Profession. Rather than completing traditional undergraduate programs in education, some teachers enter teaching through alternative programs such as Teach for America, The New Teacher Project, and other programs administered by states, districts, universities, and other organizations to expedite the transition of nonteachers into teaching. Although these programs have expanded in recent years,[35] researchers have observed few systematic differences in the training received by aspiring teachers in traditional versus alternative pathways (Humphrey, Weschler, and Hough 2008; NRC 2010; Zeichner and Conklin 2005).[36] Much of the formal training for teachers in both traditional and alternative programs takes place in university schools of education (Walsh and Jacobs 2007); according to SASS, however, a significantly smaller proportion of alternative-pathway teachers participated in practice teaching prior to beginning teaching (see "Practice Teaching" section). Some characteristics of teachers who enter through traditional and alternative programs, such as the selectivity of their undergraduate institutions or the likelihood of holding advanced degrees, are also similar (Cohen-Vogel and Smith 2007). Research has found mixed or no effects of teachers' pathway into the profession on students' achievement (Constantine et al. 2009; Boyd et al. 2006; Zeichner and Conklin 2005).

Some alternative entry programs place recruits in "high-need" schools, generally those with high levels of student poverty and low levels of student achievement. According to its website, the New Teacher Project has placed 43,000 teachers of all subjects in high-need locations since 1997, and Teach for America's annual placement of teachers in high-need schools has grown from about 2,000 to 5,000 between 2005 and 2010 (TFA 2006, 2008, 2009). Although statistics on the number of mathematics and science teachers placed are not available, the New Teacher Project and Teach for America include increasing the supply of teachers in those subject areas among their goals.[37]

In 2007, 19% of all public middle and high school mathematics teachers and 22% of science teachers had entered the profession through an alternative certification program, compared with 16% of teachers in other fields (appendix table 1-13). Teachers who had entered through alternative programs were more concentrated in schools with high rates of minority enrollment and school poverty. For example, 26% of mathematics teachers in schools with the highest poverty levels had entered teaching through an alternative program, compared with 12% of those in schools with the lowest poverty levels. Nationwide, the supply of new mathematics and science teachers may not be sufficient to replace those who retire or leave the profession for other reasons, and teacher shortages in these subjects are not distributed evenly across schools (Ingersoll and Perda 2009). High-poverty schools in urban areas tend to have the highest rates of teacher turnover; resulting shortages may contribute to schools' decision to hire teachers from alternative entry programs.

National Board Certification

Some experienced teachers pursue certification from the National Board for Professional Teaching Standards, a nonprofit organization that evaluates teachers' performance against a set of professional standards and confers certificates indicating superior teaching quality.[38] Applicants must have completed 3 years of teaching and must hold state certification to be eligible. They must then complete 10 assessments reviewed by evaluators in their subject area—requirements that are more rigorous than those for state certification. Assessments include six online exercises, which test content knowledge in specific certificate areas, and four portfolio submissions, including video recordings of classroom practice and examples of student work.

Research on the effects of National Board Certification on student outcomes has generally been inconclusive. An assessment of 11 such studies by the National Academy of Sciences concluded that in any case, such a relationship is not a strong one (Hakel, Koenig, and Elliott 2008). Research in several states has shown that teachers holding this certification are less likely to teach in schools with high proportions of poor, minority, and low-performing students (Goldhaber, Choi, and Cramer 2007; Humphrey, Koppich, and Hough 2005). According to the National Board website, more than 90,000 teachers were National Board Certified as of 2010, a 90% increase since 2005, and 42% teach in schools eligible for Title I, a federal program to provide funds to schools and districts with high percentages of low-income students.[39] About one-quarter of school districts offer pay incentives for teachers who earn National Board Certification (Aritomi and Coopersmith 2009).

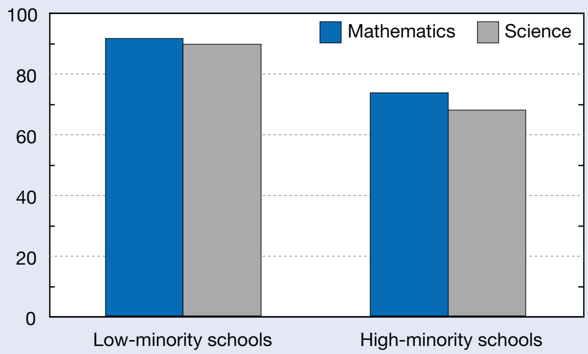
Practice Teaching

Practice teaching (also called student teaching) offers prospective teachers hands-on classroom experience to help them transfer what they learn from coursework into classroom teaching. Practical experience in the classroom affects teaching quality (Boyd et al. 2008),[40] and SASS data support this finding: among teachers with fewer than 5 years of experience (referred to here as "new teachers"), those who had participated in practice teaching were more likely to report feeling well prepared or very well prepared for various aspects of teaching during their first year than did those who had not had practice teaching (appendix table 1-14).

Among new public middle and high school mathematics and science teachers in 2007, about three-quarters had participated in practice teaching (appendix table 1-15). The proportion differed by school composition: 91% of new mathematics and 90% of new science teachers at low-minority schools participated in practice teaching, compared with 73% and 68%, respectively, at high-minority schools (figure 1-8).

The proportion of new mathematics and science teachers who have participated in practice teaching has declined during recent years. Seventy-five percent of new mathematics and 72% of new science teachers reported participation in practice

Figure 1-8
Participation of new public middle and high school teachers in practice teaching, by teaching field and minority enrollment: Academic year 2007–08



NOTES: "New teachers" refers to those with fewer than 5 years of teaching experience. Minority students constitute 0%–5% of the student population at low-minority schools and more than 45% of the population at high-minority schools.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2010) of 2007–08 Schools and Staffing Survey, National Center for Education Statistics. See appendix table 1-15.

Science and Engineering Indicators 2012

teaching in 2007, compared with 79% and 75%, respectively, in 2003 (appendix table 1-15). The decline may be due to the increasing number of teachers who enter the profession through alternative programs and who are significantly less likely to have participated in practice teaching. In 2007, 43% of mathematics teachers and 51% of science teachers who entered the profession through an alternative program had participated in practice teaching, lower than the 94% of mathematics and 92% of science teachers who entered teaching the traditional way (appendix table 1-16). Thirty-nine states require prospective teachers in traditional preparation programs to participate in practice teaching, while six require teachers in alternative programs to practice teach (Editorial Projects in Education Research Center 2010).

Self-Assessment of Preparedness

New middle and high school teachers (i.e., those with fewer than 5 years of experience) generally felt well prepared to perform various tasks during their first year of teaching, and science teachers in particular have seen improvements in feeling prepared (appendix table 1-17). In 2007, 88% of new mathematics teachers and 89% of new science teachers felt prepared to teach their subject matter. Among new science teachers, this represents an increase since 2003, when 79% felt prepared to teach the subject matter. More new science teachers also felt prepared to use computers in instruction: 75% reported feeling prepared in 2007, compared with 62% in 2003.

New teachers' assessments of their preparation varied with the characteristics of their schools. For example, 99% of new mathematics teachers and 95% of new science teachers in low-minority schools felt prepared to teach their subject matter, compared with 84% and 85% of their peers in high-minority schools (appendix table 1-17).

Experience

Teachers generally are more effective in helping students learn as they gain years of experience, particularly during their first few years (Boyd et al. 2006; Clotfelter, Ladd, and Vigdor 2007; Harris and Sass 2008; Rice 2010). In 2007, about one-fifth of public middle and high school mathematics and science teachers were novices with 3 or fewer years of experience (appendix table 1-18). Proportionally more mathematics teachers at high-minority schools were novice teachers than at low-minority schools (22% versus 13%). Similarly, novice science teachers were more prevalent in high-poverty schools than in low-poverty schools (25% versus 15%).

School Factors Contributing to Teachers' Effectiveness

Teachers bring a variety of knowledge, skills, and experience into their classrooms, but conditions in their schools and districts also influence their effectiveness in promoting student outcomes and their decisions about remaining in the profession. This section presents indicators of district and school attributes that affect teachers' success, including the assignment of teachers to subjects, initial and ongoing professional development, salaries, and working conditions.

In-Field Teaching

Over the past decade, few issues related to teaching quality have received more attention than in-field teaching assignment in middle and high schools (Almy and Theokas 2010; Dee and Cohodes 2008; Peske and Haycock 2006). NCLB mandates that all students have teachers who demonstrate competence in subject knowledge and teaching. NCLB does not provide specific guidance or criteria for adequate preparation to teach mathematics and science, however, leaving that task to states.

To determine whether teachers have subject-specific preparation for the fields they teach, recent research focused on matching teachers' formal preparation (as indicated by degree major and certification field) with their teaching field (Hill and Gruber 2011; McGrath, Holt, and Seastrom 2005; Morton et al. 2008). Following this line of research, the National Science Board (2010b) distinguished four levels of formal preparation for teaching mathematics and science at the middle and high school levels.[41] In order of decreasing rigor of preparation, they are as follows:

- *In field:* Mathematics teachers with a degree and/or full certification in mathematics or mathematics education. Science teachers with a degree and/or full certification in science or science education.

- *Related field:* Mathematics teachers with a degree and/or full certification in a field related to mathematics (e.g., science, science education, computer sciences, engineering). Science teachers with a degree and/or full certification in a field related to their teaching field (e.g., high school biology teachers with a degree and/or full certification in chemistry). This category is omitted for middle school science teachers because science teachers at this level are usually not distinguished by specific science fields such as physics, chemistry, or biology.
- *General preparation:* Mathematics and science teachers with a degree and/or full certification in general elementary, middle, or secondary education.
- *Other:* Mathematics and science teachers without a degree or certification in their teaching field, a related field, or general elementary, middle, or secondary education.

In-field mathematics teachers in public middle schools increased from 53% in 2003 to 64% in 2007 (table 1-8). Seventy percent of science teachers in public middle schools were teaching in field in 2007, not a significant increase over 67% in 2003. In both years, between 27% and 38% of middle school mathematics and science teachers were teaching their subject with general education preparation.

The level of in-field mathematics and science teachers in high schools did not change between 2003 and 2007. In both years, large majorities of high school mathematics teachers (87% in 2003 and 88% in 2007), biology/life science teachers (92% in 2003 and 93% in 2007), and physical science teachers (78% in 2003 and 82% in 2007) taught in field. Relatively few (3% or lower) mathematics and science teachers in high schools had general education preparation.

In-field teachers were more likely in low-minority and low-poverty schools than in their high-minority and high-poverty counterparts (appendix table 1-19). In 2007, for example, 95% of high school mathematics teachers in low-minority schools were teaching in field, compared with 83% in high-minority schools, and 94% of high school mathematics teachers in low-poverty schools were teaching in field, compared with 81% in high-poverty schools.

In-field mathematics teaching became somewhat more common at high-poverty and high-minority middle schools between 2003 and 2007; for example, the rate of in-field mathematics teachers increased from 47% to 65% at high-poverty middle schools and from 51% to 61% at high-minority middle schools.

Professional Development for Mathematics and Science Teachers

Professional development enables teachers to update their knowledge, sharpen their skills, and acquire new teaching techniques, all of which may enhance the quality of teaching and learning (Davis, Petish, and Smithey 2006; Richardson and Placier 2001). Research indicates that professional development can have measurable effects on student performance; an analysis examining outcomes across 16 studies of professional development for mathematics and science teachers found that professional development had statistically significant effects on student performance in mathematics (CCSSO 2009).[42]

New Teacher Induction and Support. Professional development often begins during a teachers' first year in the classroom. Without sufficient support and guidance, teachers in their first and second years may struggle, become less committed to teaching, and leave the profession altogether (Smith and Ingersoll 2004; Smith and Rowley 2005). Teacher induction programs at the school, local, or state level are designed to help teachers in their first 2 years improve their professional practice, deepen their understanding of teaching, and prevent early attrition (Britton et al. 2003; Fulton, Yoon, and Lee 2005; Smith and Ingersoll 2004).

Table 1-8
Preparation of public school mathematics and science teachers for teaching in their field, by school level and teaching field: Academic years 2003–04 and 2007–08
(Percent)

School level/teaching field	Academic year 2003–04				Academic year 2007–08			
	In field	Related field	General education	Other	In field	Related field	General education	Other
Middle school								
Mathematics	53.5	3.9	37.5	5.1	64.3	1.6	30.6	3.4
Science	67.0	na	29.2	3.8	69.6	na	27.0	3.3
High school								
Mathematics	87.4	2.0	3.1	7.5	88.0	1.2	3.4	7.4
Biology/life sciences	91.9	3.6	1.3	3.2	93.2	3.9	0.9	2.0
Physical sciences	78.1	19.6	0.9	1.5	81.6	15.4	1.2	1.8

na = not applicable

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of 2003–04 and 2007–08 Schools and Staffing Survey, National Center for Education Statistics. See appendix table 1-19.

Science and Engineering Indicators 2012

Participation in new teacher induction programs is becoming more common. Among new public middle and high school teachers with fewer than 5 years of experience in 2007, 79% of mathematics and 73% of science teachers had participated in an induction program during their first year, compared with 71% of mathematics teachers and 68% of science teachers in 2003 (appendix table 1-20). Teacher participation in induction programs was lower in schools with high concentrations of minority and low-income students, but gaps in participation narrowed over time. In 2003, 63% of mathematics teachers in high-minority schools had participated in an induction program, compared with 88% in low-minority schools—a gap of 25 percentage points. In 2007, that gap was 8 percentage points. Gaps narrowed mainly due to increasing percentages of teachers in high-minority and high-poverty schools participating in induction programs. Appendix table 1-21 shows data on other types of support provided to new teachers when they start their careers.

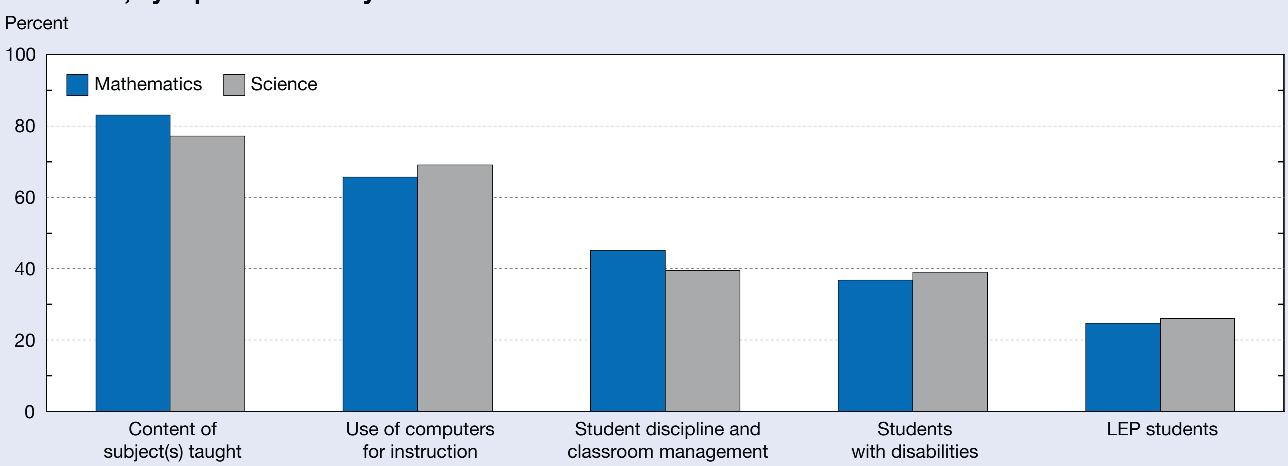
The extent to which these programs help new teachers be more effective is unclear: a recent nationwide study of induction programs at the elementary level found no effects on student achievement for teachers who received a single year of induction, and effects on student achievement for teachers in 2-year induction programs were evident only in teachers' third year of teaching (Glazerman et al. 2010). The study found no relationship between participation in new teacher induction and retention of teachers during their first 4 years. Some research suggests that a subject-matter match between teachers and induction programs improves outcomes for teachers (Luft 2009; Luft et al. 2010), but this question was not examined in the national study.

Ongoing Professional Development. Teachers' professional development does not end after their first few years of teaching. Ongoing training is often mandated by state regulations and delivered by school districts to teachers throughout their careers. In 2007, more than three-quarters of mathematics and science teachers in public middle and high schools received professional development in the content of their teaching subject during the previous 12 months (figure 1-9). Another common focus of teacher professional development programs was the use of computers for instruction: 66% of mathematics and 69% of science teachers received professional development on that topic (appendix table 1-22). Fewer than half received training in classroom discipline or management, teaching students with disabilities, or teaching Limited English Proficient (LEP) students.

The duration of professional development programs is often shorter than what research suggests may be desirable. Although more research is needed to establish a threshold, some studies have suggested 80 hours or more of professional development is necessary to affect teacher practice (Banilower et al. 2006; CCSSO 2009; NSB 2008). Among teachers who received professional development in their subject area, 28% of mathematics and 29% of science teachers received 33 hours or more (figure 1-10).[43]

The three top priority areas for professional development programs identified by mathematics and science teachers at public middle and high schools were student discipline and classroom management, the content of their main subject field, and use of technology in instruction (appendix table 1-23). Teachers in different types of schools had different priorities. For example, 29% of science teachers in high-poverty schools identified student discipline and classroom

Figure 1-9
Participation of public middle and high school teachers in professional development activities during past 12 months, by topic: Academic year 2007–08

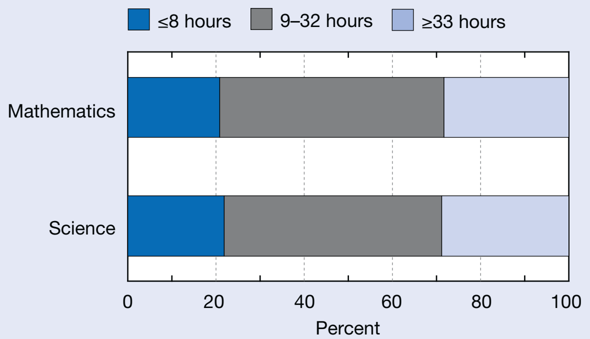


LEP = limited English proficiency

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2010) of 2007–08 Schools and Staffing Survey, National Center for Education Statistics. See appendix table 1-22.

Science and Engineering Indicators 2012

Figure 1-10
Duration of professional development received by public middle and high school teachers in the content of subject(s) taught, by teaching field: Academic year 2007–08



NOTE: Figure includes mathematics and science teachers who received professional development in their subject area during past 12 months.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2010) of 2007–08 Schools and Staffing Survey, National Center for Education Statistics. See appendix table 1-22.

Science and Engineering Indicators 2012

management as their top priority, compared with 10% of their peers at low-poverty schools.

Teacher Salaries

Financial incentives have been associated with increased teacher recruitment (Berry 2004; Steele, Murnane, and Willet 2009) and retention (Clotfelter et al. 2008; Hanushek, Kain, and Rivkin 2004) (see sidebar "Teacher Attrition"). In 2007, 15% of school districts offered pay incentives in fields of shortage—usually mathematics, science, and special education—and 10% offered rewards for excellence in teaching (Aritomi and Coopersmith 2009). Whether these policies improve overall teaching quality has not been established (Fryer 2011; Hanushek et al. 2005; Hanushek and Rivkin 2007; Rand Corporation 2006; Springer et al. 2010).

Research has indicated that teachers earn less than other professionals with similar levels of education (AFT 2008; Allegretto, Corcoran, and Mishel 2008; Hanushek and Rivkin 2007). The circumstances of employment and the nature of the work differ between teachers and non-teachers, however, and may account for salary differences to some extent. Teachers are more likely than other professionals to work in rural areas, for example, where costs of living and salaries are lower (Taylor 2008). Selecting the appropriate comparison group for teachers also complicates salary comparisons: some research uses figures for most fields requiring a bachelor's degree (AFT 2008), and at least one study suggests that a smaller set of occupations requiring more similar skills may be more appropriate (Milanowski 2008).

In 2007, the average base salary of middle and high school mathematics and science teachers was approximately $50,000, based on teachers' reports in SASS (appendix table 1-24). Salaries varied among schools with different student populations. For example, the average salary of mathematics teachers in public middle and high schools with the lowest rates of minority enrollment was approximately $4,000 less than that of their colleagues in schools with the highest minority enrollment (figure 1-11). High-minority schools tend to be located in urban areas (Keigher 2009), where living expenses are usually higher than in other areas. The pattern is reversed when examining school poverty rates: the average salary for mathematics teachers at schools with the lowest poverty rates was about $7,000 higher than those at schools with the highest rates.

When asked to rate their satisfaction with their salaries, slightly more than half of mathematics teachers reported being satisfied (figure 1-11). Those in low-poverty and low-minority schools were more likely to be satisfied with their salaries than their colleagues in high-poverty and high-minority schools, even though teachers in high-minority schools earned higher base salaries than those in low-minority schools. Patterns were similar among science teachers (appendix table 1-24).

Teacher Perceptions of Working Conditions

Like salaries, working conditions play a role in determining the supply of qualified teachers and influencing their decisions about remaining in the profession. Safe environments, strong administrative leadership, cooperation among teachers, high levels of parent involvement, and sufficient learning resources can improve teacher effectiveness, enhance commitment to their schools, and promote job satisfaction (Berry, Smylie, and Fuller 2008; Brill and McCartney 2008; Guarino, Santibanez, and Daley 2006; Ingersoll and May 2010).

SASS asked teachers whether they agreed with several statements about their school environments and working conditions. Although agreement was not unanimous, large majorities of mathematics and science teachers at public middle and high schools agreed with the following statements regarding their working conditions in 2007: 88% of mathematics and 86% of science teachers reported that the principal knows what kind of school he or she wants and has communicated it to the staff; 85% of mathematics and 82% of science teachers agreed that the necessary materials for teaching were available; and 76% of mathematics and 73% of science teachers agreed that staff were recognized for a job well done (appendix table 1-25).[44]

Responses to some questions differed, however, with the composition of the school's student body. For example, about half of mathematics teachers at high-poverty and high-minority schools reported that students' tardiness and class cutting interfered with teaching, compared with 34–35% of teachers at low-poverty and low-minority schools (figure 1-12). Patterns were similar when mathematics teachers were asked whether student misbehavior interferes with teaching (53% agreed at high-minority schools and 56%

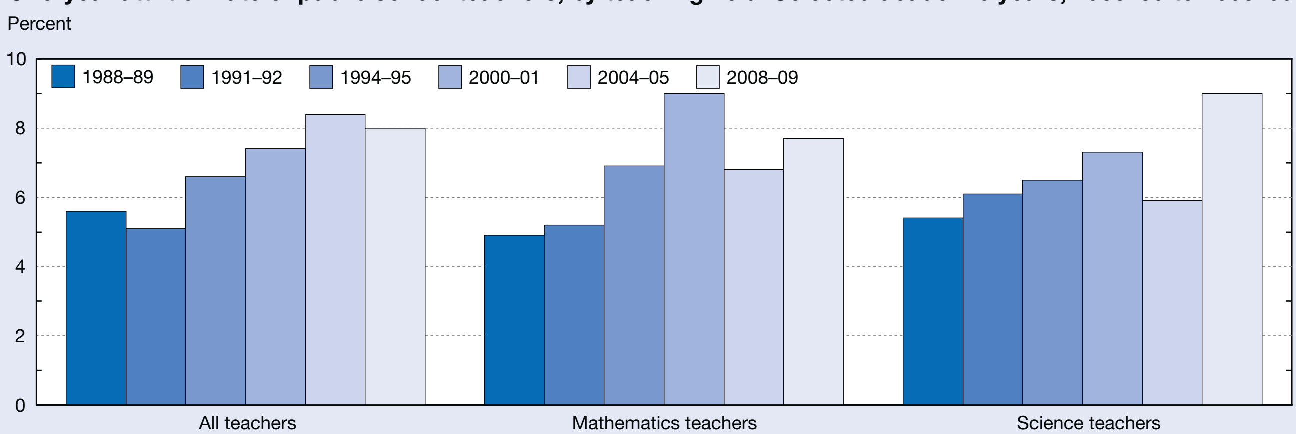
Teacher Attrition

Concerns about K–12 teacher shortages, teaching quality, and the need to retain high-quality instructors in the nation's elementary and secondary schools have led to considerable research on rates of attrition among teachers (Borman and Dowling 2008; Boyd et al. 2009; Ingersoll and Perda 2009; Jalongo and Heider 2006). A recent national study revealed that from 1988 to 2008, 5−9% of public school mathematics and science teachers left the teaching profession each year (figure 1-B) (Keigher and Cross 2010). The annual attrition rates of mathematics and science teachers are not higher than the average for all teachers (8−9% versus 8% in 2008, for example). Mathematics and science teachers who left teaching were also no more likely than other teachers who left to take noneducation jobs (appendix table 1-26).

Another study found large school-to-school differences in mathematics and science turnover (defined as teachers leaving their schools by either moving to another school or leaving teaching altogether) (Ingersoll and May 2010). High-poverty, high-minority, and urban public schools had among the highest mathematics and science teacher turnover rates. Reasons prompting mathematics teachers to leave their schools included lack of individual classroom autonomy, student discipline problems, and the extent to which teachers received useful content-focused professional development. For science teachers, the strongest factors included the maximum potential salary, student discipline problems, and the extent to which teachers received useful content-focused professional development (Ingersoll and May 2010).

More research is needed to establish conclusively links between how teachers enter the profession and attrition, but some has suggested that teachers who enter through alternative programs may be more likely to leave their schools or the profession than traditional-pathway teachers (Boyd et al. 2006; Kane, Rockoff, and Staiger 2006; Smith 2007).

Figure 1-B
One-year attrition rate of public school teachers, by teaching field: Selected academic years, 1988–89 to 2008–09



SOURCES: Whitener SD, Gruber KJ, Lynch H, Tingos K, Perona M, Fondelier S, *Characteristics of Stayers, Movers, and Leavers: Results From the Teacher Follow-up Survey: 1994–95,* National Center for Education Statistics (NCES), NCES 97-450 (1997); Luekens MT, Lyter DM, Fox EE, *Teacher Attrition and Mobility: Results from the Teacher Follow-up Survey,* 2000–01, NCES 2004-301 (2004); Marvel J, Lyter DM, Peltola P, Strizek GA, Morton BA, *Teacher Attrition and Mobility: Results from the 2004–05 Teacher Follow-up Survey,* NCES 2007-307 (2006); Keigher A, *Teacher Attrition and Mobility: Results From the 2008–09 Teacher Follow-up Survey,* NCES 2010-353 (2010).

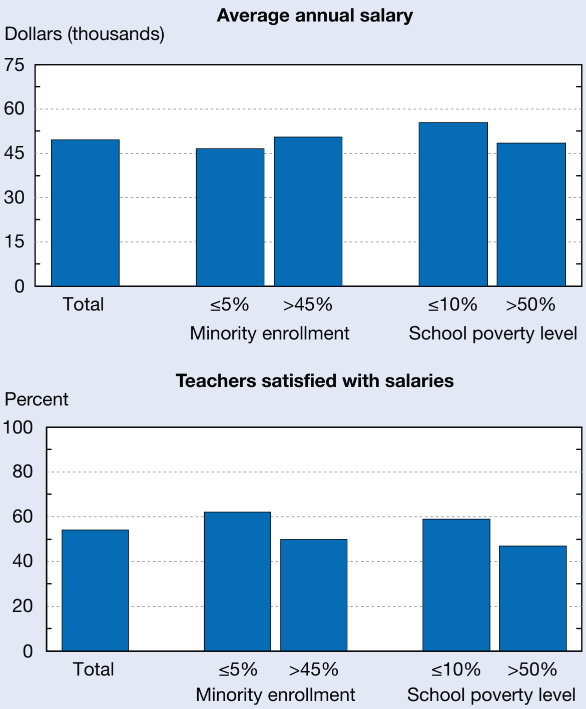
Science and Engineering Indicators 2012

agreed at high-poverty schools whereas 34% agreed at low-minority schools and 35% agreed at low-poverty schools).

Teacher perceptions about certain problems in their schools improved slightly between 2003 and 2007. The percentage of mathematics and science teachers at middle and high schools reporting student apathy and students coming to school unprepared to learn as serious problems declined from 2003 to 2007. For example, 28% of mathematics teachers in 2007, compared with 31% in 2003, identified student apathy as a serious problem at their schools (appendix table 1-27). About 33% of mathematics teachers in 2007, compared with 37% in 2003, identified unpreparedness for learning as a serious problem at their schools. Similar reductions were observed among science teachers.

Although these improvements were small overall, most of the improvement in teachers' responses occurred at schools with high concentrations of low-income and minority students. For example, in 2003, 48% of mathematics teachers at high-poverty schools reported that student apathy was a serious problem, compared with 12% at low-poverty schools—a

Figure 1-11
Salaries of public middle and high school mathematics teachers and teacher satisfaction with salaries, by minority enrollment and school poverty level: Academic year 2007–08



NOTES: School poverty level is percentage of students in school qualifying for free/reduced-price lunch. Average salaries have been rounded to the nearest 100.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2010) of 2007–08 Schools and Staffing Survey, National Center for Education Statistics. See appendix table 1-24.

Science and Engineering Indicators 2012

gap of 36 percentage points (figure 1-13). In 2007, that gap had closed by about 20 percentage points, with fewer teachers at high-poverty schools reporting this as a serious problem. A similar change occurred in mathematics teachers reporting students' lack of preparedness for learning as a serious problem: the gap between teachers at high- and low-poverty schools shrank from 52 percentage points in 2003 to about 36 in 2007.

Transition to Higher Education

Preparing students for postsecondary education is an important goal of high schools in the United States. This section presents indicators related to students' transitions from high school to college. It begins with data on high school completion rates in the United States, followed by international comparisons of high school graduation rates. It then examines students' expectations for enrolling in college, the proportion of students enrolling in college immediately after completing high school, and the relative international standing of postsecondary enrollment rates in the United States. Together, these data present an overview of the nation's effectiveness in preparing students for postsecondary education, the topic of the next chapter.

Completion of High School

On-Time Graduation Rates

The on-time graduation rate in the United States is the percentage of students who graduate with a regular high school diploma 4 years after entering ninth grade. In 2009, 76% of students completed high school on time (table 1-9), an improvement from 73% in 2006 (Chapman, Laird, and KewalRamani 2010; Stillwell and Hoffman 2008). Asian/Pacific Islander students graduated on time at a higher rate than white students did (92% versus 82%).

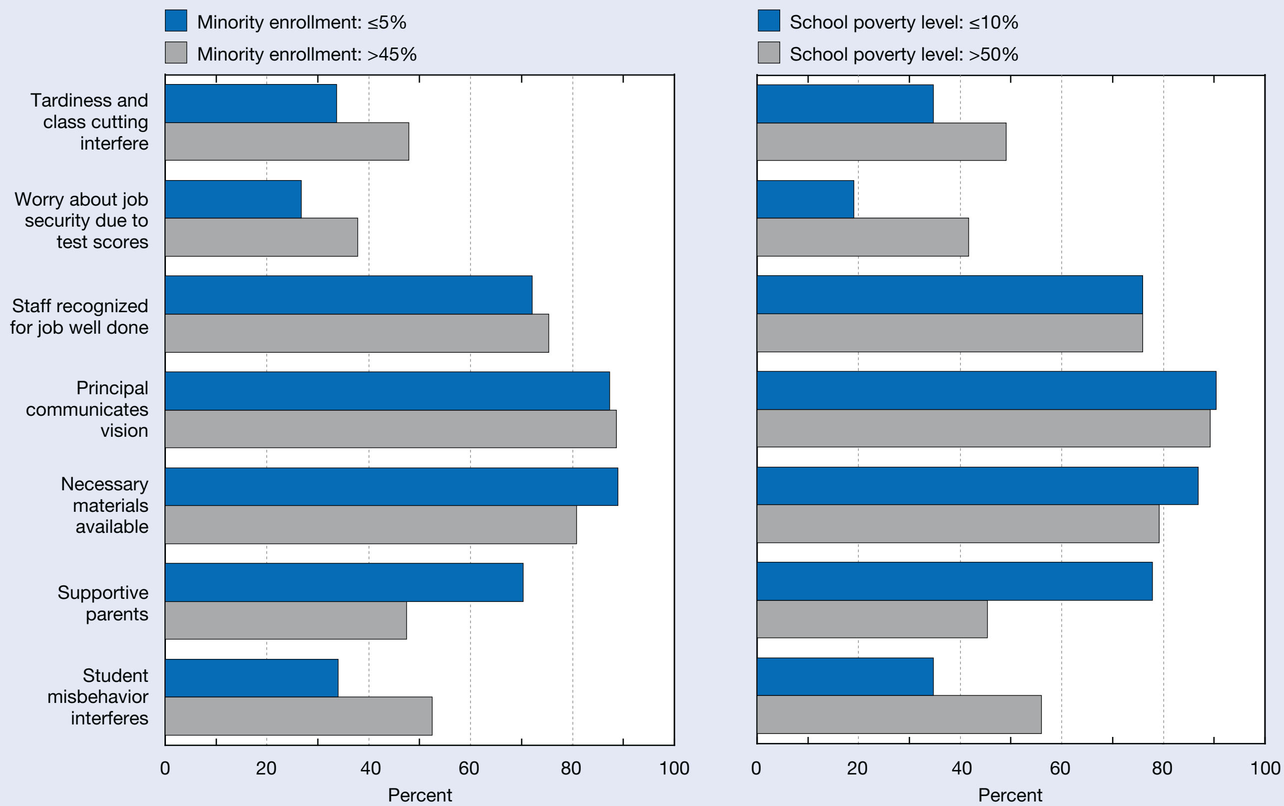
Students of other races and ethnicities graduated at lower rates. Rates of black, Hispanic, and American Indian/Alaska Native students were lowest, at 64%, 66%, and 65%, nearly 20–30 percentage points below the rate of white and Asian/Pacific Islander students. These rates have increased slightly since 2006, however, when they stood at 59%, 61%, and 62% respectively (Stillwell and Hoffman 2008). The gaps in on-time graduation rates between white and black students and between white and Hispanic students have declined slightly since 2006, by 3 percentage points.

Many students who did not complete high school within 4 years eventually went on to earn a high school diploma or equivalency credential. In 2008, an estimated 90% of 18- to 24-year-olds who were not enrolled in high school had received a high school diploma (84%) or earned an equivalency credential (6%), such as a General Educational Development (GED) certificate (Chapman, Laird, and KewalRamani 2010). Although most colleges and employers accept the GED as an alternative to a regular high school diploma, GED recipients do not fare as well as diploma holders across a variety of measures, including college completion rates and lifetime earnings (Chapman, Laird, and KewalRamani 2010).

Historically, not all states have used the same method for calculating graduation rates, leading to wide variation in the rates reported by each state. To facilitate state-by-state comparisons, the National Governors Association endorsed the NCES method as the standard method for calculating graduation rates in 2005, and all 50 governors agreed to work toward implementing that method (NGA 2005). This method calculates the high school graduation rate by dividing the number of graduates in a given year by the number of students who entered ninth grade 4 years earlier, adjusting the denominator for transfers into and out of the state over those 4 years.

Currently, 18 states use graduation rates calculated with this method to indicate whether they have met the graduation rate requirements for adequate yearly progress under NCLB (NGA 2010). Beginning with the 2011–12 school year, all states are required to use the NCES method. In addition, all states will be required to set and meet their own high

Figure 1-12
Perceptions of working conditions of public middle and high school mathematics teachers, by minority enrollment and school poverty level: Academic year 2007–08



NOTES: Teachers asked to indicate their agreement with various statements about their school conditions. Response categories included “strongly agree,” “somewhat agree,” “somewhat disagree,” and “strongly disagree.” Percentages based on teachers responding “strongly agree” or “somewhat agree” to various statements. School poverty level is percentage of students in school qualifying for free/reduced-price lunch.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2010) of 2007–08 Schools and Staffing Survey, National Center for Education Statistics. See appendix table 1-25.

Science and Engineering Indicators 2012

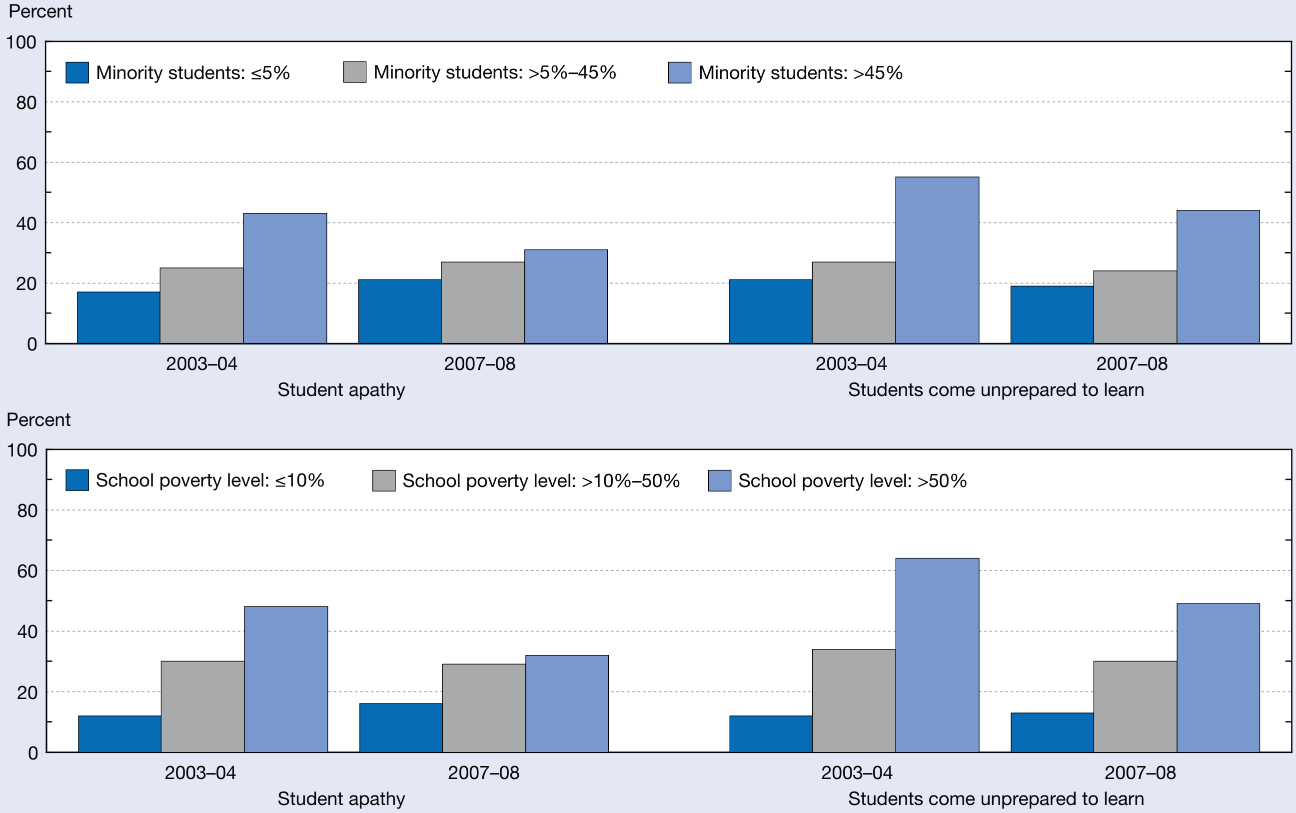
school graduation rate goals by 2014. As of summer 2010, 22 states had set the graduation rate goal at 90% or higher, and 27 states had set the goal between 80 and 89%, an improvement over previous years, when more than half the states set the goal at 75% or lower (NGA 2010; NSB 2010a). In 2008, the federal government issued revised graduation rate requirements, including the provision that, beginning in 2011–12, states and districts must meet not only overall graduation rate goals but also graduation rate goals for all student *subgroups* to achieve adequate yearly progress (U.S. Department of Education 2008).

Traditionally, rates of high school completion have been difficult to calculate accurately because of varying requirements for earning a regular diploma across states and districts and inadequate state data systems that track outcomes for individual students (Barton 2009). The increased demand for accurate data for federal accountability purposes, both for graduation rates and other school outcomes, has led states to develop data systems to track student progress more accurately. In 2005, the federal government created a grants program designed to support states in their efforts to create statewide longitudinal data systems. These systems will track individual students from pre-kindergarten through high school, college, and beyond (see sidebar “State Student Tracking Systems”).

High School Graduation Rates in the United States and Other OECD Nations

U.S. high school graduation rates calculated by OECD to articulate with reporting of other OECD members show that U.S. graduation rates are lagging behind those of other member countries. OECD calculates graduation rates by dividing the number of high school graduates in a country by the number of students of typical graduation age (OECD 2010a). Of the 25 OECD nations for which graduation rate data were available in 2008, the United States ranked 18th, with an average graduation rate of 77% compared with the OECD average of 80% (figure 1-14). The U.S. graduation rate remained at 77% from 2006 to 2008 according to OECD figures (OECD 2009, 2010b).

Figure 1-13
Serious student problems reported by public middle and high school mathematics teachers, by minority enrollment and school poverty level: Academic years 2003–04 and 2007–08



NOTES: Teachers asked to indicate the seriousness of various student problems in their schools. Response categories include "serious problem," "moderate problem," "minor problem," and "not a problem." Percentages based on teachers viewing various student problems as "serious." School poverty level is percentage of students in school qualifying for free/reduced-price lunch.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2010) of 2003-04 and 2007-08 Schools and Staffing Survey, National Center for Education Statistics. See appendix table 1-27.

Science and Engineering Indicators 2012

Table 1-9
On-time graduation rates of U.S. public high school students, by race/ethnicity: 2006 and 2009
(Percent)

Race/ethnicity	2006	2009
All students	73.2	75.5
White	80.6	82.0
Black	59.1	63.5
Hispanic	61.4	65.9
Asian/Pacific Islander	89.9	91.8
American Indian/Alaska Native	61.8	64.8

NOTE: On-time high school graduation rate is percentage of entering ninth graders who graduated 4 years later.

SOURCES: Stillwell R, Hoffman L. Public School Graduates and Dropouts from the Common Core of Data: School Year 2005–06, National Center for Education Statistics (NCES), NCES 2008-353rev (2008); Stillwell R, Sable J, Plotts C, Public School Graduates and Dropouts from the Common Core of Data: School Year 2008–09, National Center for Education Statistics, NCES 2011-312 (2011).

Science and Engineering Indicators 2012

Enrollment in Postsecondary Education

A majority of high school seniors expect to continue their education after high school. Among the 2009 high school senior class, 86% of graduating students planned to attend a postsecondary institution in the first year after high school, with 62% planning to attend a 4-year institution, 19% planning to attend a 2-year college, and 5% planning to attend a vocational, technical, or business school (NCES 2010).

Not all students fulfilled these expectations for immediate college enrollment. Seventy percent of 2009 high school graduates had enrolled in a postsecondary institution by the October following high school completion (figure 1-15). Of these students, 28% enrolled in a 2-year college and 42% enrolled in a 4-year institution (appendix table 1-28).

From 1975 through 2009, the immediate college enrollment rate rose by 19 percentage points (from 51% to 70%). Female enrollment increased at a much higher rate (49% to 74%) than did male enrollment during the same period (53% to 66%). (For more detail on the gender gap in U.S. higher

State Student Tracking Systems

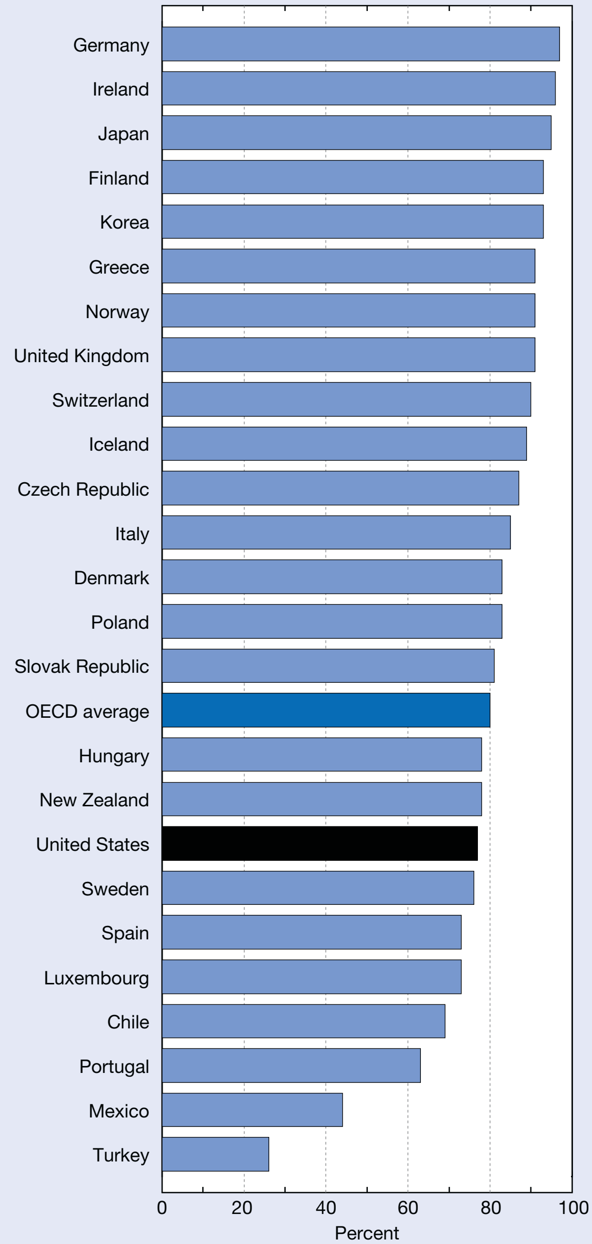
For the most part, existing state data systems are cross-sectional and do not track students over time. Statewide longitudinal data systems (SLDS) are designed to follow individual students from early childhood through high school and into postsecondary education and employment. The impetus for these new data systems comes from the need for more comprehensive and reliable data for accountability and evidence-based decisionmaking in education (DQC 2011a).

In 2005, the Institute of Education Sciences of the U.S. Department of Education introduced the SLDS Grant Program to encourage the development of these systems (IES 2011a). At the same time, a group of prominent education stakeholders launched the Data Quality Campaign to provide a national forum for discussions about SLDS implementation and to avoid duplication of effort and encourage collaboration across states (DQC 2011b). Although several states had been developing SLDS before 2005, most began designing their systems with the first round of federal funding in 2005, and many have made significant progress over the past 6 years (DQC 2011c). As of early 2011, for example, all states and the District of Columbia had collected student-level data on graduation and dropout rates (DQC 2011a).

Since 2005, 41 states and the District of Columbia have received at least one SLDS grant through one of four federal funding opportunities, including the American Recovery and Reinvestment Act (ARRA) (IES 2011b). To obtain ARRA funds, all governors and most legislatures agreed to implement SLDS that link preschool, K–12, postsecondary education, and workforce data and that conform to the requirements outlined in the America Competes Act by 2013 (U.S. Department of Education 2009). In addition, some states are linking their education data with data on corrections and social welfare assistance (Carson et al. 2010).

SLDS not only improve the quality of secondary and postsecondary education data, but also expose problems, such as the misalignment of state programs and inconsistencies in articulation of the data, that can then be addressed to improve education. SLDS are limited, however, by their inability to track students across state borders and into private colleges. A pilot project in Florida, Georgia, and Texas aims to develop a possible remedy for this problem by linking state data with college enrollment data from the National Student Clearinghouse (Bill & Melinda Gates Foundation 2010).

Figure 1-14
High school graduation rates, by OECD country: 2008



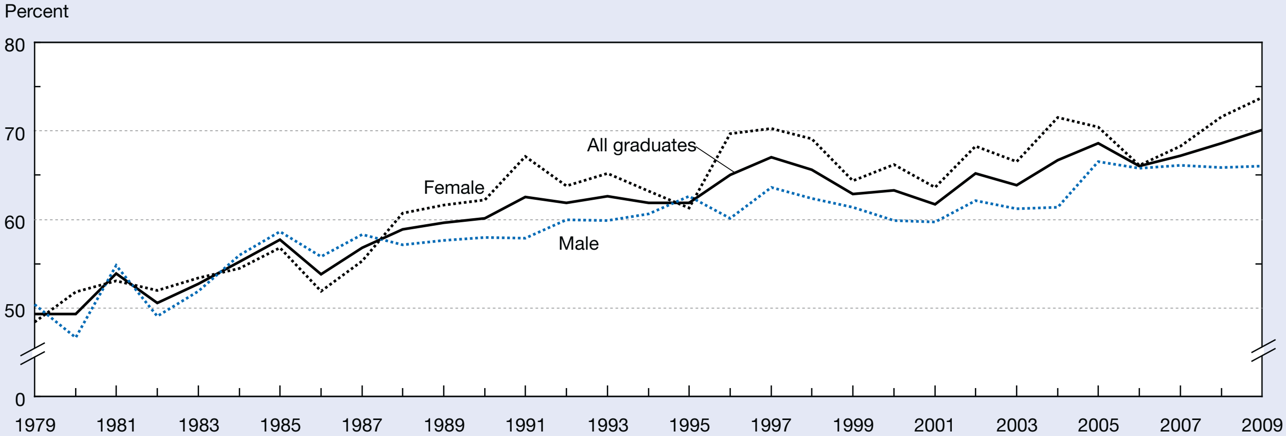
OECD = Organisation for Economic Co-operation and Development

NOTES: High school graduation rate is percentage of population at typical upper secondary graduation age (e.g., 18 years old in United States) completing upper secondary education programs. OECD average based on all OECD countries with available data. To generate estimates that are comparable across countries, rates are calculated by dividing the number of graduates in the country by the population of the typical graduation age.

SOURCE: OECD, *Education at a Glance: OECD Indicators 2010* (2010).

Science and Engineering Indicators 2012

Figure 1-15
Immediate college enrollment rates among high school graduates, by sex: 1979–2009



NOTES: Includes students ages 16–24 completing high school in survey year. Immediate college enrollment rates defined as rates of high school graduates enrolled in college in October after completing high school.

SOURCE: Aud S, Hussar W, Kena G, Bianco K, Frohlich L, Kemp J, Tahan K. *The Condition of Education 2011,* National Center for Education Statistics (NCES), NCES 2011-033 (2011). See appendix table 1-28.

Science and Engineering Indicators 2012

education enrollment and degree attainment, see chapter 2 sidebar “Gender Gap in Undergraduate Education.”)

Immediate college enrollment in the United States is associated with parental education levels and family income. In 2009, 40% of students whose parents had less than a high school education enrolled in college immediately after high school completion, compared with 82% of students whose parents had a bachelor’s or advanced degree (appendix table 1-28). Students from high-income families enrolled in college at higher rates than did students from middle- or low-income families (84% versus 67% and 55%, respectively) in 2009.

The rate of immediate enrollment in college for white students was 71%, compared with 63% for black and 62% for Hispanic students. Immediate college enrollment rates for black and Hispanic students have increased over time, showing gains of about 6 percentage points for blacks and 7 percentage points for Hispanics since 2002. However, the white-black and white-Hispanic gaps persisted over time.

Postsecondary Enrollment in an International Context

According to OECD data, the percentage of U.S. young adults enrolling in college for the first time was 64% in 2008. The overall average was 56% for the 25 countries participating in the study. The United States ranked 11th out of 25 in 2008 (appendix table 1-29). The data show that females enroll in college at higher rates than males in most OECD countries, including the United States. In the United States, females enrolled at a rate of 72% (compared with the OECD average of 63%), and males enrolled at a rate of 57% (compared with 50% internationally) (OECD 2010a).

Conclusion

Indicators in this chapter produce a mixed picture of the progress of elementary and secondary mathematics and science education in the United States. Although improvements are evident in many areas, overall they are slow and uneven. Gaps among students of different demographic backgrounds and among schools with different student populations have been a persistent challenge in K−12 education in the United States. These gaps are reflected in many indicators in this chapter, including teacher qualifications, school environment, and, ultimately, learning outcomes.

NAEP mathematics and science assessment results show that, although average mathematics scores for 8th graders have improved steadily since 1990 and average mathematics scores for 12th graders have increased between 2005 and 2009, improvement among 4th graders leveled off in 2009. Achievement gaps are found among many student subgroups. Whereas boys performed slightly better than girls in both subjects, relatively larger gaps existed among students of different racial/ethnic backgrounds or with different family incomes. Over time, some gaps narrowed at grade 4: gaps in mathematics achievement between white and black students, between high- and low-performing students, and between private and public school students were smaller in 2009 than in 1990.

Overall, large majorities of 4th, 8th, and 12th graders did not demonstrate proficiency in the knowledge and skills taught at their grade level. While a majority of ninth graders reached proficiency in low-level algebra skills, few mastered higher level skills. Results of international mathematics and science literacy tests show that U.S. 15-year-olds continue to lag behind their peers in many other countries, even though their scores have improved somewhat in recent years.

Efforts to improve student achievement include raising high school graduation requirements, strengthening the rigor of curriculum standards, increasing advanced coursetaking, promoting early participation in gatekeeper courses such as algebra I, and improving teaching quality. From 1987 to 2008, the number of states requiring at least 3 years of mathematics and science courses for high school graduation increased from just a few states to more than 30. By the end of 2010, 44 states had adopted a common set of rigorous academic standards designed to ensure that students graduate from high school prepared for college and careers. Trend data from 1990 to 2009 show an upward trend of students earning more mathematics and science credits and participating in advanced mathematics and science courses. Nevertheless, completion rates in some advanced courses remained relatively low, and wide gaps in advanced mathematics and science coursetaking persisted among racial/ethnic subgroups.

Indicators related to teaching quality show that virtually all mathematics and science teachers in public middle and high schools have such basic credentials as a bachelor's degree and teaching certificate, and proportionally more mathematics and science teachers had advanced degrees in 2007 than in 2003. Likewise, more science teachers held full certification in 2007 than in 2003. Large majorities of mathematics and science teachers in high school also had a degree and/or certificate in their teaching field. Although in-field mathematics and science teachers are not as prevalent in middle schools as in high schools, the percentage of such teachers in middle schools has increased in recent years. Mathematics and science teachers with these qualifications are not evenly distributed across schools, however: schools with lower concentrations of minority and low-income students tend to have higher proportions of teachers with advanced degrees, full certification, in-field preparation, and more experience.

An increasing proportion of new mathematics and science teachers entered the profession through alternative programs. These teachers often begin teaching before completing their training, engaging in practice teaching, or earning full state certification, and they are more often found in schools with high concentrations of minority and poor students. Nevertheless, a majority of new mathematics and science teachers in public middle and high schools participate in practice teaching before entering the teaching force, and many of them also participate in induction programs during their first year in the classroom. In addition, a majority of mathematics and science teachers participate in professional development activities during the school year, although the duration of many such activities is relatively short.

Annual attrition rates for public school mathematics and science teachers fluctuated in the range of 5–9% between 1988 and 2008. Although teachers' salaries have not kept pace with those in occupations requiring comparable education, most teachers had favorable perceptions of their working conditions. Teachers in high-minority and high-poverty schools were less likely than others to have such positive perceptions, but some gaps have narrowed in recent years.

Most high school students graduate with a regular diploma 4 years after entering ninth grade. On-time graduation rates have improved, though slowly. Significant racial/ethnic gaps exist, with white and Asian/Pacific Islander students having graduation rates higher than those of students of other races and ethnicities. The U.S. ranked 18th in graduation rates among 25 OECD countries with available data in 2008.

A majority of high school seniors expect to continue their education after high school, and many enroll in college directly after high school graduation. Immediate college enrollment rates have increased for all students as well as for many demographic subgroups. Gaps persisted, however. Black students, Hispanic students, low-income students, and students whose parents have less education enroll in college at rates lower than their counterparts.

Notes

1. The terms *achievement* and *performance* are used interchangeably in this section when discussing scores on mathematics and science assessments.

2. Differences between two estimates were tested using Student's *t*-test statistic to minimize the chances of concluding that a difference exists based on the sample when no true difference exists in the population from which the sample was drawn. These tests were done with a significance level of 0.05, which means that a reported difference would occur by chance no more than once in 20 samples when there was no actual difference between the population means.

3. Race to the Top is a $4.35 billion competitive grant program funded by the U.S. Department of Education as part of the American Rec overy and Reinvestment Act of 2009. This program is designed to encourage and reward states creating the conditions for education innovation and reform, achieving significant improvement in student outcomes, and implementing reform plans in four core areas: 1) adopting standards and assessments that prepare students to succeed in college and the workplace; 2) building data systems that measure student growth and success and inform teachers and principals how to improve instruction; 3) recruiting, developing, rewarding, and retaining effective teachers and principals; and 4) turning around the lowest performing schools. In March 2010, Delaware and Tennessee won grants in the first phase of the competition, receiving approximately $100 million and $500 million, respectively, to implement their comprehensive school reform plans. In August 2010, nine states (Florida, Georgia, Hawaii, Maryland, Massachusetts, New York, North Carolina, Ohio, and Rhode Island) and the District of Columbia won grants in the second phase of the competition. Grant levels depend on a state's student population: large states like New York and Florida receive up to $700 million and smaller states like Hawaii and Rhode Island receive up to $75 million. See the Race to the Top

Fund website for more information: http://www2.ed.gov/programs/racetothetop/index.html.

4. The U.S. Department of Education awarded School Improvement Grants to states under the Elementary and Secondary Education Act of 1965 (reauthorized in 2002 as the No Child Left Behind Act) to support focused school improvement efforts. In 2009, the department dramatically increased the funds that would be provided to states (from $491,265 in 2008 to $3.546 billion in 2009) and charged states with using the funds for leveraging changes needed to turn around persistently low-achieving schools.

5. These two NAEP assessment programs differ in many aspects, including samples of students and assessment times, instruments, and contents. See http://nces.ed.gov/nationsreportcard/about/ltt_main_diff.asp.

6. The 2010 volume reviewed long-term trends in mathematics from 1973 to 2008, and the 2004 volume examined trends in science from 1969 to 1999. The long-term trend assessment in mathematics will be administered again in 2012; the long-term trend assessment in science has not been conducted since 1999.

7. Students in the below-basic category have scores lower than the minimum score for the basic level. Students in the basic category have scores at or above the minimum score for the basic level, but lower than the minimum for the proficient level. Students in the proficient category have scores at or above the minimum score for the proficient level, but lower than the minimum score for the advanced level. Students in the advanced category have scores at or above the minimum score for the advanced level.

8. See NAEP's mathematics and science achievement levels defined by grade at http://nces.ed.gov/nationsreportcard/mathematics/achieveall.asp and http://nces.ed.gov/nationsreportcard/science/achieveall.asp.

9. Percentiles are scores below which a specified percentage of the population falls. For example, among fourth graders in 2009, the 10th percentile score for mathematics was 202. This means that 10% of fourth graders had mathematics scores at or below 202 and 90% scored above 202. The scores at various percentiles indicate students' performance levels.

10. In 2005, NAGB adopted a new mathematics framework for the grade 12 assessment to reflect contemporary standards of high school curriculum and coursework. Based on this new framework, the 2005 assessment changed its content areas (e.g., increasing coverage on algebra, data analysis, and probability) and adopted a new reporting scale (i.e., 0–300 as opposed to 0–500 in earlier years). These changes made the 2005 assessment results not comparable to those in earlier years. Some changes were also made to the 2009 framework; the purpose was to enable NAEP to better measure how well prepared 12th grade students are for postsecondary education and training (e.g., adding content that is beyond what is typically taught in a standard 3-year course of study in high school mathematics). However, special analyses of 2005 and 2009 data determined that the 2009 grade 12 mathematics results could still be compared with results from the 2005 assessment despite the changes to the 2009 framework. More information about the mathematics frameworks for the 2005 and 2009 grade 12 assessments and how they differ from the previous framework is available at http://nces.ed.gov/nationsreportcard/mathematics/frameworkcomparison.asp.

11. Results for private school students in 2009 could not be reported separately due to the low participation rate for private schools.

12. Special NSF tabulations.

13. Students' eligibility for free/reduced-price lunch is often used as a proxy measure of family poverty. Students who are eligible for free/reduced-price lunch are considered to come from low-income families, and those who are not eligible for free/reduced-price lunch are considered to come from relatively high-income families.

14. Data on parental education for grade 4 were unreliable and therefore excluded from the analysis.

15. Cross-grade comparisons are acceptable for mathematics scores of fourth and eighth graders because these scores were put on a common scale. However, mathematics scores for 4th and 8th graders cannot be compared to those of 12th graders because they used different score scales (0 to 500 for grades 4 and 8 and 0 to 300 for grade 12). Cross-grade comparisons are also not appropriate for other subjects because the scales were derived independently at each grade level. See http://nces.ed.gov/nationsreportcard/mathematics/interpret-results.asp.

16. Gender gaps are not consistent across racial/ethnic subgroups. For example, the results from the 2009 NAEP mathematics assessment show that, whereas white and Hispanic boys had higher scores than their girl counterparts at grade 4, the pattern was opposite among blacks—girls outperformed boys. Similar differences were also found among students in grade 8 (special NSF tabulations).

17. Differences in performance between public and private school students reflect in part different types of students enrolled in public and private schools. Proportionally, private schools enroll more white students and students from advantaged socioeconomic backgrounds than public schools (Snyder and Dillow 2011).

18. The reduction in the white-black gap at grade 4 is likely attributable to larger improvements made by black female students (Vanneman et al. 2009). From 1990 to 2007, the average mathematics score gains of black females at grade 4 were greater than those of their white peers, reducing the white-black gap. However, among male students at grade 4, no similar gap reductions were observed during this period.

19. Previous volumes of *Science and Engineering Indicators* (e.g., NSB 2010b) also used data from the Trends in International Mathematics and Science Study (TIMSS) to examine the relative standing of U.S. students in mathematics and science achievement. No new data from TIMSS, however, were available when this chapter was prepared. The latest administration of TIMSS was in spring 2011, and international comparisons based on TIMSS data will be

available in the 2014 volume of *Science and Engineering Indicators*.

20. Information on OECD and its assessment programs is available at http://www.pisa.oecd.org/pages/0,2987,en_32252351_32235731_1_1_1_1_1,00.html.

21. PISA differs from NAEP in several key aspects. NAEP assesses the knowledge and skills students need for an in-depth understanding of mathematics and science at various grade levels. PISA measures the "yield" of education systems, that is, the skills and competencies students have acquired and can apply in real-world contexts by age 15. NAEP emphasizes curriculum-based knowledge, whereas PISA focuses on literacy and applications, drawing on learning both in and outside of school. Although NAEP and PISA both are sample-based assessments, NAEP uses grade-based samples of students in grades 4, 8, and 12, and PISA uses an age-based sample of 15-year-old students nearing completion of compulsory schooling in many countries. Both assessments are developed from a framework specifying the content and skills to be measured, but the PISA framework is organized around overarching ideas (e.g., space and shape) with emphasis on the contexts in which concepts are applied (e.g., in school, in society), as opposed to curriculum-based topics, such as geometry and algebra.

22. In this section, "coursetaking" refers only to completed courses for which students earned at least one credit. The High School Transcript Study contains no data on students who did not graduate or who may have enrolled in a course but did not complete it.

23. Not all high schools have the same standards for course titles and content. To allow comparisons, HSTS standardizes the transcript information. To control for variation in course titles, a coding system called the Classification of Secondary School Courses is used for classifying courses on the basis of information in school catalogs and other information sources. (For more information, see http://nces.ed.gov/surveys/hst/courses.asp.)

24. Advanced mathematics course categories used in this edition are based on the categories reported by HSTS for 2009. HSTS has changed these categories since 2005, so the percentages shown in figures 1-5 and 1-6 are not comparable to those reported in previous editions.

25. HSTS converts high schools' transcript credits to standardized Carnegie units of credit (or Carnegie credits), in which a single unit is equal to 120 hours of classroom time over the course of a year. A credit is equivalent to a 1-year course in a subject.

26. Precalculus/analysis includes courses referred to as mathematics analysis courses, but they include the same content as precalculus courses.

27. Advanced science course categories used in this edition are based on the categories reported by HSTS for 2009. HSTS has changed these categories since 2005, so the percentages for each subject area shown in figure 1-7 are not comparable to those reported in previous editions.

28. AP/IB science courses were not coded separately in 1990 and therefore are not reported for that year.

29. Of 500 possible points awarded to grant applications, 138 points, or 28% of the total, were given to plans for "Great Teachers and Leaders." Specifically, plans were solicited for providing high-quality pathways for aspiring teachers and principals (21 points), improving teacher and principal effectiveness based on performance (58 points), ensuring equitable distribution of effective teachers and principals (25 points), improving the effectiveness of teacher and principal preparation programs (14 points), and providing effective support to teachers and principals (20 points). Detailed information is available at http://www2.ed.gov/programs/racetothetop/executive-summary.pdf.

30. Middle and high school teachers, included in these indicators, are identified using a SASS variable that indicates the level of the school at which teachers are employed. Middle schools are defined as those with no grade lower than 5 and no grade higher than 8; high schools are defined as those with no grade lower than 7 and at least one grade higher than 8. Elementary school teachers, not included in these indicators, typically teach multiple subjects, and most of them hold a certification in general education.

31. Based on the percentage of students in school qualifying for free/reduced-price lunch.

32. To simplify the discussion, schools in which 10% or fewer of the students are eligible for the federal free and reduced-price lunch program are called low-poverty schools, and schools in which more than 50% of the students are eligible are called high-poverty schools. Similarly, low-minority schools are those in which 5% or fewer of the students are members of a minority, and high-minority schools are those in which more than 45% of the students are members of a minority.

33. Probationary certification generally is awarded to those who have completed all requirements except for a probationary teaching period. Provisional or temporary certification is awarded to those who still have requirements to meet. States also issue emergency certification to those with insufficient teacher preparation who must complete a regular certification program to continue teaching (Henke et al. 1997). Teachers' type of certification differs from their pathway into the profession: teachers from both traditional and alternative programs may have any type of state certification in order to teach. Alternative-pathway teachers, however, are more likely to begin teaching with a provisional or temporary certification.

34. As of 2009, 48 states required teachers to pass a test covering topics such as basic academic skills and pedagogical knowledge to obtain certification (Editorial Projects in Education Research Center 2010).

35. In 2010, the National Academy of Sciences counted 130 alternative programs, differing in goals, requirements, structure, and candidate pools (NRC 2010). Some programs, such as Teach for America, receive direct federal support, and others are themselves federal programs, such as the U.S. Department of Defense's "Troops to Teachers" program, which facilitates the entry of military personnel into teaching careers. Race to the Top, a federal competitive grant

program encouraging certain education reforms, awarded points to applicant states for providing high-quality alternative pathways for aspiring teachers.

36. Large variation has been observed between programs within each pathway (Boyd et al. 2008).

37. More information about these programs is available at http://www.teachforamerica.org and http://tntp.org/about-us/. Information about the Troops to Teachers program is available at http://www2.ed.gov/programs/troops/index.html.

38. More information about National Board Certification is available at http://www.nbpts.org.

39. Information on the number of teachers is available at http://www.nbpts.org/about_us/national_board_certifica1/national_board_certifica; information on their diversity initiatives and teacher placement is at http://www.nbpts.org/resources/diversity_initiatives.

40. Research suggests that characteristics of the practice teaching placement and program affect subsequent teacher effectiveness. In New York City, teachers who were placed in easy-to-staff schools during their practice teaching were more likely to remain teaching in the district and see gains in student achievement, regardless of the characteristics of the school at which they were ultimately employed (Ronfeldt 2010); teachers whose preparation programs provided oversight of their practice teaching and required a capstone project saw larger student achievement gains during their first year (Boyd et al. 2008).

41. For a slightly different measurement of in-field teaching, see *Education and Certification Qualifications of Departmentalized Public High School-Level Teachers of Core Subjects: Evidence From the 2007–08 Schools and Staffing Survey* (NCES 2011-317), http://nces.ed.gov/pubs2011/2011317.pdf.

42. A recent experimental study of professional development for middle school mathematics teachers found that a 2-year training program for 7th-grade mathematics teachers had no effect on either teacher knowledge or student performance (Garet et al. 2011). A report from the study's first year found that the training did significantly increase the frequency of one "good practice" for teaching mathematics: engaging in activities that elicit student thinking (Garet et al. 2010).

43. The maximum duration SASS provides as an option in its teacher questionnaire is "33 hours or more," which is reported in this chapter. Research suggests that teachers who receive content-focused professional development already have relatively strong content knowledge (Desimone, Smith, and Ueno 2006).

44. The statements about working conditions included in this section represent a selection of those measured in SASS. For a complete list of questions and results for public elementary and secondary teachers, see http://nces.ed.gov/programs/digest/d10/tables/dt10_076.asp.

Glossary

Student Learning in Mathematics and Science

Eligibility for National School Lunch Program: Student eligibility for this program, which provides free or reduced-price lunches, is a commonly used indicator for family poverty. Eligibility information is part of the administrative data kept by schools and is based on parent reported family income and family size.

Repeating cross-sectional studies: This type of research focuses on how a specific group of students performs in a particular year, and then looks at the performance of a similar group of students at a later point in time. An example would be comparing fourth graders in 1990 to fourth graders in 2009.

Scale score: Scale scores place students on a continuous achievement scale based on their overall performance on the assessment. Each assessment program develops its own scales.

Student Coursetaking in High School Mathematics and Science

Advanced Placement: Courses that teach college-level material and skills to high school students who can earn college credits by demonstrating advanced proficiency on a final course exam. The curricula and exams for AP courses, available for a wide range of academic subjects, are developed by the College Board.

International Baccalaureate: An internationally recognized pre-university academic subject course designed for high school students.

Teachers of Mathematics and Science

High schools: Schools that have at least one grade higher than 8 and no grade in K–6.

Main teaching assignment field: The field in which teachers teach the most classes in school.

Major: A field of study in which an individual has taken substantial academic coursework at the postsecondary level, implying that the individual has substantial knowledge of the academic discipline or subject area.

Middle schools: Schools that have any of grades 5–8 and no grade lower than 5 and no grade higher than 8.

Practice teaching: Programs designed to offer prospective teachers hands-on classroom practice. Practice teaching is often a requirement for completing an educational degree or state certification, or both.

Professional development: In-service training activities designed to help teachers improve their subject-matter knowledge, acquire new teaching skills, and stay informed about changing policies and practices.

Secondary schools: Schools that have any of grades 7–12 and no grade in K–6.

Teaching certification: A license or certificate awarded to teachers by the state to teach in a public school. Certification typically includes the following five types:

(1) regular or standard state certification or advanced professional certificate; (2) probationary certificate issued to persons who satisfy all requirements except the completion of a probationary period; (3) provisional certificate issued to persons who are still participating in what the state calls an "alternative certification program"; (4) temporary certificate issued to persons who need some additional college coursework, student teaching, and/or passage of a test before regular certification can be obtained; and (5) emergency certificate issued to persons with insufficient teacher preparation who must complete a regular certification program to continue teaching.

Teacher induction: Programs designed at the school, local, or state level for beginning teachers in their first few years of teaching. The purpose of the programs is to help new teachers improve professional practice, deepen their understanding of teaching, and prevent early attrition. One key component of such programs is that new teachers are paired with mentors or other experienced teachers to receive advice, instruction, and support.

Transition to Higher Education

Postsecondary education: The provision of a formal instructional program with a curriculum designed primarily for students who have completed the requirements for a high school diploma or its equivalent. These programs include those with an academic, vocational, or continuing professional education purpose and exclude vocational and adult basic education programs.

References

Abdulkadiroglu A, Angrist J, Cohodes S, Dynarski S, Fullerton J, Kane T, Pathak P. 2009. Informing the Debate: Comparing Boston's Charter, Pilot and Traditional Schools. Boston, MA: The Boston Foundation. http://www.gse.harvard.edu/~pfpie/pdf/InformingTheDebate_Final.pdf. Accessed October 2010.

Achieve, Inc. 2008. The Building Blocks of Success: Higher-Level Math for All Students. Achieve Policy Brief. Washington, DC. http://www.achieve.org/BuildingBlocksofSuccess. Accessed July 2011.

Achieve, Inc. 2011. Next Generation Science Standards. Washington, DC: http://www.achieve.org/next-generation-science-standards. Accessed July 2011.

ACT, Inc. 2010. A First Look at the Common Core and College and Career Readiness. Iowa City, IA. http://www.act.org/research/policymakers/reports/firstlook.html. Accessed July 2011.

Adelman C. 2006. The Tool Box Revisited. Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement. http://www2.ed.gov/rschstat/research/pubs/toolboxrevisit/index.html. Accessed July 2011.

Allegretto SA, Corcoran SP, Mishel L. 2008. The Teaching Penalty: Teacher Pay Losing Ground. Washington, DC: Economic Policy Institute. http://www.epi.org/publication/book_teaching_penalty/. Accessed October 2010.

Allensworth EM, Nomi T. 2009. College preparatory curriculum for all: Academic consequences of requiring algebra and English I for ninth-graders in Chicago. *Educational Evaluation and Policy Analysis* 31(4):367–91.

Almy S, Theokas C. 2010. Not Prepared for Class: High-Poverty Schools Continue to Have Fewer In-Field Teachers. Washington, DC: The Education Trust. http://www.edtrust.org/sites/edtrust.org/files/publications/files/Not%20Prepared%20for%20Class.pdf. Accessed February 2011.

American Federation of Teachers (AFT). 2008. Survey and Analysis of Teacher Salary Trends 2007. Washington, DC. http://www.aft.org/pdfs/teachers/salarysurvey07.pdf. Accessed March 2011.

Aritomi P, Coopersmith J. 2009. Characteristics of Public School Districts in the United States: Results From the 2007–08 Schools and Staffing Survey. NCES 2009-320. Washington, DC: National Center for Education Statistics.

Baker EL, Barton PE, Darling-Hammond L, Haertel E, Ladd HF, Linn RL, Ravitch D, Rothstein R, Shavelson RJ, Shepard LA. 2010. Problems With the Use of Student Test Scores To Evaluate Teachers. Washington, DC: Economic Policy Institute. http://epi.3cdn.net/b9667271ee6c154195_t9m6iij8k.pdf. Accessed May 2011.

Banilower ER, Boyd SE, Pasley JD, Weiss IR. 2006. Lessons from a Decade of Mathematics and Science Reform: A Capstone Report for the Local Systemic Change through Teacher Enhancement Initiative. Chapel Hill, NC: Horizon Research, Inc. http://www.pdmathsci.net/reports/capstone.pdf. Accessed October 2010.

Barton, P.E. 2009. Chasing the High School Graduation Rate: Getting the Data We Need and Using It Right. Princeton, NJ: Educational Testing Service. http://www.ets.org/Media/Research/pdf/PICCHASING.pdf. Accessed October 2011.

Berends M, Goldring E, Stein M, Cravens X. 2010. Instructional conditions in charter schools and students' mathematics achievement gains. *American Journal of Education* 116(3):303−36.

Berry B. 2004. Recruiting and retaining "highly qualified teacher" for hard-to-staff schools. *NASSP Bulletin* 87(March).

Berry B, Smylie M, Fuller E. 2008. Understanding Teacher Working Conditions: A Review and Look to the Future. Hillsborough, NC: Center for Teaching Quality. http://www.teachingquality.org/pdfs/TWC2_Nov08.pdf. Accessed May 2011.

Betts JR, Tang YE. 2008. Value Added and Experimental Studies of the Effect of Charter Schools on Student Achievement. Seattle, WA: National Charter School Research Project, Center on Reinventing Public Education, University of Washington, Bothell. http://

www.crpe.org/cs/crpe/download/csr_files/pub_ncsrp_bettstang_dec08.pdf. Accessed October 2010.

Bill & Melinda Gates Foundation. 2010. Strategic use of education data: National Student Clearinghouse Pilot. http://www.gatesfoundation.org/college-ready-education/Pages/strategic-use-education-data.aspx. Accessed February 2011.

Borman GD, Dowling NM. 2008. Teacher attrition and retention: A meta-analytic and narrative review of the research. *Review of Educational Research* 78(3):367–409.

Boyd D, Grossman P, Lankford H, Loeb S, Wyckoff J. 2006. How changes in entry requirements alter the teacher workforce and affect student achievement. *Education Finance and Policy* 1(2):176–215.

Boyd D, Grossman P, Lankford H, Loeb S, Wyckoff J. 2008. Teacher Preparation and Student Achievement. Washington, DC: National Center for the Analysis of Longitudinal Data in Education Research, Urban Institute. http://www.urban.org/UploadedPDF/1001255_teacher_preparation.pdf. Accessed May 2011.

Boyd D, Grossman P, Lankford H, Loeb S, Wyckoff J. 2009. Who Leaves? Teacher Attrition and Student Achievement. Washington, DC: The Urban Institute. http://www.urban.org/UploadedPDF/1001270_teacher_attrition.pdf. Accessed October 2010.

Bozick R, Lauff E. 2007. Education Longitudinal Study of 2002 (ELS:2002): A First Look at the Initial Postsecondary Experiences of the Sophomore Class of 2002. NCES 2008-308. Washington, DC: National Center for Education Statistics.

Braun H, Jenkins F, Grigg W. 2006. A Closer Look at Charter Schools Using Hierarchical Linear Modeling. NCES 2006-460. Washington, DC: National Center for Education Statistics.

Brill S, McCartney A. 2008. Stopping the revolving door: Increasing teacher retention. *Politics & Policy* 36(5):750–74.

Britton T, Paine L, Pimm D, Raizen S. 2003. *Comprehensive Teacher Induction: Systems for Early Career Learning*. Norwell, MA: Kluwer Academic Publishers.

Buddin R, Zimmer R. 2005. A closer look at charter school student achievement. *Journal of Policy Analysis and Management* 24:351–72.

Buddin R, Zamarro G. 2009a. Teacher Qualifications and Middle School Student Achievement. Santa Monica, CA: Rand Corporation. http://www.rand.org/content/dam/rand/pubs/working_papers/2009/RAND_WR671.pdf. Accessed July 2011.

Buddin R, Zamarro G. 2009b. Teacher Qualifications and Student Achievement in Urban Elementary Schools. Santa Monica, CA: Rand Corporation. http://www.rand.org/pubs/reprints/RP1410.html. Accessed July 2011.

Carson R, Laird E, Gaines E, Ferber T. 2010. Linking Data across Agencies: States That Are Making It Work. Washington, DC: Data Quality Campaign. http://www.dataqualitycampaign.org/files/DQCbrief_Mar19_2_.pdf. Accessed February 2011.

Center for Research on Education Outcomes (CREDO). 2009. Multiple Choice: Charter School Performance in 16 States. Stanford, CA. http://credo.stanford.edu/reports/MULTIPLE_CHOICE_CREDO.pdf. Accessed October 2010.

Chapman C, Laird J, KewalRamani A. 2010. Trends in High School Dropout and Completion Rates in the United States: 1972–2008. NCES 2011-012. Washington, DC: National Center for Education Statistics.

Chen X. 2009. Students Who Study Science, Technology, Engineering, and Mathematics (STEM) in Postsecondary Education. NCES 2009-161. Washington, DC: National Center for Education Statistics.

Clotfelter C, Glennie E, Ladd H, Vigdor J. 2008. Would higher salaries keep teachers in high-poverty schools? Evidence from a policy intervention in North Carolina. *Journal of Public Economics* 92(5–6):1352–70.

Clotfelter CT, Ladd HF, Vigdor JL. 2007. Teacher Credentials and Student Achievement in High School: A Cross-Subject Analysis With Student Fixed Effects. Working Paper Series. Cambridge, MA: National Bureau of Economic Research.

Cohen-Vogel L, Smith TM. 2007. Qualifications and assignments of alternatively certified teachers: Testing core assumptions. *American Educational Research Journal* 44(3):732–53.

Constantine J, Player D, Silva T, Grider M, Deke J. 2009. An Evaluation of Teachers Trained Through Different Routes to Certification. NCEE 2009-4043. Washington, DC: National Center for Education Evaluation and Regional Assistance, Institute of Education Sciences, U.S. Department of Education.

Council of Chief State School Officers (CCSSO). 2009. Effects of Teacher Professional Development on Gains in Student Achievement: How Meta Analysis Provides Scientific Evidence Useful to Education Leaders. Washington, DC. http://www.ccsso.org/Documents/2009/Effects_of_Teacher_Professional_2009.pdf. Accessed May 2011.

Data Quality Campaign (DQC). 2011a. About DQC. http://www.dataqualitycampaign.org/about. Accessed February 2011.

Data Quality Campaign (DQC). 2011b. Data for Action 2010: Executive Summary. Washington, DC. http://www.dataqualitycampaign.org/stateanalysis. Accessed February 2011.

Data Quality Campaign (DQC). 2011c. Data for Action 2010: Executive Summary for State Analysis Responses by State. http://www.dataqualitycampaign.org/stateanalysis/states. Accessed February 2011.

Davis EA, Petish D, Smithey J. 2006. Challenges new science teachers face. *Review of Educational Research* 76(4):607–51.

Dee TS, Cohodes SR. 2008. Out-of-field teaching and student achievement: Evidence from “matched-pairs” comparisons. *Public Finance Review* 36(1):7–32.

Desimone LM, Smith TM, Ueno K. 2006. Are Teachers Who Need Sustained, Content-Focused Professional Development Getting It? An Administrator's Dilemma. *Education Administration Quarterly* 42(2):179−215.

Easton-Brooks D, Davis A. 2009. Teacher qualification and the achievement gap in early primary grades. *Education Policy Analysis Archives* 17(15).

Editorial Projects in Education Research Center. 2010. Quality Counts 2010: Fresh Course, Swift Current. *Education Week* 29(17). http://www.edweek.org/ew/toc/2010/01/14/index.html. Accessed October 2010.

EdSource. 2010. Common core standards. http://www.edsource.org/iss_sta_commoncore.html. Accessed February 2011.

Fine S. 2010. Moving forward with the Common Core. *Education Week* 30(8):18–19. http://www.edweek.org/ew/articles/2010/10/20/08fine.h30.html?tkn=LYXFpDDbwWg77mw9AnpIQPhrrQpBWyZw4y%2Fk&cmp=clp-edweek. Accessed February 2011.

Fryer RG. 2011. Teacher Incentives and Student Achievement: Evidence from New York City Public Schools. NBER Working Paper 16850. Cambridge, MA: National Bureau of Economic Research. http://www.nber.org/papers/w16850. Accessed May 2011.

Fulton K, Yoon I, Lee C. 2005. Induction Into Learning Communities. Washington, DC: National Commission on Teaching and America's Future. http://www.nctaf.org/documents/NCTAF_Induction_Paper_2005.pdf. Accessed October 2010.

Gamoran A, Hannigan EC. 2000. Algebra for everyone? Benefits of college-preparatory mathematics for students with diverse abilities in early secondary school. *Educational Evaluation and Policy Analysis* 22(3):241−54.

Garcia D. 2008. Academic and racial segregation in charter schools: Do parents sort students into specialized charter schools? *Education and Urban Society* 40(3):590–612.

Garet MS, Wayne AJ, Stancavage F, Taylor J, Walters K, Song M, Brown S, Hurlburt S, Zhu P, Sepanik S, Doolittle F. 2010. Middle School Mathematics Professional Development Impact Study: Findings After the First Year of Implementation. NCEE 2010-4009. Washington, DC: National Center for Education Evaluation and Regional Assistance, Institute of Education Sciences, U.S. Department of Education.

Garet MS, Wayne AJ, Stancavage F, Taylor J, Eaton M, Walters K, Song M, Brown S, Hurlburt S, Zhu P, Sepanik S, Doolittle F. 2011. Middle School Mathematics Professional Development Impact Study: Findings After the Second Year of Implementation. NCEE 2010-4024. Washington, DC: National Center for Education Evaluation and Regional Assistance, Institute of Education Sciences, U.S. Department of Education.

Gewertz C. 2010. Common-standards watch: South Dakota makes 44. *Education Week*'s Curriculum Matters blog, November 29. http://blogs.edweek.org/edweek/curriculum/2010/11/common-standards_watch_south_d.html. Accessed February 2011.

Glazerman S, Isenberg E, Dolfin S, Bleeker M, Johnson A, Grider M, Jacobus M. 2010. Impacts of Comprehensive Teacher Induction: Final Results from a Randomized Controlled Study. NCEE 2010-4027. Washington, DC: National Center for Education Evaluation and Regional Assistance, Institute of Education Sciences, U.S. Department of Education.

Goe L. 2008. Key Issue: Using Value-Added Models to Identify and Support Highly Effective Teachers. Washington, DC: The National Comprehensive Center for Teacher Quality. http://www2.tqsource.org/strategies/het/UsingValueAddedModels.pdf. Accessed October 2010.

Goldhaber D, Choi H, Cramer L. 2007. A descriptive analysis of the distribution of NBPTS-certified teachers in North Carolina. *Economics of Education Review* 26(2):160−72.

Grady S, Bielick S. 2010. Trends in the Use of School Choice: 1993 to 2007. NCES 2010-004. Washington, DC: National Center for Education Statistics.

Greenberg J, Walsh K. 2008. No Common Denominator: The Preparation of Elementary Teachers in Mathematics by America's Education Schools. Washington, DC: National Council on Teacher Quality. http://www.nctq.org/p/publications/docs/nctq_ttmath_fullreport_20080626115953.pdf. Accessed May 2011.

Gruber KJ, Wiley SD, Broughman SP, Strizek GA, Burian-Fitzgerald M. 2002. Schools and Staffing Survey, 1999−2000: Overview of the Data for Public, Private, Public Charter, and Bureau of Indian Affairs Elementary and Secondary Schools. NCES 2002-313. Washington, DC: National Center for Education Statistics.

Guarino CM, Santibanez L, Daley GA. 2006. Teacher recruitment and retention: A review of the recent empirical literature. *Review of Educational Research* 76(2):173–208.

Hakel MD, Koenig JA, Elliott SW (editors). 2008. Assessing Accomplished Teaching: Advanced-Level Certification Programs. Committee on Evaluation of Teacher Certification by the National Board for Professional Teaching Standards. 2008. Washington, DC: The National Academies Press.

Hanushek EA, Kain JF, O'Brien DM, Rivkin SG. 2005. The Market for Teacher Quality. Working Paper Series. Cambridge, MA: National Bureau of Economic Research.

Hanushek EA, Kain JF, Rivkin SG. 2004. Why public schools lose teachers. *Journal of Human Resources* 39(2):326–54.

Hanushek EA, Peterson PE, Woessmann L. 2010. U.S. Math Performance in Global Perspective: How Well Does Each State Do at Producing High-Achieving Students? Cambridge, MA: Harvard's Program on Education Policy & Governance, Harvard Kennedy School. http://www.hks.harvard.edu/pepg/PDF/Papers/PEPG10-19_HanushekPetersonWoessmann.pdf. Accessed January 2011.

Hanushek EA, Rivkin SG. 2006. Teacher quality. In: Hanushek EA and Welch F, editors. *Handbook of the Economics of Education*. Volume 2. Amsterdam, The Netherlands: North Holland.

Hanushek EA, Rivkin SG. 2007. Pay, working conditions, and teacher quality. *Excellence in the Classroom* 17(1):69–86. http://www.futureofchildren.org/futureofchildren/publications/journals/article/index.xml?journalid=34 &articleid=76. Accessed January 2011.

Hanushek EA, Rivkin SG. 2010. Using Value-Added Measures of Teacher Quality. Washington, DC: National Center for the Analysis of Longitudinal Data in Education Research, Urban Institute. http://www.urban.org/uploadedpdf/1001371-teacher-quality.pdf. Accessed May 2011.

Harris DN, Sass TR. 2007. The Effects of NBPTS-Certified Teachers on Student Achievement. Working Paper 4. Washington, DC: National Center for Analysis of Longitudinal Data in Education Research, Urban Institute. http://www.caldercenter.org/PDF/1001060_NBPTS_Certified.pdf. Accessed October 2010.

Harris DN, Sass TR. 2008. Teacher Training, Teacher Quality, and Student Achievement. Working Paper 3. Washington, DC: National Center for Analysis of Longitudinal Data in Education Research, Urban Institute. http://www.caldercenter.org/PDF/1001059_Teacher_Training.pdf. Accessed May 2011.

Henke RR, Choy SP, Chen X, Geis S, Alt MN. 1997. America's Teachers: Profile of a Profession, 1993–94. NCES 97-460. Washington, DC: National Center for Education Statistics.

Hill JG, Gruber KJ. 2011. Education and Certification Qualifications of Departmentalized Public High School-Level Teachers of Core Subjects: Evidence From the 2007−08 Schools and Staffing Survey. NCES 2011-317. Washington, DC: National Center for Education Statistics.

Hoffman L. 2008. Numbers and Types of Public Elementary and Secondary Schools From the Common Core of Data: School Year 2006–07. NCES 2009-304. Washington, DC: National Center for Education Statistics.

Hoxby CM, Murarka S, Kang J. 2009. How New York City's Charter Schools Affect Achievement. Cambridge, MA: New York City Charter Schools Evaluation Project. http://www.nber.org/~schools/charterschoolseval/how_NYC_charter_schools_affect_achievement_sept2009.pdf. Accessed July 2011.

Humphrey DC, Koppich JE, Hough HJ. 2005. Sharing the wealth: National Board certified teachers and the schools that need them most. *Education Policy Analysis Archives* 13(18).

Humphrey DC, Weschler ME, Hough HJ. 2008. Characteristics of effective alternative teacher certification programs. *Teachers College Record* 110(4). http://policyweb.sri.com/cep/publications/AltCert_finalTCversion.pdf. Accessed February 2011.

Ingels SJ, Dalton B, Holder TE, Lauff E, Burns LJ. 2011. High School Longitudinal Study of 2009 (HSLS:09): A First Look at Fall 2009 Ninth-Graders. NCES 2011-327. Washington, DC: National Center for Education Statistics.

Ingersoll R, Perda D. 2009. The Mathematics and Science Teacher Shortage: Fact and Myth. Philadelphia, PA: Consortium for Policy Research in Education. http://www.cpre.org/images/stories/cpre_pdfs/math%20science%20shortage%20paper%20march%202009%20final.pdf. Accessed May 2011.

Ingersoll RM, May H. 2010. The Magnitude, Destinations, and Determinants of Mathematics and Science Teacher Turnover. Philadelphia, PA: Consortium for Policy Research in Education. http://www.gse.upenn.edu/pdf/rmi/MathSciTeacherTurnover.pdf. Accessed May 2011.

Institute of Education Sciences (IES). 2011a. Statewide Longitudinal Data Systems Grant Program: Grantee states. http://nces.ed.gov/programs/slds/stateinfo.asp. Accessed February 2011.

Institute of Education Sciences (IES). 2011b. Statewide Longitudinal Data Systems Grant Program: Program overview. http://nces.ed.gov/programs/slds. Accessed February 2011.

Jacob BA, Lefgren L. 2008. Can principals identify effective teachers? Evidence on subjective performance evaluation in education. *Journal of Labor Economics* 26:101–36.

Jalongo MR, Heider K. 2006. Teacher attrition: An issue of national concern. *Early Childhood Education Journal* 33(6):379–80.

Kane TJ, Rockoff JE, Staiger DO. 2006. What Does Certification Tell Us About Teacher Effectiveness? Evidence from New York City. NBER Working Paper 12155. Cambridge, MA: National Bureau of Economic Research. http://www.nber.org/papers/w12155. Accessed May 2011.

Kane TJ, Taylor ES, Tyler JH, Wooten AL. 2010. Identifying Effective Classroom Practices Using Student Achievement Data. NBER Working Paper 15803. Cambridge, MA: National Bureau of Economic Research. http://www.gse.harvard.edu/ncte/resources/publications/Identifying_Effective_Classroom_Practices_-_Kane_Taylor_Tyler_Wooten.pdf. Accessed July 2011.

Kane TJ, Staiger DO. 2008. Estimating Teacher Impacts on Student Achievement: An Experimental Evaluation. NBER Working Paper 14607. Cambridge, MA: National Bureau of Economic Research. http://www.nber.org/papers/w14607. Accessed May 2011.

Keigher A. 2009. Characteristics of Public, Private, and Bureau of Indian Education Elementary and Secondary Schools in the United States: Results From the 2007–08 Schools and Staffing Survey. NCES 2009-321. Washington, DC: National Center for Education Statistics.

Keigher A, Cross F. 2010. Teacher Attrition and Mobility: Results From the 2008–09 Teacher Follow-up Survey. NCES 2010-353. Washington, DC: National Center for Education Statistics.

Klecker BM. 2008. Is Teacher Quality Related to Eighth-Grade Mathematics Achievement? Evidence from the 2007 NAEP Data. Paper presented at annual meeting of Mid-South Educational Research Association, Knoxville, TN. http://www.eric.ed.gov/PDFS/ED503409.pdf. Accessed February 2011.

Kober N, Rentner DS. 2011. States' Progress and Challenges in Implementing Common Core State Standards. Washington, DC: Center on Education Policy. http://www.cep-dc.org/cfcontent_file.cfm?Attachment=KoberRentner_Report_StateProgressCommonCoreStateStandards_010611.pdf. Accessed May 2011.

Loveless T. 2008. High-Achieving Students in the Era of NCLB, Part 1: An Analysis of NAEP Data. Washington, DC: Thomas B. Fordham Institute. http://www.edexcellencemedia.net/publications/2008/200806_highachievingstudentsintheeraofnochildleftbehind/20080618_high_achievers.pdf. Accessed October 2010.

Lubienski C, Lubienski ST. 2006. Charter, Private, Public Schools and Academic Achievement: New Evidence From NAEP Mathematics Data. New York, NY: National Center for the Study of Privatization in Education, Teachers College, Columbia University. http://epsl.asu.edu/epru/articles/EPRU-0601-137-OWI.pdf. Accessed October 2010.

Luft JA. 2009. Beginning secondary science teachers in different induction programs: The first year of teaching. *International Journal of Science Education* 31(17):2355−84.

Luft JA, Neakrase J, Adams K, Firestone J, Bang EJ. 2010. Bringing content into induction programs: Examples from science. In: Wang J, Odell S, Cliff R, editors. *Past, Present, and Future Research on Teacher Induction: An Anthology for Researchers, Policy Makers, and Practitioners*. Lanham, MD: Rowman & Littlefield Education.

Ma X, Wilkins JLM. 2007. Mathematics coursework regulates growth in mathematics achievement. *Journal for Research in Mathematics Education* 38(3):230–57.

Matthews MS, Farmer JL. 2008. Factors affecting the algebra I achievement of academically talented learners. *Journal of Advanced Academics* 19(3):472–501.

McGrath DJ, Holt EW, Seastrom MM. 2005. Qualifications of Public Secondary School Biology Teachers, 1999–2000. NCES 2005-081. Washington, DC: National Center for Education Statistics.

Measures of Effective Teaching. 2010. Learning about teaching: Initial findings from the measures of effective teaching project. Bill & Melinda Gates Foundation. http://www.gatesfoundation.org/college-ready-education/Documents/preliminary-findings-research-paper.pdf. Accessed May 2011.

Metiri Group. 2009. National Trends Report: Enhancing Education Through Technology (EETT) Round 6, Fiscal Year 2007. Washington, DC: The State Educational Technology Directors Association. http://www.setda.org/c/document_library/get_file?folderId=6&name=DLFE-329.pdf. Accessed May 2011.

Milanowski A. 2008. Using Occupational Characteristics Information From O*NET to Identify Occupations for Compensation Comparisons with K–12 Teaching. WCER Working Paper 2008-4. Madison, WI: Consortium for Policy Research in Education, Wisconsin Center for Education Research, School of Education, University of Wisconsin–Madison. http://www.wcer.wisc.edu/publications/workingpapers/Working_Paper_No_2008_04.pdf. Accessed May 2011.

Morton BA, Peltola P, Hurwitz MD, Orlofsky GF, Strizek, GA. 2008. Education and Certification Qualifications of Departmentalized Public High School-Level Teachers of Core Subjects: Evidence from the 2003–04 Schools and Staffing Survey. NCES 2008-338. Washington, DC: National Center for Education Statistics.

National Academy of Engineering. 2010. *Standards for K−12 Engineering Education?* Washington, DC: The National Academies Press.

National Assessment Governing Board (NAGB). 2008. Science Framework for the 2009 National Assessment of Educational Progress. Washington, DC: National Assessment Governing Board. http://www.nagb.org/publications/frameworks/science-09.pdf. Accessed February 2011.

National Center for Education Statistics (NCES). 2010. The Nation's Report Card: Grade 12 Reading and Mathematics 2009 National and Pilot State Results. NCES 2011-455. Washington, DC.

National Center for Education Statistics (NCES). 2011. The Nation's Report Card: Science 2009. NCES 2011-451. Washington, DC.

National Governors Association (NGA). 2005. Graduation Counts: A Report of the National Governors Association Task Force on State High School Graduation Data. Washington, DC. http://www.nga.org/cms/home/nga-center-for-best-practices/center-publications/page-edu-publications/col2-content/main-content-list/graduation-counts-a-report-of-th.html. Accessed May 2011.

National Governors Association (NGA). 2009. Forty-Nine States and Territories Join Common Core Standards Initiative: NGA Center, CCSSO Convene State-led Process to Develop Common English-language arts and Mathematics Standards. News Release. http://www.nga.org/cms/home/news-room/news-releases/page_2009/col2-content/main-content-list/title_forty-nine-states-and-territories-join-common-core-standards-initiative.html. Accessed February 2011.

National Governors Association (NGA). 2010. Implementing Graduation Counts: State Progress to Date, 2010. Washington, DC: NGA Center for Best Practices. http://www.nga.org/cms/home/nga-center-for-best-practices/center-publications/page-edu-publications/col2-content/main-content-list/implementing-graduation-2010.html. Accessed May 2011.

National Mathematics Advisory Panel (NMAP). 2008. Foundations for Success: The Final Report of the National Mathematics Advisory Panel. Washington, DC: U.S. Department of Education. http://www2.ed.gov/about/bdscomm/list/mathpanel/report/final-report.pdf. Accessed May 2011.

National Research Council (NRC). 2010. *Preparing Teachers: Building Evidence for Sound Policy.* Washington, DC: The National Academies Press.

National Science Board (NSB). 2008. *Science and Engineering Indicators 2008.* NSB 08-01. Arlington, VA: National Science Foundation.

National Science Board (NSB). 2010a. *Preparing the Next Generation of STEM Innovators: Identifying and Developing Our Nation's Human Capital*. Arlington, VA: National Science Foundation.

National Science Board (NSB). 2010b. *Science and Engineering Indicators 2010.* NSB 10-01. Arlington, VA: National Science Foundation.

Nord C, Roey S, Perkins R, Lyons M, Lemanski N, Brown J, Schuknecht J. 2011. America's High School Graduates: Results of the 2009 NAEP High School Transcript Study. NCES 2011-462. Washington, DC: National Center for Education Statistics.

The Opportunity Equation. 2011. Common core standards: Why did states choose to adopt? http://opportunityequation.org/standards-and-assessments/common-core-standards-why-did-states. Accessed February 2011.

Organisation for Economic Co-operation and Development (OECD). 2009. *Education at a Glance 2009: OECD Indicators*. Paris, France. http://www.oecd.org/document/24/0,3746,en_2649_39263238_43586328_1_1_1_1,00.html. Accessed October 2010.

Organisation for Economic Co-operation and Development (OECD). 2010a. *Education at a Glance 2010: OECD Indicators*. Paris, France. http://www.oecd.org/dataoecd/45/39/45926093.pdf. Accessed January 2011.

Organisation for Economic Co-operation and Development (OECD). 2010b. *Lessons from PISA for the United States, Strong Performers and Successful Reformers in Education*. Paris, France. http://www.oecd.org/dataoecd/32/50/46623978.pdf. Accessed March 2011.

Pellegrino JW, Jones LR, Mitchell KJ. 1999. *Grading the Nation's Report Card: Evaluating NAEP and Transforming the Assessment of Educational Progress*. Washington, DC: The National Academies Press.

Peske HG, Haycock K. 2006. Teaching Inequality: How Poor and Minority Students Are Shortchanged on Teacher Quality. Washington, DC: The Education Trust. http://www.edtrust.org/sites/edtrust.org/files/publications/files/TQReportJune2006.pdf. Accessed May 2011.

President's Council of Advisors on Science and Technology. 2010. Prepare and Inspire: K–12 Education in Science, Technology, Engineering, and Math (STEM) for America's Future. Washington, DC: Office of Science and Technology Policy, Executive Office of the President. http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-stemed-report.pdf. Accessed May 2011.

Rand Corporation. 2006. Effect of Teacher Pay on Student Performance: Findings from Illinois. Santa Monica, CA.

Rice JK. 2010. The Impact of Teacher Experience: Examining the Evidence and Policy Implications. Washington, DC: National Center for the Analysis of Longitudinal Data in Education Research, Urban Institute. http://www.urban.org/uploadedpdf/1001455-impact-teacher-experience.pdf. Accessed May 2011.

Richardson V, Placier P. 2001. Teacher change. In: Richardson V, editor. *Handbook of Research on Teaching.* 4th ed. New York, NY: Macmillan.

Ronfeldt M. 2010. Where Should Student Teachers Learn to Teacher? Effects of Field Placement School Characteristics on Teacher Retention and Effectiveness. Stanford, CA. http://www.stanford.edu/group/irepp/uploads/WhereLearnToTeach30Apr2010.pdf. Accessed July 2011.

Rothstein J. 2008. Teacher Quality in Educational Production: Tracking, Decay, and Student Achievement. Working Paper 14442. Cambridge, MA: National Bureau of Economic Research. http://www.nber.org/papers/w14442. Accessed May 2011.

Smith TM. 2007. How do state-level induction and standards-based reform policies affect induction experiences and turnover among new teachers? *American Journal of Education* 113(2):273−311.

Smith TM, Ingersoll RM. 2004. What are the effects of inductaion and mentoring on beginning teacher turnover? *American Educational Research Journal* 41(3):681–714.

Smith TM, Rowley KJ. 2005. Enhancing commitment or tightening control: The function of teacher professional development in an era of accountability. *Educational Policy* 19(1):126–54.

Snyder TD, Dillow SA. 2011. *Digest of Education Statistics 2010*. NCES 2011-015. Washington, DC: National Center for Education Statistics.

Springer MG, Ballou D, Hamilton L, Le V, Lockwood JR, McCaffrey D, Pepper M, Stecher B. 2010. Teacher Pay for Performance: Experimental Evidence from the Project on Incentives in Teaching. Nashville, TN: National Center on Performance Incentives at Vanderbilt University. http://www.rand.org/content/dam/rand/pubs/reprints/2010/RAND_RP1416.pdf. Accessed May 2011.

Steele JL, Murnane RJ, Willett JB. 2009. Do Financial Incentives Help Low-Performing Schools Attract and Keep Academically Talented Teachers? Evidence from California. Working Paper 14780. Cambridge, MA: National Bureau of Economic Research. http://www.nber.org/papers/w14780. Accessed May 2011.

Stillwell R, Hoffman L. 2008. Public School Graduates and Dropouts from the Common Core of Data: School Year 2005–06. NCES 2008-353rev. Washington, DC: National Center for Education Statistics.

Subedi BR, Swan B, Hynes MC. 2010. Are School Factors Important for Measuring Teacher Effectiveness? A Multilevel Technique to Predict Student Gains Through a Value-Added Approach. Paper presented at Annual Meeting of American Educational Research Association, Denver. http://www.eric.ed.gov/PDFS/ED509792.pdf. Accessed May 2011.

Taylor LL. 2008. Comparing teacher salaries: Insights from the U.S. census. *Economics of Education Review* 27(1):48−57.

Teach for America (TFA). 2006. 2006 Annual Report. New York, NY. http://www.givewell.org/files/unitedstates/TFA/TFA.%20Annual%20Report%202006.pdf. Accessed May 2011.

Teach for America (TFA). 2008. 2008 Annual Report: Priorities and Results. New York, NY. http://www.givewell.org/files/unitedstates/TFA/TFA.%20Annual%20Report%202008.pdf. Accessed May 2011.

Teach for America (TFA). 2009. 2009 Annual Report: Priorities and Results. New York, NY. http://s3.amazonaws.com/tfaweb-radiant/assets/92/2009_Annual_Report_070810_rev_original.pdf. Accessed May 2011.

U.S. Department of Education. 2009. Statewide longitudinal data systems. http://www2.ed.gov/programs/slds/factsheet.html. Accessed February 2011.

U.S. Department of Education, Office of Elementary and Secondary Education. 2008. Title I—Improving the Academic Achievement of the Disadvantaged, Final Rule. 73 Fed. Reg. 64435. Washington, DC.

Vanneman A, Hamilton L, Baldwin AJ, Rahman T. 2009. Achievement Gaps: How Black and White Students in Public Schools Perform in Mathematics and Reading on the National Assessment of Educational Progress. NCES 2009-455. Washington, DC: National Center for Education Statistics.

Walsh K, Jacobs S. 2007. Alternative Certification Isn't Alternative. Washington, DC: Thomas B. Fordham Institute. http://www.nctq.org/p/publications/docs/Alternative_Certification_Isnt_Alternative_20071124023109.pdf. Accessed May 2011.

WestEd. 2010. Technology and Engineering Literacy Framework for the 2014 National Assessment of Educational Progress (Pre-Publication Edition). San Francisco, CA. http://www.nagb.org/publications/frameworks/prepub_naep_tel_framework_2014.pdf. Accessed February 2011.

The White House. n.d. Educate to innovate. http://www.whitehouse.gov/issues/education/educate-innovate. Accessed May 2011.

Zeichner KM, Conklin J. 2005. Teacher education programs. In: Cochran-Smith, Zeichner KM, editors. *Studying Teacher Education: The Report of the AERA Panel on Research and Teacher Education.* Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Zimmer R, Buddin R, Chau D, Daley G, Gill B, Guarino C, Hamilton L, Krop C, McCaffrey D, Sandler M, Brewer D. 2003. Charter School Operations and Performance: Evidence from California. Santa Monica, CA: Rand Corporation. http://www.lao.ca.gov/2003/rand_charter/053003_rand_charter_schools.pdf. Accessed February 2011.

Zimmer R, Gill B, Booker K, Lavertu S, Sass T, Witte J. 2009. Charter Schools in Eight States: Effects on Achievement, Attainment, Integration, and Competition. Santa Monica, CA: Rand Corporation. http://www.rand.org/pubs/monographs/2009/RAND_MG869.pdf. Accessed October 2010.

Chapter 2
Higher Education in Science and Engineering

List of Sidebars

List of Tables

List of Figures

Highlights

Characteristics of the U.S. Higher Education System

Research institutions are the leading producers of S&E degrees at the bachelor's, master's, and doctoral levels, but other types of institutions are also important in the education of S&E graduates.

- Baccalaureate colleges are the source of relatively few S&E bachelor's degrees, but are a more prominent source of future S&E doctorate recipients.
- Master's colleges and universities awarded more than one-third of S&E bachelor's and master's degrees in 2009.
- Nearly one in five U.S. citizen/permanent residents who received a doctoral degree from 2005 to 2009 had earned some college credit from a community or 2-year college.

Over the past decade in the United States, tuition and fees for colleges and universities have grown faster than median income.

- In the 2007–08 academic year, two-thirds of all undergraduates received some kind of financial aid and 39% took out loans to finance their education.
- At the time of doctoral degree conferral, 45% of 2009 S&E doctorate recipients had debt related to their undergraduate or graduate education.

In 2009, the federal government was the primary source of financial support for 18% of full-time S&E graduate students.

- In 2009, the federal government funded 63% of S&E graduate students on traineeships, 49% of those with research assistantships, and 23% of those with fellowships.
- Graduate students in the biological sciences, the physical sciences, and engineering received relatively more federal financial support compared with those in computer sciences, mathematics, other life sciences, psychology, and social sciences.

Undergraduate Education, Enrollment, and Degrees

Enrollment in U.S. higher education rose from 14.5 million in fall 1994 to 20.7 million in fall 2009.

- Between 2007 and 2009, enrollment increased faster than in most previous years.
- Enrollment in higher education is projected to grow through 2019 because of increases in the college-age population.
- Postsecondary enrollment is projected to increase for all racial/ethnic groups, except for whites. The percentage for white students is projected to decrease from 63% in 2008 to 58% in 2019, reflecting demographic changes.

The number of S&E bachelor's degrees has risen steadily over the past 15 years, reaching a new peak of about half a million in 2009.

- With the exception of computer sciences, most S&E fields experienced increases in the number of degrees awarded in 2009. In computer sciences, the number of bachelor's and master's degrees awarded decreased sharply from 2004 to 2007, but then remained stable through 2009.
- Women have earned about 57% of all bachelor's degrees and half of all S&E bachelor's degrees since the late 1990s. In general, men earn a majority of bachelor's degrees in engineering, computer sciences, and physics. More women than men earn degrees in chemistry; biological, agricultural, and social sciences; and psychology.
- In the last 10 years, the proportion of S&E bachelor's degrees awarded to women has not grown measurably and has declined in computer sciences, mathematics, and engineering.

The racial/ethnic composition of those earning S&E bachelor's degrees is changing, reflecting both population change and an increase in college attendance by members of minority groups.

- For all racial/ethnic groups, the total number of bachelor's degrees earned, the number of S&E bachelor's degrees earned, and the number of bachelor's degrees in most S&E fields have generally increased since 2000.

Undergraduate students majoring in S&E fields persist and complete their degrees at a higher rate than non-S&E students.

- Six years after enrolling in a 4-year college or university in academic year 2003–04, 63% of undergraduates with an S&E major had completed a bachelor's degree, compared to 55% of students with other majors.
- Among students who began 4-year colleges in 2003–04, the proportion majoring in S&E in 2009 was higher than the proportion majoring in S&E in 2004. Thus, the number of students switching majors out of S&E fields was lower than the number entering S&E fields as a whole.
- Within S&E, undergraduate attrition out of engineering was greater than transfers into this field, and transfers into social/behavioral sciences exceeded attrition. About 10% of engineering majors switched to mathematics or physical or computer sciences majors.

Graduate Education, Enrollment, and Degrees

The proportion of women and minorities in S&E graduate education has been growing steadily but slowly.

- Nearly half of the 611,600 S&E graduate students enrolled in the United States in fall 2009 were women, with considerable field variation.
- Women continued to enroll at disproportionately lower rates in engineering, computer sciences, physical sciences, and economics.
- In 2009, underrepresented minority students (blacks, Hispanics, and American Indians/Alaska Natives) made up 12% of students enrolled in graduate S&E programs, with Asian/Pacific Islanders representing 6% and whites 48%. Temporary residents accounted for remainder of graduate S&E enrollment.

The number of total foreign graduate students continued to increase through fall 2010, with all of the increase occurring in S&E fields.

- About 60% of all foreign graduate students in the United States in 2010 were enrolled in S&E fields, compared with 32% at the undergraduate level.
- Most of the growth in the number of foreign graduate students in S&E between 2009 and 2010 occurred in engineering and computer sciences.
- India and China were the countries of origin for nearly two-thirds of the foreign S&E graduates in the United States in November 2010.

Master's degrees awarded in S&E fields increased from 120,200 in 2007 to 134,000 in 2009, after holding steady for the previous 3 years.

- Increases occurred in most major science fields.
- The number and percentage of master's degrees awarded to women in most major S&E fields have increased since 2000.
- The number of S&E master's degrees awarded increased for all racial/ethnic groups from 2000 to 2009. During this period, the proportion earned by blacks and Hispanics increased, that of Asians/Pacific Islanders and American Indians/Alaska Natives remained flat, and that of whites decreased.

In 2009, U.S. academic institutions awarded 41,100 S&E doctorates.

- The number of S&E doctorates conferred annually by U.S. universities increased steeply (43%) from 2003 to 2007, then flattened and declined slightly in 2009.
- Among fields that award large numbers of doctorates, the biggest increases between 2000 and 2009 were in engineering (47%) and biological sciences (49%).

Students on temporary visas earned high proportions of U.S. S&E doctorates and dominated degrees in some fields. They also earned large shares of the master's degrees in S&E fields.

- Foreign students earned 57% of all engineering doctorates, 54% of all computer science degrees, and 51% of physics doctoral degrees. Their overall share of S&E degrees was one-third.
- After a 64% growth from 2002 to 2008, the number of temporary residents earning S&E doctoral degrees declined by about 4% in 2009 to 13,400.
- In 2009, temporary visa students earned 27% of S&E master's degrees, receiving 46% of those in computer sciences, 43% of those in engineering, and 36% of those in physics.

International S&E Higher Education

In 2008, about 5 million first university degrees were awarded in S&E worldwide. Students in China earned about 23%, those in the European Union earned about 19%, and those in the United States earned about 10% of these degrees.

- The number of S&E first university degrees awarded in China and Taiwan more than doubled between 2000 and 2008. Those awarded in the United States and many other countries generally increased. Those awarded in France, Spain, and Japan decreased in recent years.
- S&E degrees continue to account for about one-third of all bachelor's degrees awarded in the United States. In Japan and China, more than half of first degrees were awarded in S&E fields in 2008.
- In the United States, about 4% of all bachelor's degrees awarded in 2008 were in engineering. This compares with about 19% throughout Asia and 31% in China specifically.

In 2008, the United States awarded the largest number of S&E doctoral degrees of any individual country, followed by China, Russia, Germany, and the United Kingdom.

- The number of S&E doctoral degrees awarded in China, the United States, and Italy has risen substantially in recent years; S&E doctorates awarded in India, Japan, South Korea, and many European countries have risen more modestly. The number in Russia increased from 2002 to 2007, but fell sharply in 2008.
- In 2007, China overtook the United States as the world leader in the number of doctoral degrees awarded in the natural sciences and engineering.
- Women earned 41% of S&E doctoral degrees awarded in the United States in 2008, about the same as women's percentages in Australia, Canada, the European Union, and Mexico.

International student mobility expanded over the past two decades and countries are increasingly competing for foreign students.

- The United States remains the destination for the largest number of foreign students worldwide (undergraduate and graduate), although its share of foreign students worldwide decreased from 24% in 2000 to 19% in 2008.
- Some countries expanded recruitment of foreign students as their own populations of college-age students decreased, both to attract highly skilled workers and to increase revenue for colleges and universities.
- In addition to the United States, other countries that are among the top destinations for foreign students include the United Kingdom, Germany, and France.

Introduction

Chapter Overview

Higher education performs a number of societal functions, including developing human capital, building the knowledge base (through research and knowledge development), and disseminating, using, and maintaining knowledge (OECD 2008). S&E higher education provides the advanced skills needed for a competitive workforce and, particularly in the case of graduate-level S&E education, the research capability necessary for innovation. This chapter focuses on the development of human capital by higher education.

Indicators presented in this chapter are discussed in the context of national and global events, including changing demographics, increasing foreign student mobility, and global competition in higher education. The U.S. college-age population is currently increasing and projected to continue to grow for the next decade. Its composition is also changing, with Asians and Hispanics becoming an increasing share of the population. Recent enrollment and degree trends, to some extent, reflect these changes.

As the world becomes more interconnected, more students travel to study in a different country, and more countries invest in their higher education systems. Increases in foreign students contributed to most of the growth in overall S&E graduate enrollment in the United States in recent years. Despite a decline in the number of foreign students coming to the United States after 11 September 2001, foreign graduate student enrollment in S&E has recovered. Although the United States has historically been a world leader in providing broad access to higher education and in attracting foreign students, many other countries are providing expanded educational access to their own population and attracting growing numbers of foreign students. The effects of these trends, as well as the effects of the recent global financial crisis on domestic and foreign student enrollment in U.S. institutions, remain to be seen.

Chapter Organization

This chapter describes characteristics of the U.S. higher education system and trends in higher education worldwide. It begins with an overview of the characteristics of U.S. higher education institutions providing instruction in S&E, followed by a discussion of characteristics of undergraduate and graduate education. Trends are discussed by field and demographic group, with a focus on the flow of foreign students into the United States by country. The chapter then presents various international higher education indicators, including comparative S&E degree production in several world regions and indicators that measure the growing dependence of all industrialized countries on foreign S&E students.

The data in this chapter come from a variety of federal and nonfederal sources, primarily from surveys conducted by the National Science Foundation's (NSF) National Center for Science and Engineering Statistics (NCSES) and the National Center for Education Statistics (NCES) at the U.S. Department of Education. Data also come from international organizations, such as the Organisation for Economic Co-operation and Development (OECD) and the United Nations Educational, Scientific and Cultural Organization (UNESCO), and individual countries. Most of the data in the chapter are from censuses of the population—for example, all students receiving degrees from U.S. academic institutions—and are not subject to sampling variability.

The U.S. Higher Education System

Higher education in S&E is important because it produces an educated S&E workforce and an informed citizenry. It has also been receiving increased attention as an important component of U.S. economic competitiveness. In his 24 February 2009 address to a joint session of Congress, President Barack Obama called for every American to commit to at least 1 year of education or career training after completing high school. This section discusses the characteristics of U.S. higher education institutions providing S&E education and the financing of higher education.

Institutions Providing S&E Education

The U.S. higher education system consists of a large number of diverse academic institutions that vary in their missions, learning environments, selectivity, religious affiliation, types of students served, types of degrees offered, and sector (public, private nonprofit, or private for-profit) (NCES 2010a). Among the approximately 4,500 postsecondary degree-granting institutions in the United States in the 2009–10 academic year, 62% offered bachelor's or higher degrees, 31% offered associate's degrees, and 8% offered degrees that were at least 2-year but less than 4-year as the highest degree awarded (NCES 2010b). In 2009, U.S. academic institutions awarded more than 3.1 million associate's, bachelor's, master's, and doctoral degrees; 23% of the degrees were in S&E (appendix table 2-1).

Doctorate-granting institutions with very high research activity are the leading producers of S&E degrees at the bachelor's, master's, and doctoral levels. In 2009, these research institutions awarded 75% of doctoral degrees, 42% of master's degrees, and 38% of bachelor's degrees in S&E fields. (See sidebar "Carnegie Classification of Academic Institutions.") Master's colleges and universities awarded another 29% of S&E bachelor's degrees and 26% of S&E master's degrees in 2009. Baccalaureate colleges were the source of relatively few S&E bachelor's degrees (12%) (appendix table 2-1), but they produce a large proportion of future S&E doctorate recipients. When adjusted by the number of bachelor's degrees awarded in all fields, baccalaureate colleges as a group yield more future S&E doctorates per hundred bachelor's degrees awarded than other types of institutions, except research universities (NSF/NCSES 2008).

Carnegie Classification of Academic Institutions

The Carnegie Classification of Institutions of Higher Education is widely used in higher education research to characterize and control for differences in academic institutions.

The 2010 classification update retains the same structure initially adopted in 2005 and illustrates the most current landscape of U.S. colleges and universities. Compared with the 2005 update, there are 483 newly classified institutions in the 2010 classifications (from a universe of 4,633). More than three-quarters of the new institutions (77%) are from the private for-profit sector, 19% from the private nonprofit sector, and 4% from the public institution sector.

Academic institutions are categorized primarily on the basis of highest degree conferred, level of degree production, and research activity.* In this report, several categories have been aggregated for statistical purposes. The characteristics of those aggregated groups are as follows:

- *Doctorate-granting universities* include institutions that award at least 20 doctoral degrees per year. They include three subgroups based on level of research activity: very high research activity (108 institutions), high research activity (99 institutions), and doctoral/research universities (90 institutions).
- *Master's colleges and universities* include the 727 institutions that award at least 50 master's degrees and fewer than 20 doctoral degrees per year.
- *Baccalaureate colleges* include the 808 institutions for which baccalaureate degrees represent at least 10% of all undergraduate degrees and that award fewer than 50 master's degrees or 20 doctoral degrees per year.
- *Associate's colleges* include the 1,920 institutions at which all degrees awarded are associate's degrees or at which bachelor's degrees account for less than 10% of all undergraduate degrees.
- *Special-focus institutions* are the 851 institutions in which at least 75% of degrees are concentrated in a single field or a set of related fields (e.g., medical schools and medical centers, schools of engineering, and schools of business and management).
- *Tribal colleges* are the 32 colleges and universities that are members of the American Indian Higher Education Consortium.

---

*Research activity is based on two indices (aggregate level of research and per capita research activity) derived from a principal components analysis of data on R&D expenditures, S&E research staff, and field of doctoral degree. See http://classifications.carnegiefoundation.org for more information on the classification system and on the methodology used in defining the categories.

Community Colleges

Community colleges (also known as public 2-year colleges or associate's colleges) play a key role in increasing access to higher education for all citizens. These institutions serve diverse groups of students and offer a more affordable means of participating in postsecondary education. They are likely to serve groups with lower college attendance rates in past generations. Community colleges are important in preparing students to enter the workforce with certificates or associate's degrees and in preparing students to transition to 4-year colleges or universities (Karp 2008). They provide the education needed for S&E or S&E-related occupations that require less than a bachelor's degree, and they provide the first 2 years of many students' education before they transfer to an S&E program at a 4-year college or university.

In the 2008–09 academic year, there were more than 1,000 community colleges in the United States. These colleges enrolled about 7.2 million students, or about a third of all postsecondary students. Nearly six out of ten of these students were enrolled part-time (NCES 2011a). With the economic recession, enrollment in community colleges increased by about 800,000 students between 2007 and 2009 (NCES 2009a and 2011a).

Community colleges play a significant role in the education of individuals with advanced S&E credentials. Among U.S. citizen and permanent resident S&E doctorate holders who received their doctorates between 2005 and 2009, nearly one in five indicated they had earned college credit from a community or 2-year college (table 2-1). According to data from the National Survey of Recent College Graduates, in the last decade, the proportion of recent bachelor's S&E graduates who reported ever attending a community college increased (table 2-2). Forty-six percent of 2006 and 2007 S&E graduates indicated they had attended a community college (49% of the bachelor's recipients and 35% of the master's recipients). Graduates in engineering and physical sciences[1] were the least likely to have attended a community college. Between 1999 and 2008, the proportion of S&E graduates who attended community colleges increased in the life sciences, social sciences, mathematics, and computer sciences (figure 2-1).

In 2008, female S&E bachelor's and master's degree recipients were more likely to have attended a community college than their male counterparts (table 2-3). Attendance was also higher among U.S. citizens and permanent visa holders than among temporary visa holders. Attendance was higher for Hispanic and black S&E graduates than for whites or Asians. The likelihood of attending a community college before receiving an S&E bachelor's or master's degree was related to parental education level. More than half of the S&E graduates who reported that their fathers or mothers had less than a high school diploma attended a community college, compared to about one-third of those whose fathers or mothers had a professional or a doctoral degree.

Over the last 10 years, the top reason for attending a community college among science and engineering graduates

Table 2-1

U.S. citizen/permanent resident S&E doctorate recipients who reported earning college credit from a community or 2-year college, by race/ethnicity: 2005–09

Race/ethnicity	All	Earned college credit from a community or 2-year college: Yes	No	Percent yes
All races/ethnicities	87,790	17,033	70,757	20
American Indian/Alaska Native	313	122	191	39
Asian	8,783	1,158	7,625	13
Black	3,982	706	3,276	18
Hispanic	4,529	1,024	3,505	23
White	67,250	13,369	53,881	20
Native Hawaiian/Other Pacific Islander	200	50	150	25
Unknown/unreported	2,733	604	2,129	22

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2010) of Survey of Earned Doctorates, 2005–09.

Science and Engineering Indicators 2012

Table 2-2

Community college attendance among recent recipients of S&E bachelor's and master's degrees, by degree level and degree year: 1999–2008

Degree level	1999 Recent degree recipients	1999 Attended community college (%)	2001 Recent degree recipients	2001 Attended community college (%)	2003 Recent degree recipients	2003 Attended community college (%)	2006 Recent degree recipients	2006 Attended community college (%)	2008 Recent degree recipients	2008 Attended community college (%)
All graduates	900,400	41	918,400	44	958,400	45	1,634,200	45	1,138,400	46
Bachelor's	743,400	43	758,300	46	794,400	47	1,343,000	47	934,300	49
Master's	157,000	35	160,100	34	164,000	34	291,200	34	204,100	35

NOTES: Recent graduates are those who earned degrees in the 2 academic years preceding survey year, or, for 2006 survey year, in the 3 preceding academic years. For 2006, recent graduates are those who earned degrees between 1 July 2002 and 30 June 2005. Data rounded to the nearest 100. Detail may not add to total because of rounding.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2010) of National Survey of Recent College Graduates, 1999, 2001, 2003, 2006, and 2008.

Science and Engineering Indicators 2012

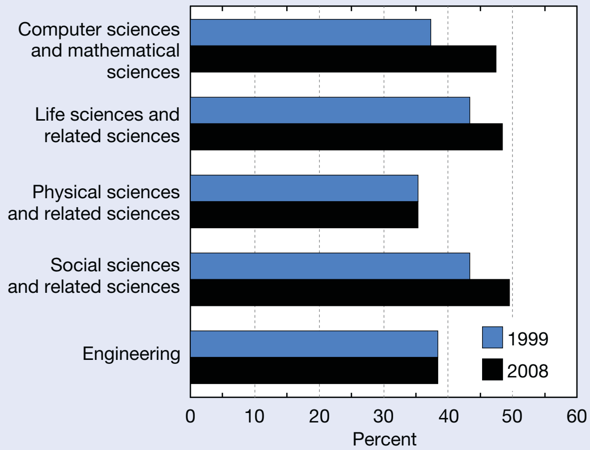
remained the same—earning credits for a bachelor's degree (figure 2-2). However, the prevalence of other reasons for attending a community college changed over time. The importance of community colleges as bridges between high school and college in the form of dual enrollment programs increased from 13% in 1999 to 28% in 2008. Attending a community college to facilitate a change in fields or for financial reasons also became more important, while gaining skills and knowledge in their fields, having opportunities to increase advancement, or attending for leisure or personal interest became less important.

For-Profit Institutions

Two-year, for-profit institutions enroll considerably fewer students than community colleges. Over the past 10 years, however, the number of for-profit institutions has grown rapidly and the number of degrees they awarded has more than doubled (NCES 2010c; appendix table 2-2). A large part of that increase is accounted for by the growth of University of Phoenix Online Campus. In 2009, about 2,900 academic institutions in the United States operated on a for-profit basis. About half of these institutions offer less-than-2-year programs and fewer than half are degree-granting institutions. Of the degree-granting institutions, close to half award associate's degrees as their highest degree (NCES 2010b).

In 2009, for-profit academic institutions awarded between 1% and 5% of S&E degrees at the bachelor's, master's, and doctoral levels, and 31% of S&E degrees at the associate's level. Computer sciences accounted for 91% of the associate's degrees and 67% of the bachelor's degrees awarded by for-profit institutions in science and engineering fields in 2009 (appendix table 2-3). For-profit institutions award relatively few S&E master's and doctoral degrees; those degrees are mainly in psychology. In 2009, degrees in psychology represented 51% of the master's and 81% of the doctoral degrees awarded by for-profit institutions in science and engineering fields.

Figure 2-1
Community college attendance among recent recipients of S&E degrees, by field of highest degree: 1999 and 2008



NOTE: Recent graduates are those who earned degrees in the 2 academic years preceding survey year.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, National Survey of Recent College Graduates, 1999 and 2008.

Science and Engineering Indicators 2012

Table 2-3
Community college attendance among recent recipients of S&E degrees, by sex, race/ethnicity, and citizenship status: 2008

Characteristic	Number	Percent
All graduates	1,138,400	46
Sex		
Female	570,500	49
Male	567,900	43
Race/ethnicity		
American Indian/Alaska Native	2,000	61
Hispanic	98,000	53
Black	73,400	51
White	713,900	45
Asian	192,800	43
Native Hawaiian/other Pacific Islander	6,800	66
Multiple race	51,500	45
Citizenship status		
U.S. citizen	1,029,500	48
Permanent visa	30,900	46
Temporary visa	78,000	17
Father's education		
Less than high school	68,800	55
High school diploma or equivalent	203,500	50
Some college, vocational, or trade school	219,900	54
Bachelor's	294,400	45
Master's	181,500	41
Professional degree	81,800	31
Doctorate	70,100	36
Not applicable	18,400	46
Mother's education		
Less than high school	77,500	58
High school diploma or equivalent	232,000	50
Some college, vocational, or trade school	268,000	51
Bachelor's	312,700	42
Master's	180,400	41
Professional degree	32,700	31
Doctorate	27,400	34
Not applicable	7,700	56

NOTES: Recent graduates are those who earned degrees between 1 July 2006 and 30 June 2007. Data rounded to nearest 100.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2010) of National Survey of Recent College Graduates, 2008.

Science and Engineering Indicators 2012

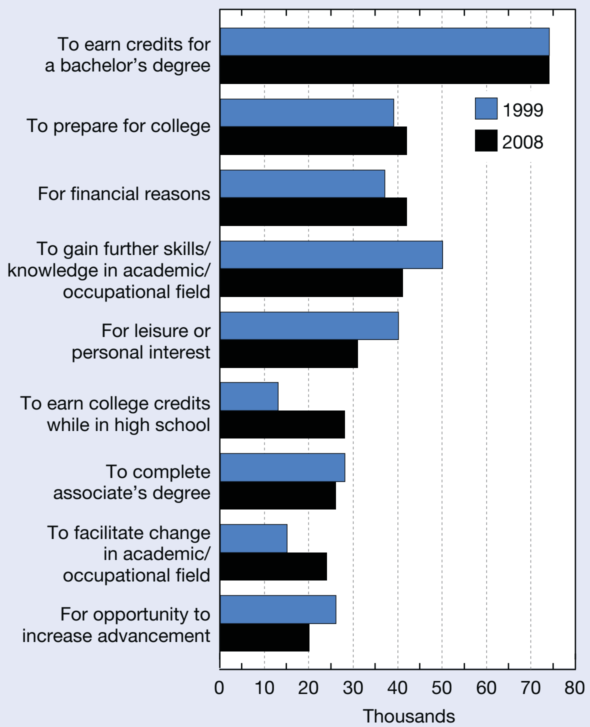
Online and Distance Education

Online education and distance education enable institutions of higher education to reach a wider audience by expanding access to students in remote geographic locations and providing greater flexibility for students who have time constraints, physical impairments, responsibility for caring for dependents, etc. Online education is a relatively new phenomenon and online enrollment has grown substantially in recent years. In 2007–08, about 4.3 million undergraduate students (20% of all undergraduates) took at least one distance education course, up from 2.9 million (16% of all undergraduates) in 2003–04. In addition, nearly 800,000 (22%) of all postbaccalaureate students took distance education courses in 2007–08 (NCES 2011b).[2]

At the undergraduate level, students at private for-profit 4-year institutions were more likely to participate in distance education courses than students at public or private not-for-profit institutions (appendix table 2-4). Similarly, a higher proportion of students at private for-profit 4-year institutions took their entire program through distance education than students at any other type of institution. Most institutions, for-profit institutions in particular, believe that online education will be a critical part of their long-term strategy (Allen and Seaman 2010).

In recent years, academic institutions have begun developing online courses for public access—examples include the Open Learning Initiative at Carnegie Mellon and the MIT OpenCourseWare.[3] Other kinds of initiatives involve working with faculty and organizations such as the National Center for Academic Transformation to redesign courses to incorporate the use of information technology.

Figure 2-2
Reasons for attending community college among recent S&E graduates: 1999 and 2008



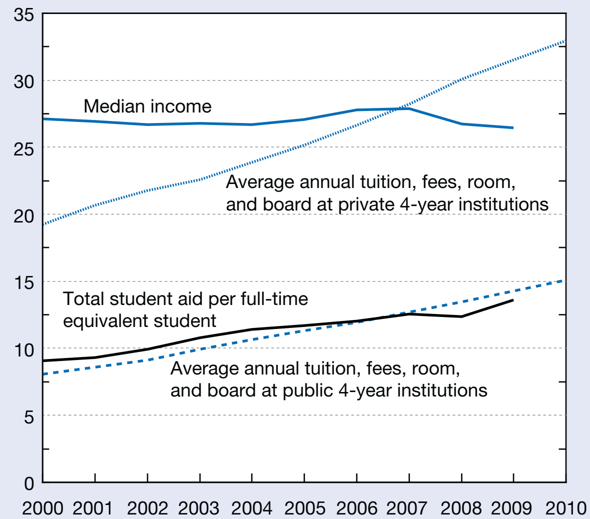
NOTE: Recent graduates are those who earned degrees in the 2 academic years preceding survey year.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, National Survey of Recent College Graduates, 1999 and 2008.

Science and Engineering Indicators 2012

Figure 2-3
Average annual tuition, fees, room, and board for public and private 4-year institutions, total student aid dollars, and median income: 2000–10

Constant 2010 dollars (thousands)



NOTE: Data on median income and total student aid per full-time equivalent student not available for 2009–10.

SOURCES: College Board, *Trends in College Pricing 2010;* and Census Bureau, Historical Income Tables, Table P-7, http://www.census.gov/hhes/www/income/data/historical/people/P07AR_2009.xls, accessed 15 March 2011.

Science and Engineering Indicators 2012

Financing Higher Education

Cost of Higher Education

Affordability and access to U.S. higher education institutions are perennial concerns (NCPPHE 2008; NSB 2003). For at least the past 10 years, tuition and fees for colleges and universities in the United States have grown rapidly, faster than median income (figure 2-3). In the 2010–11 academic year, average tuition and fees for 4-year colleges rose faster than inflation. While the Consumer Price Index increased by 1.2% between July 2009 and July 2010 (College Board 2010a), average tuition and fees rose 7.9% from the previous academic year for in-state students at public 4-year colleges, 4.5% for students in private nonprofit 4-year colleges, and 6% for students at public 2-year colleges. Another inflation index, the Higher Education Price Index, which measures the average relative level in the price of a fixed-market basket of goods and services purchased by colleges and universities each year, rose 0.9% in fiscal year 2010 (Commonfund Institute 2010).

In the 5-year interval between 2005–06 and 2010–11, average published tuition and fees rose much faster than other prices in the economy. However, compared to 5 years ago, estimated average net tuition and fees (i.e., the published prices minus grant aid and tax benefits) are lower for all sectors. Large increases in federal Pell grants and veterans' benefits in 2009–10 and the passage of the American Recovery and Reinvestment Act of 2009 largely drove the decline in average net prices (College Board, 2010a). According to the College Board (2010b), in the coming years, rising tuition prices are likely to continue in response to state reductions in higher education funding (see sidebar "State Appropriations to Public Research Universities: A Volatile Decade"), but the rate of increase in grant funds is not likely to keep pace.

Undergraduate Financial Support Patterns and Debt

Financial Support for Undergraduate Education. With rising tuition, students increasingly rely on financial aid (particularly loans) to finance their education. Financial aid for undergraduate students comes mainly in the form of grants, student loans, and work study. A financial aid package may contain one or more of these kinds of support. In the 2007–08 academic year, two-thirds of all undergraduate students received some kind of financial aid: 52% received grants and 39% took out loans (NCES 2009b). A higher proportion of undergraduates in private for-profit institutions (96%) and in nonprofit 4-year institutions (85%) than those

State Appropriations to Public Research Universities: A Volatile Decade

Increases in the number of students seeking an affordable college education and competing demands on state government budgets have affected the resources available for state-funded higher education. Because funding for major state research universities has been a particular focus of concern, this sidebar examines trends in state support for these institutions between 2002 and 2010.[4] Data cover 101 public research universities with broad educational missions (i.e., excluding free-standing medical and engineering schools when possible). These institutions are either the leading recipient of academic R&D funding in their state or among the nation's top 100 recipients of academic R&D funding to public universities.

According to data collected by the U.S. Department of Education's National Center for Education Statistics and Illinois State University's Center for the Study of Education Policy (CSEP), total state funding in current dollars for these 101 universities, including state appropriations and state operating grants and contracts, grew during the period of 2002 through 2010 from $23.8 billion in 2002 to $25.8 billion in 2010.[5] Funding fluctuated over this period, dipping in the early years and then rising until 2008 when it began to fall sharply. In constant dollars, this represented a decline of 10% (figure 2-A). As a percentage of the universities' total revenues, state funding declined from 28% in 2001 to 19% in 2009.

In constant dollars, 72 of the 101 universities experienced an overall reduction in state appropriations. More than half of the universities, 54, had reductions of more than 10%. For 29 institutions, state appropriations in 2010 were between 90% and 110% of the 2002 level. The remaining 18 universities received increases of more than 10%.

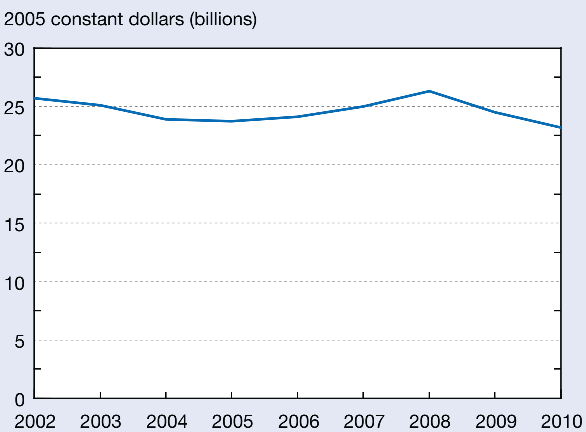
Funding changes varied widely by institution and by state. For example, all of the nine research universities in California experienced reductions ranging from 17% to 35%. By contrast, the four State University of New York (SUNY) campuses received substantial increases ranging from 71% to 171%. In Texas, three universities had very different funding trends: the University of Texas at Dallas experienced a 19% increase, Texas A&M a 12% decrease, and the University of Texas at Austin had a 3% decrease. In Michigan, the University of Michigan–Ann Arbor experienced a 28% decrease and Michigan State University had a 21% decrease.

While the value of overall state funding declined nationally, enrollment was growing consistently. As a result, state funding per enrolled student dropped in constant dollars by 20%, going from $10,195 per student in 2002 to $8,157 per student in 2010 (figure 2-B).

Preliminary data prepared by CSEP—available by state but not by university—suggest a continuing state funding decline. In particular, between 2009 and 2011, 35 of the 50 states reported reductions in state appropriations and other state support, ranging from less than 1% to more than 28%.

Additional indicators of state-level trends in the affordability of higher education, including state appropriations for operating expenses as a percentage of GDP and average undergraduate charges at public 4-year institutions, can be found in chapter 8.

Figure 2-A
State appropriations to major public research universities: 2002–10

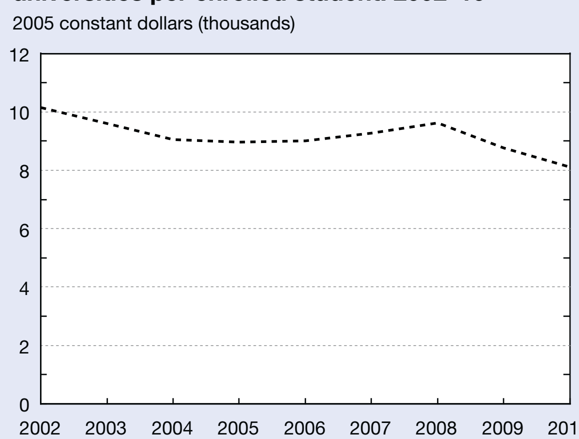


NOTE: Data for 2010 are preliminary.

SOURCES: National Center for Education Statistics, Integrated Postsecondary Education Data System; Illinois State University, Center for the Study of Education Policy.

Science and Engineering Indicators 2012

Figure 2-B
State appropriations to major public research universities per enrolled student: 2002–10



NOTE: Data for 2010 are preliminary.

SOURCES: National Center for Education Statistics, Integrated Postsecondary Education Data System; Illinois State University, Center for the Study of Education Policy.

Science and Engineering Indicators 2012

in public 4-year (71%) or public 2-year institutions (48%) received some type of financial aid.

Undergraduate Debt. Undergraduate debt does not vary by undergraduate major (NSF/NCSES 2010a); however, levels of debt vary by type of institution and state. Levels of undergraduate debt for students from public colleges and universities are almost as high as those for students from private colleges and universities. The median level of debt for 2007–08 bachelor's degree recipients who took out loans was $20,000 for those who graduated from public colleges and universities and $24,600 for those who graduated from private nonprofit institutions. Students who attend private for-profit institutions are more likely to borrow than those who attend public and private nonprofit institutions (College Board 2010b).

Levels of debt varied widely by state. Average debt for 2009 graduates of public 4-year colleges and universities ranged from $14,739 in California to $29,675 in New Hampshire. Average debt for graduates of private nonprofit colleges and universities ranged from $11,312 in Utah to $32,434 in Rhode Island (Project on Student Debt 2009).

Graduate Financial Support Patterns and Debt

Financial Support for S&E Graduate Education. More than one-third of all S&E graduate students are primarily self-supporting; i.e, they rely primarily on loans, their own funds, or family funds for financial support. The other approximately two-thirds receive primary financial support from a variety of sources, including the federal government, university sources, employers, nonprofit organizations, and foreign governments.

Support mechanisms include research assistantships (RAs), teaching assistantships (TAs), fellowships, and traineeships. Sources of funding include federal agency support, nonfederal support, and self-support. Nonfederal support includes state funds, particularly in the large public university systems; these funds are affected by the condition of overall state budgets. Most graduate students, especially those who pursue doctoral degrees, are supported by more than one source or mechanism during their time in graduate school, and some receive support from several different sources and mechanisms in any given academic year.

Other than self-support (37%), RAs are the most prevalent primary mechanism of financial support for all full-time S&E graduate students. In 2009, 27% of full-time S&E graduate students were supported primarily by RAs, 18% were supported primarily through TAs, and 12% relied primarily on fellowships or traineeships (table 2-4).

Primary mechanisms of support differ widely by S&E field of study (appendix table 2-5). For example, in fall 2009, full-time students in physical sciences were financially supported mainly through RAs (42%) and TAs (38%) (figure 2-4, appendix table 2-5). RAs also were important in agricultural sciences (51%); earth, atmospheric, and ocean sciences (40%); biological sciences (39%); and engineering (40%). In computer science, more than half (51%) of full-time students were supported primarily through TAs and another 22% were self-supported. Full-time students in mathematics and the social and behavioral sciences were mainly self-supporting (48% respectively) or received TAs (15% and 19% respectively). Students in medical/other life sciences were mainly self-supporting (62%).

The federal government plays a substantial role in supporting S&E graduate students through some mechanisms in some fields, and a smaller role in others. Federal financial support for graduate education reaches relatively more students in the biological sciences; the physical sciences;

Table 2-4
Full-time S&E graduate students, by source and mechanism of primary support: 2009

Source	All	Research assistantship	Fellowship	Traineeship	Teaching assistantship	Other	Self-support[a]
				Number			
All sources	441,743	120,008	38,115	12,799	78,317	29,791	162,713
Federal	81,205	58,341	8,592	8,068	1,248	4,956	NA
Nonfederal	197,825	61,667	29,523	4,731	77,069	24,835	NA
				Percent			
All sources	100.0	27.2	8.6	2.9	17.7	6.7	36.8
Federal	100.0	71.8	10.6	9.9	1.5	6.1	NA
Nonfederal	100.0	31.2	14.9	2.4	39.0	12.6	NA

NA = not available

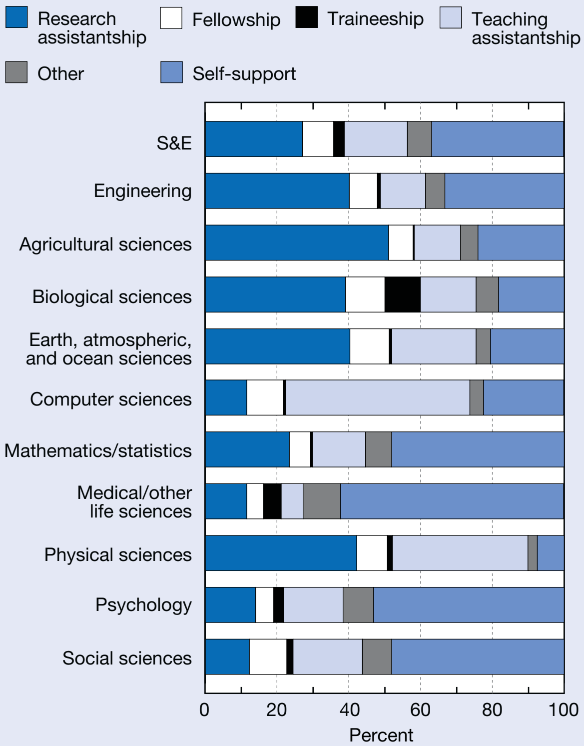
[a]Includes any loans (including federal) and support from personal or family financial contributions.

NOTES: S&E includes health fields (i.e., medical sciences and other life sciences). These fields reported separately in National Science Foundation, National Center for Science and Engineering Statistics, Graduate Students and Postdoctorates in Science and Engineering (annual series). S&E excludes fields that were collected in this survey (architecture, communication, and family and consumer sciences/human sciences) that are not included in other tables in this report from other data sources. Self-support not included in federal or nonfederal counts. Percentages may not add to 100% because of rounding.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Graduate Students and Postdoctorates in Science and Engineering, Integrated Science and Engineering Resources Data System (WebCASPAR), http://webcaspar.nsf.gov.

Science and Engineering Indicators 2012

Figure 2-4
Full-time S&E graduate students, by field and mechanism of primary support: 2009

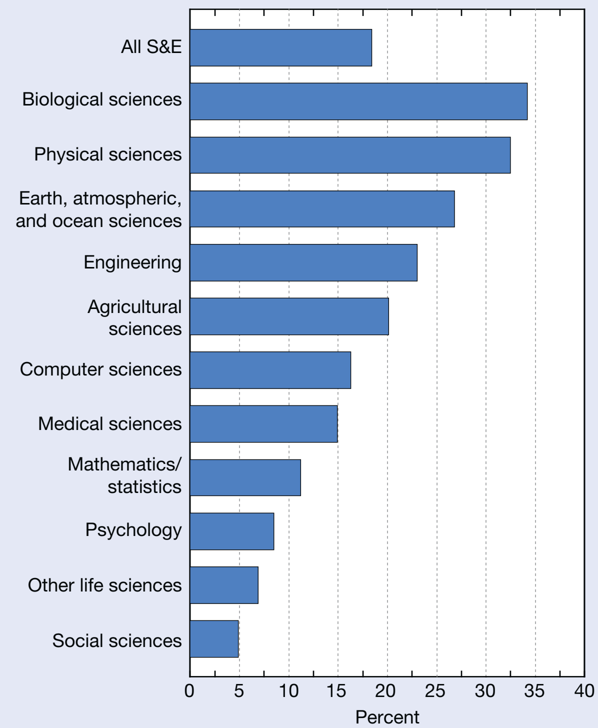


NOTE: Self-support includes any loans (including federal) and support from personal or family financial contributions.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, 2009 Survey of Graduate Students and Postdoctorates in Science and Engineering, WebCASPAR database, http://webcaspar.nsf.gov. See appendix table 2-5.

Science and Engineering Indicators 2012

Figure 2-5
Full-time S&E graduate students with primary support from federal government, by field: 2009



SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, 2009 Survey of Graduate Students and Postdoctorates in Science and Engineering, WebCASPAR database, http://webcaspar.nsf.gov. See appendix table 2-6.

Science and Engineering Indicators 2012

the earth, atmospheric, and ocean sciences; and engineering. Relatively fewer students in computer sciences, mathematics, other life sciences, psychology, and social sciences receive federal support (figure 2-5). Appendix table 2-6 provides detailed information by field and mechanism.

The federal government was the primary source of financial support for 18% of full-time S&E graduate students in 2009 (appendix table 2-6). In 2009, the federal government funded 63% of S&E graduate students on traineeships, 49% of those with RAs, and 23% of those with fellowships. Most federal financial support for graduate education is in the form of RAs funded through grants to universities for academic research. RAs are the primary mechanism of support for 72% of federally supported full-time S&E graduate students. Fellowships and traineeships are the means of funding for 21% of the federally funded full-time S&E graduate students. For students supported through nonfederal sources in 2009, TAs were the most prominent mechanism (39%) followed by RAs (31%) (table 2-4).

The National Institutes of Health (NIH) and NSF support most of the full-time S&E graduate students whose primary support comes from the federal government. In 2009, these institutions supported about 26,400 and 21,600 students respectively. NIH funded about 75% of such students in the biological sciences, 64% of those in the medical sciences, and 40% of those in psychology. NSF supported nearly 60% of students in computer sciences or mathematics; nearly 50% of those in earth, atmospheric, and ocean sciences; and 34% of those in engineering (appendix table 2-7).

For doctoral degree students, notable differences exist in primary support mechanisms by type of doctorate-granting institution. In 2009, RAs were the primary support mechanism for S&E doctorate recipients from research universities (i.e., doctorate-granting institutions with very high research activity, which receive the most federal funding). For those from medical schools, which are heavily funded by NIH, fellowships or traineeships accounted for the main source of support. Students at less research-intensive universities relied mostly on personal funds (table 2-5). These differences by type of institution hold for all S&E fields (NSF/NCSES 2000). As noted earlier in this chapter, the majority of S&E doctorate recipients (about 75%) received their doctorate from research universities with very high research activity.

Table 2-5
Primary support mechanisms for S&E doctorate recipients, by 2010 Carnegie classification of doctorate-granting institution: 2009

Mechanism	All institutions	Research universities (very high research activity)	Research universities (high research activity)	Doctoral/research universities	Medical schools and medical centers	Other/not classified
Doctorate recipients (*n*)	35,564	27,166	5,275	1,123	1,184	816
All mechanisms (%)	100.0	100.0	100.0	100.0	100.0	100.0
Fellowship or traineeship	21.9	23.6	13.6	12.9	32.9	14.5
Grant	5.9	6.1	3.3	1.6	16.3	4.3
Teaching assistantship	15.2	15.2	21.3	8.8	1.6	4.5
Research assistantship	32.6	35.7	26.3	10.1	25.8	13.0
Other assistantship	0.6	0.5	1.1	0.4	0.7	0.5
Personal	10.2	6.8	18.0	39.3	10.6	31.5
Other	3.1	2.6	4.8	6.8	3.3	4.4
Unknown	10.6	9.6	11.7	20.2	8.8	27.3

NOTES: Personal support mechanisms include personal savings, other personal earnings, other family earnings or savings, and loans. Traineeships include internships and residency. Other support mechanisms include employer reimbursement or assistance, foreign support, and other sources. Percentages may not add to 100% because of rounding.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2010) of Survey of Earned Doctorates.

Science and Engineering Indicators 2012

Notable differences also exist in primary support mechanisms for doctoral degree students by sex, race/ethnicity, and citizenship. In 2009, among U.S. citizens and permanent residents, men were more likely than women to be supported by RAs (29% compared with 22%) and women were more likely than men to support themselves from personal sources (19% compared with 12%). Also, among U.S. citizens and permanent residents, whites and Asians were more likely than other racial/ethnic groups to receive primary support from RAs (27% and 33%, respectively), whereas underrepresented minorities depended more on fellowships or traineeships (38%). The primary source of support for doctoral degree students with temporary visas was an RA (50%) (appendix table 2-8).

To some extent, the sex, citizenship, and racial/ethnic differences in types of support mechanisms are related to differences in field of study. White and Asian men, as well as foreign doctoral degree students, are more likely than white and Asian women and underrepresented minority doctoral degree students of both sexes to receive doctorates in engineering and physical sciences, fields largely supported by RAs. Women and underrepresented minorities are more likely than other groups to receive doctorates in social sciences and psychology, fields in which self-support is prevalent. However, differences in type of support by sex, race/ethnicity, or citizenship remain, even after accounting for doctorate field (NSF/NCSES 2000, NSB 2010).

Debt Levels of S&E Graduate Students. At the time of doctoral degree conferral, 45% of S&E doctorate recipients have debt related to their undergraduate or graduate education. In 2009, 27% of S&E doctorate recipients reported having undergraduate debt and 32 % reported having graduate debt. For some, debt levels were high, especially for graduate debt: 4% reported more than $40,000 of undergraduate debt and 6% reported more than $70,000 of graduate debt (appendix table 2-9).

Levels of debt vary widely by doctorate field. In 2009, high levels of graduate debt were most common among doctorate recipients in psychology, social sciences, and medical/other health sciences. Psychology doctorate recipients were most likely to report having graduate debt and also high levels of debt.[6] In 2009, 20% of psychology doctoral degree recipients reported graduate debt of more than $70,000. Doctorate recipients in mathematics; computer sciences; physical sciences; engineering; biological sciences; and earth, atmospheric, and ocean sciences were least likely to report graduate debt. A higher percentage of doctorate recipients in non-S&E fields (49%) than those in S&E fields (32%) reported graduate debt.

Although men and women differed little in level of debt, U.S citizens and permanent residents accumulated more debt than temporary visa holders, and blacks and Hispanics had higher levels of graduate debt than whites, even accounting for differences in field of doctorate (NSF/NCSES 2010b).

The proportion of S&E master's recipients with debt increased between 2000 and 2008 (table 2-6). In 2000, about 40% of all master's students had incurred debt while studying for their master's degree, with no meaningful differences between those in S&E and non-S&E. By 2008, this proportion had increased to 51% among S&E master's recipients and 58% among those in non-S&E fields. Among graduates who had incurred debt, there was a statistically significant increase in the amount of the debt for those in non-S&E fields, but not for S&E students.[7]

Table 2-6
Master's degree recipients with debt from graduate student loans upon graduation and average amount owed, by broad field: 1999–2000 and 2007–08

Field	1999–2000[a] With debt from master's degree program (%)	1999–2000[a] Average amount owed (constant 2000 dollars)[c]	2007–08[b] With debt from master's degree program (%)	2007–08[b] Average amount owed (constant 2000 dollars)[c]
All fields	40.1	23,366	53.8	28,375
S&E	41.1	22,954	51.3	27,282
Non-S&E	40.2	22,452	57.9	30,000

[a]Data as of late 2000.
[b]Data as of late 2008.
[c]Average excludes respondents who did not owe any money from their master's degree program upon graduation.

NOTE: Debt is total amount owed on all loans for graduate education.

SOURCE: U.S. Department of Education, National Center for Education Statistics, special tabulations (2011) of 1999–2000 and 2007–08 National Postsecondary Student Aid Study (NPSAS: 2000 and NPSAS: 2008), http://nces.ed.gov/datalab/index.aspx.

Science and Engineering Indicators 2012

Undergraduate Education, Enrollment, and Degrees in the United States

Undergraduate education in S&E courses prepares students majoring in S&E for the workforce. It also prepares nonmajors to become knowledgeable citizens with a basic understanding of science and mathematics concepts. This section includes indicators related to enrollment and intentions to major in S&E fields, recent trends in the number of earned degrees in S&E fields, and persistence and retention in undergraduate education and in S&E.

Undergraduate Enrollment in the United States

Recent trends in higher education enrollment reflect the expanding U.S. college-age population. This section examines trends in undergraduate enrollment by type of institution, field, and demographic characteristics. For information on enrollment rates of high school seniors, see chapter 1, "Transition to Higher Education."

Overall Enrollment

Over the last 15 years studied, enrollment in U.S. institutions of higher education at all levels rose from 14.5 million students in fall 1994 to 20.7 million in fall 2009, with most of the growth occurring in the last 10 years (appendix table 2-10). In 2009, the types of institutions enrolling the most students were associate colleges (8.2 million, 40% of all students enrolled), master's colleges/universities (4.7 million, 23%), and doctorate-granting universities with very high research activity (2.8 million, 14%). Between 1994 and 2009, enrollment nearly doubled at doctoral/research universities and increased by about 50% or more at associate's colleges, master's colleges, and medical schools/medical centers (appendix table 2-10). (See sidebar "Carnegie Classification of Academic Institutions" for definitions of the types of academic institutions.) These trends are expected to continue for the near future.

On the basis of demographics, household income, and age-specific unemployment rates,[8] NCES projects that undergraduate enrollment in higher education will increase 16% between 2008 and 2019 (NCES 2011c).[9] According to Census Bureau projections, the number of college-age individuals (ages 20–24) is expected to grow from 21.8 million in 2010 to 28.2 million by 2050 (appendix table 2-11). Enrollment of first-time freshmen is projected to increase by 13% between 2008 and 2019, although the number of high school graduates is projected to change little because of relatively flat numbers of 18-year-olds during this period (NCES 2011c).

Increased enrollment in higher education at all levels is projected to come mainly from minority groups, particularly Hispanics. Enrollment of all racial/ethnic groups is projected to increase, but the percentage for whites is projected to decrease from 63% in 2008 to 58% in 2019, whereas the percentages for blacks and Hispanics are projected to increase from 14% and 12% respectively, to 15% for both groups. (For further information on assumptions underlying these projections, see "Projection Methodology" in *Projections of Education Statistics to 2019* [NCES 2011c], http://nces.ed.gov/pubs2011/2011017.pdf, accessed 14 March 2011.)

Undergraduate Enrollment in S&E

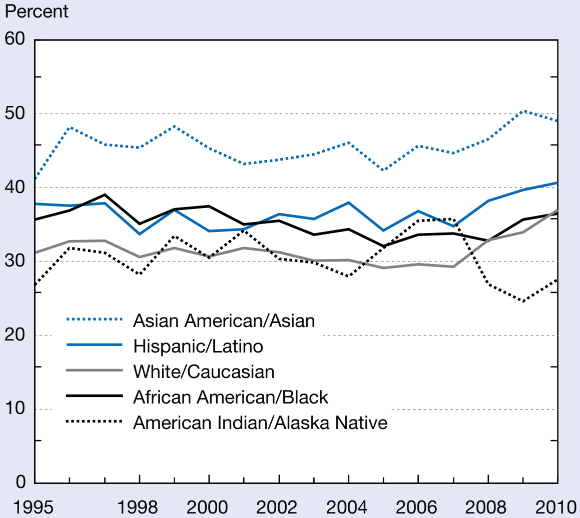
Freshmen Intentions to Major in S&E. Since 1972, the annual Survey of the American Freshman, National Norms, administered by the Higher Education Research Institute at the University of California–Los Angeles, has asked freshmen at a large number of universities and colleges about their intended majors.[10] The data have proven to be a broadly accurate picture of trends in degree fields several years later.[11] Between 1972 and 2007, about one-third of all freshmen planned to study S&E; this proportion gradually rose to 38% by 2010. Increases in the proportion of freshmen planning to major in biological/agricultural sciences in recent years account for most of this growth. In 2010, about 11% of freshmen intended to major in each of the following disciplines:

biological/agricultural sciences, social/behavioral sciences, and engineering. Between 1% and 3% intended to major in physical sciences, computer sciences, and mathematics/statistics (appendix table 2-12).

In 2010, about one in three white, black, and Hispanic freshmen; 28% of American Indian/Alaska Native freshmen; and 49% of Asian American/Asian freshmen reported that they intended to major in S&E (figure 2-6). The proportions planning to major in S&E were higher for men than for women in every racial/ethnic group (appendix table 2-12). For most racial/ethnic groups, about 10%–16% planned to major in social/behavioral sciences, about 6%–15% in engineering, about 9%–18% in biological/agricultural sciences, 2%–3% in computer sciences, 2%–3% in physical sciences, and 1% in mathematics or statistics. Higher proportions of Asian American/Asian freshmen than of those from other racial/ethnic groups p lanned to major in biological/agricultural sciences (18%) and engineering (15%). The percentage of all freshmen intending to major in computer sciences has dropped in recent years, whereas the percentage intending to major in biological/agricultural sciences has increased. (See appendix table 2-19 and the section on "S&E Bachelor's Degrees" for trends in bachelor's degrees.)

Generally, the percentages of students earning bachelor's degrees in particular S&E fields are similar to the percentages planning to major in those fields, with the exception of engineering and social/behavioral sciences. (See section on "Persistence and Retention in Undergraduate Education and S&E.") The percentage of students earning bachelor's degrees in engineering is smaller than the percentage planning to major in it for men and women as well as for all ethnic/racial groups, but the difference is larger for blacks (figures 2-7 and 2-8). The percentage earning bachelor's degrees in

Figure 2-6
Freshmen intending S&E major, by race/ethnicity: 1995–2010

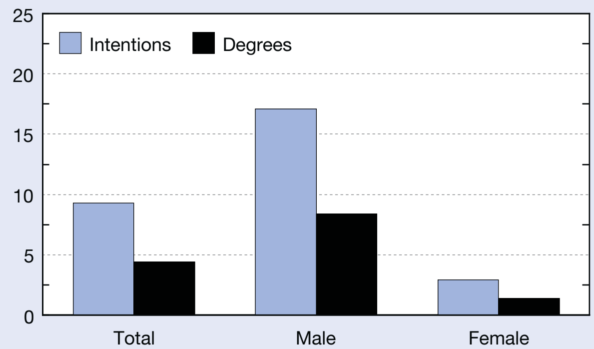


NOTES: In 2001 Native Hawaiian/Pacific Islander was added as a category under Asian American/Asian.

SOURCE: Higher Education Research Institute, University of California at Los Angeles, Survey of the American Freshman: National Norms, special tabulations (2011). See appendix table 2-12.

Science and Engineering Indicators 2012

Figure 2-7
Engineering: Freshmen intentions and degrees, by sex

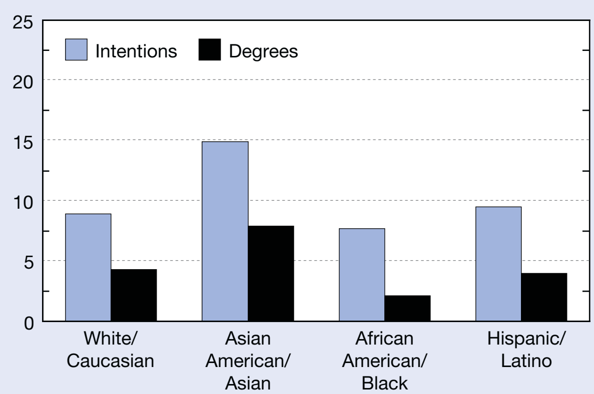


NOTES: Data for freshmen intentions are for 2003; data for degrees are for 2009. Degrees do not reflect the same student cohort.

SOURCES: Higher Education Research Institute, University of California at Los Angeles, Survey of the American Freshman: National Norms, special tabulations (2011); National Center for Education Statistics, Integrated Postsecondary Education Data System, Completions Survey; and National Science Foundation, National Center for Science and Engineering Statistics, WebCASPAR database, http://webcaspar.nsf.gov. See appendix tables 2-12 and 2-18.

Science and Engineering Indicators 2012

Figure 2-8
Engineering: Freshmen intentions and degrees, by race/ethnicity



NOTES: Data for freshmen intentions are for 2003; data for degrees are for 2009. Degrees do not reflect the same student cohort. Asian American/Asian includes Native Hawaiian/Pacific Islander.

SOURCES: Higher Education Research Institute, University of California at Los Angeles, Survey of the American Freshman: National Norms, special tabulations (2011); National Center for Education Statistics, Integrated Postsecondary Education Data System, Completions Survey; and National Science Foundation, National Center for Science and Engineering Statistics, WebCASPAR database, http://webcaspar.nsf.gov. See appendix tables 2-12 and 2-19.

Science and Engineering Indicators 2012

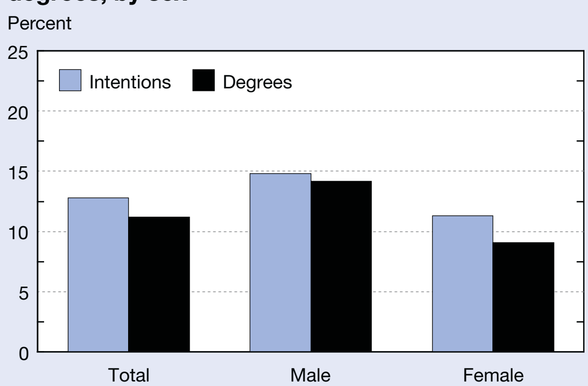
social/behavioral sciences is larger than previous years' percentages planning to major in those fields. The proportion earning bachelor's degrees in the natural sciences is smaller than the proportion planning to major in these fields for women, blacks, and Hispanics (figures 2-9 and 2-10).

The demographic composition of students planning to major in S&E has become more diverse over time. The proportion of white students planning to major in S&E declined from 77% in 1995 to 71% in 2010. On the other hand, the proportion of Asian American/Asian students increased from 7% to 12% and the proportion of Hispanic students increased from 5% to 13%. American Indian/Alaska Native and black students accounted for roughly 2% and 11%, respectively, of freshmen intending to major in S&E in both 1995 and 2010 (appendix table 2-13).

Foreign Undergraduate Enrollment.[12] In the 2009–10 academic year, the number of foreign students enrolled in bachelor's degree programs in U.S. academic institutions rose 5% from the previous year, to approximately 206,000 (IIE 2010). This continues a 3-year trend in which foreign student enrollment has risen after a 4-year decline (between the 2001–02 and 2005–06 academic years). The number of foreign undergraduates enrolled in 2009–10 was 5% above the peak in 2001–02. Among new foreign undergraduates, enrollment decreased 3% in 2009–10, the first decline in 5 years following a 20% increase in 2008–09. The countries that accounted for the largest numbers of foreign undergraduates enrolled in a U.S. institution in 2009–10 were China (almost 40,000), South Korea (36,200), India (15,200), Canada (13,600), and Japan (13,100). The number of Chinese undergraduates increased 52% over the previous year, and the numbers of South Korean and Indian undergraduates decreased 2% and 3% respectively. Among all foreign students (undergraduate and graduate) in 2009–10, the number of those studying agricultural sciences increased 15%; engineering, 7%; and mathematics and computer sciences, 8%. The physical and life sciences decreased 1% compared with the preceding year (IIE 2010).

More recent data from the Bureau of Citizenship and Immigration Services show a 7% increase in undergraduate enrollment of S&E foreign students in the U.S. from November 2009 to November 2010, mostly in engineering, social sciences, and mathematics. China, South Korea, Canada, Japan, and India were among the top countries sending foreign undergraduates in fall 2010, and were also among the top countries sending foreign S&E undergraduates (figure 2-11; appendix table 2-14). Although Nepal and Saudi Arabia sent comparatively fewer total undergraduates, they were also among the top countries sending foreign undergraduates in S&E fields—more than Canada and Japan. About one-third of all foreign students in undergraduate programs at U.S. institutions are enrolled in S&E fields.[13] Undergraduate foreign enrollment in S&E has increased each year between 2006 and 2010, while growth in non-S&E fields has slowed down (table 2-7).

Figure 2-9
Natural sciences: Freshmen intentions and degrees, by sex

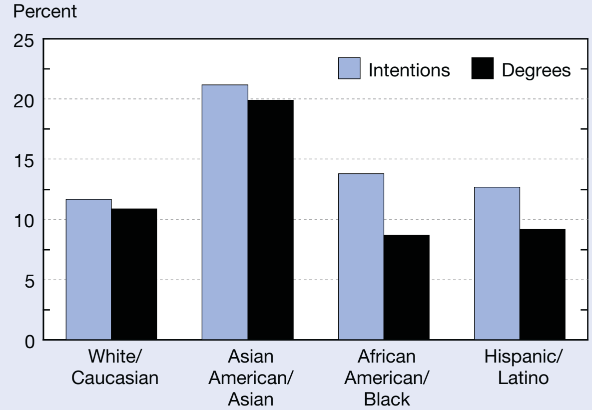


NOTES: Data for freshmen intentions are for 2003; data for degrees are for 2009. Degrees do not reflect the same student cohort.

SOURCES: Higher Education Research Institute, University of California at Los Angeles, Survey of the American Freshman: National Norms, special tabulations (2011); National Center for Education Statistics, Integrated Postsecondary Education Data System, Completions Survey; and National Science Foundation, National Center for Science and Engineering Statistics, WebCASPAR database, http://webcaspar.nsf.gov. See appendix tables 2-12 and 2-18.

Science and Engineering Indicators 2012

Figure 2-10
Natural sciences: Freshmen intentions and degrees, by race/ethnicity

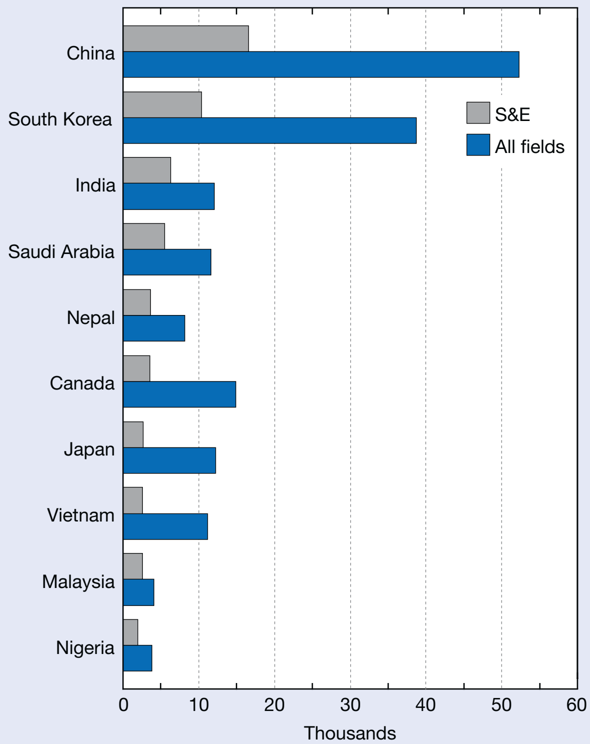


NOTES: Data for freshmen intentions are for 2003; data for degrees are for 2009. Degrees do not reflect the same student cohort. Asian American/Asian includes Native Hawaiian/ Pacific Islander.

SOURCES: Higher Education Research Institute, University of California at Los Angeles, Survey of the American Freshman: National Norms, special tabulations (2011); National Center for Education Statistics, Integrated Postsecondary Education Data System, Completions Survey; and National Science Foundation, National Center for Science and Engineering Statistics, WebCASPAR database, http://webcaspar.nsf.gov. See appendix tables 2-12 and 2-19.

Science and Engineering Indicators 2012

Figure 2-11
Foreign undergraduate student enrollment in U.S. universities, by top 10 places of origin and field: November 2010



SOURCE: Bureau of Citizenship and Immigration Services, Student and Exchange Visitor Information System database, special tabulations (2011). See appendix table 2-14.

Science and Engineering Indicators 2012

Engineering Enrollment. For the most part, students do not declare majors until their sophomore year, therefore, undergraduate enrollment data are not available by field. However, engineering is an exception. Engineering programs generally require students to declare a major in the first year of college, so engineering enrollment data can serve as an early indicator of both future undergraduate engineering degrees and student interest in engineering careers. The Engineering Workforce Commission administers an annual fall survey that tracks enrollment in undergraduate and graduate engineering programs (EWC 2010).

Undergraduate engineering enrollment was flat in the late 1990s, increased from 2000 to 2003, declined slightly through 2006, and rose for the next 3 years to a peak of 468,100 in 2009 (figure 2-12; appendix table 2-15). The number of undergraduate engineering students increased 15% between 2006 and 2009, with particularly steep increases in 2007 (7%) and 2009 (6%). Full-time freshman enrollment followed a similar pattern, reaching 114,700 in 2009—the highest since 1982. These trends correspond with declines in the college-age population through the mid-1990s, particularly the drop in white 20–24-year-olds, who account for the majority of engineering enrollment (NSF/NCSES 2011). Similar trends in undergraduate engineering enrollment are reported by the American Society for Engineering Education (Gibbons 2009).

Undergraduate Degree Awards

The number of undergraduate degrees awarded by U.S. academic institutions has been increasing over the past two decades in both S&E and non-S&E fields. These trends are expected to continue at least through 2019 (NCES 2011c).

Table 2-7
Foreign students enrolled in U.S. higher education institutions, by broad field and academic level: 2006–10

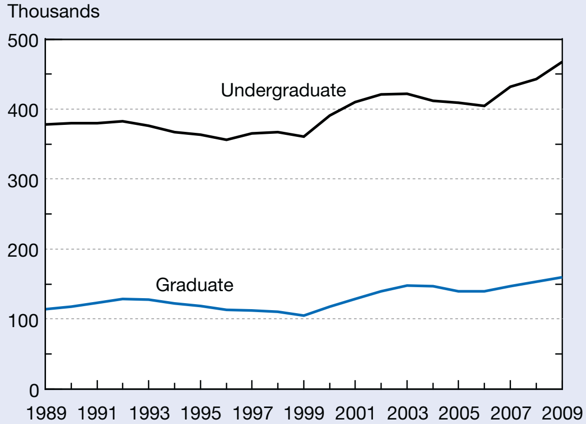
Level and field	2006	2007	2008	2009	2010
All fields					
All levels	525,470	548,090	568,400	585,510	592,790
Undergraduate	256,090	266,870	281,550	291,440	295,550
Graduate	269,380	281,210	286,840	294,070	297,240
S&E fields					
All levels	232,780	240,130	248,260	259,200	269,350
Undergraduate	74,740	77,150	81,700	86,950	93,230
Graduate	158,040	162,980	166,560	172,250	176,120
Non-S&E fields					
All levels	292,680	307,960	320,130	326,300	323,450
Undergraduate	181,340	189,730	199,850	204,480	202,320
Graduate	111,340	118,230	120,280	121,820	121,120

NOTES: Foreign doctorate recipients are those holding temporary visas. Undergraduate level includes associate's and bachelor's degrees; graduate level includes master's and doctoral degrees. Numbers rounded to nearest 10. Detail may not add to total because of rounding.

SOURCE: U.S. Department of Homeland Security, U.S. Immigration and Customs Enforcement, Student and Exchange Visitor Information System database, special tabulations (2010).

Science and Engineering Indicators 2012

Figure 2-12
U.S. engineering enrollment, by level: 1989–2009



NOTE: Enrollment data include full- and part-time students.

SOURCE: American Association of Engineering Societies, Engineering Workforce Commission, Engineering & Technology Enrollments (various years). See appendix tables 2-15 and 2-22.

Science and Engineering Indicators 2012

S&E Associate's Degrees

Community colleges often are an important and relatively inexpensive gateway for students entering higher education. Associate's degrees, largely offered by 2-year programs at community colleges, are the terminal degree for some, but others continue their education at 4-year colleges or universities and subsequently earn higher degrees.[14] Many who transfer to baccalaureate-granting institutions do not earn associate's degrees before transferring. Associate's degrees in S&E and engineering technology accounted for about 11% of all associate's degrees in 2009 (appendix table 2-16).

S&E associate's degrees from all types of academic institutions rose from 38,400 in 2000 to 62,800 in 2003, declined to 47,500 through 2007, and increased to 54,300 in 2009. The overall trend mirrors the pattern of computer sciences, which also peaked in 2003, declined through 2007, and increased through 2009. Associate's degrees earned in engineering technology (not included in S&E degree totals because of their applied focus) declined from about 40,500 in 2000 to 29,700 in 2006, but have since increased to 33,200 (appendix table 2-16).

In 2009, women earned 62% of all associate's degrees, up from 60% in 2000, and 40% of S&E associate's degrees, down from 48% in 2000. Most of the decline is attributable to a decrease in women's share of computer science degrees, from 42% in 2000 to 25% in 2009. In 2009, women's share of S&E associate's degrees rose slightly due largely to an increase in psychology degrees (appendix table 2-16).

Students from underrepresented groups (blacks, Hispanics, and American Indians/Alaska Natives) earn a higher proportion of associate's degrees than of bachelor's or more advanced degrees.[15] (See "S&E Bachelor's Degrees by Race/Ethnicity" and "Doctoral Degrees by Race/Ethnicity.") In 2009, underrepresented minorities earned 28% of S&E associate's degrees—more than one-third of all associate's degrees in social and behavioral sciences, and more than one-quarter of all associate's degrees in biological sciences, computer sciences, and mathematics (appendix table 2-17). In the last 10 years, the number of S&E associate's degrees earned by these students increased by 52%, compared with the overall national increase of 41%.

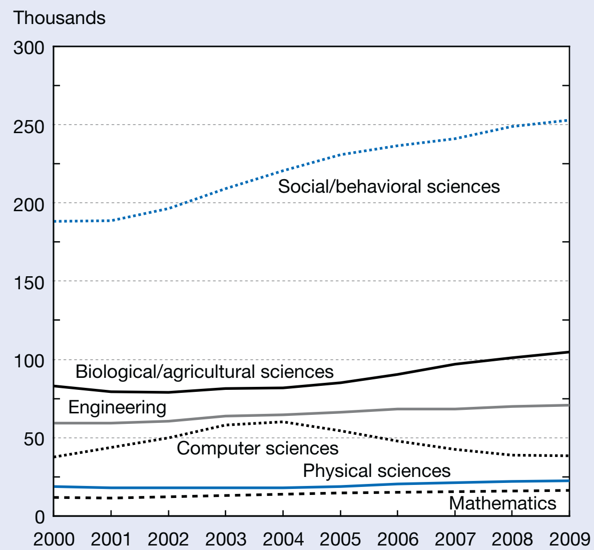
S&E Bachelor's Degrees

The baccalaureate is the most prevalent S&E degree, accounting for about 70% of all S&E degrees awarded. S&E bachelor's degrees have consistently accounted for roughly one-third of all bachelor's degrees for at least the past 10 years. The number of S&E bachelor's degrees awarded rose steadily from 399,000 in 2000 to 505,000 in 2009 (appendix table 2-18).

In the last decade, the number of bachelor's degrees awarded increased fairly consistently, though to different extents, in all S&E fields. The exception was computer sciences, where the number increased sharply from 1998 to 2004, dropped as sharply through 2008, and remained flat in 2009 (figure 2-13, appendix table 2-18).

S&E Bachelor's Degrees by Sex. Since 1982, women have outnumbered men in undergraduate education. They

Figure 2-13
S&E bachelor's degrees, by field: 2000–09



NOTE: Physical sciences include earth, atmospheric, and ocean sciences.

SOURCES: National Center for Education Statistics, Integrated Postsecondary Education Data System, Completions Survey; and National Science Foundation, National Center for Science and Engineering Statistics, WebCASPAR database, http://webcaspar.nsf.gov. See appendix table 2-18.

Science and Engineering Indicators 2012

have earned relatively constant fractions of all bachelor's and S&E bachelor's degrees for several years (see sidebar "Gender Gap in Undergraduate Enrollment"). Since the late 1990s, women have earned about 57% of all bachelor's degrees and about half of all S&E bachelor's degrees. Among U.S. citizens and permanent residents, women also earn about half of all S&E bachelor's degrees (NSF/NCSES 2011).

Within S&E, men and women tend to study different fields. In 2009, men earned a majority of bachelor's degrees awarded in engineering, computer sciences, and physics (82%, 82%, and 81%, respectively). Women earned half or more of the bachelor's degrees in psychology (77%), agricultural sciences (51%), biological sciences (60%), chemistry (50%), and social sciences (54%) (appendix table 2-18).

In the last 10 years studied, changes have not followed a consistent pattern. The share of bachelor's degrees awarded to women declined in computer sciences (by 10%), mathematics (by 5%), and engineering (by 2%) (figure 2-14). Fields where the proportion of bachelor's degrees awarded to women grew during this period include astronomy (from 34% to 44%), atmospheric sciences (from 23% to 33%), agricultural sciences (from 46% to 51%), chemistry (from 47% to 50%), and anthropology (from 67% to 70%) (appendix table 2-18).

The number of bachelor's degrees awarded to men and women in S&E and in all fields increased in similar proportions between 2000 and 2009.[16]

S&E Bachelor's Degrees by Race/Ethnicity. The racial/ethnic composition of S&E bachelor's degree recipients has changed over time, reflecting population changes and increasing college attendance by members of minority groups.[17] Between 2000 and 2009, the proportion of S&E degrees awarded to white students among U.S. citizens and permanent residents declined from 71% to 66%, although the number of S&E bachelor's degrees earned by white students increased during that time (figure 2-15, appendix table 2-19). The proportion awarded to Hispanic students increased from 7% to 9% and to Asians/Pacific Islanders from 9% to 10%. The shares to black and American Indian/Alaska Native students have remained flat since 2000. The number of S&E bachelor's degrees earned by students of unknown race/ethnicity also increased.

Despite considerable progress over the past couple of decades for underrepresented minority groups earning

Gender Gap in Undergraduate Education

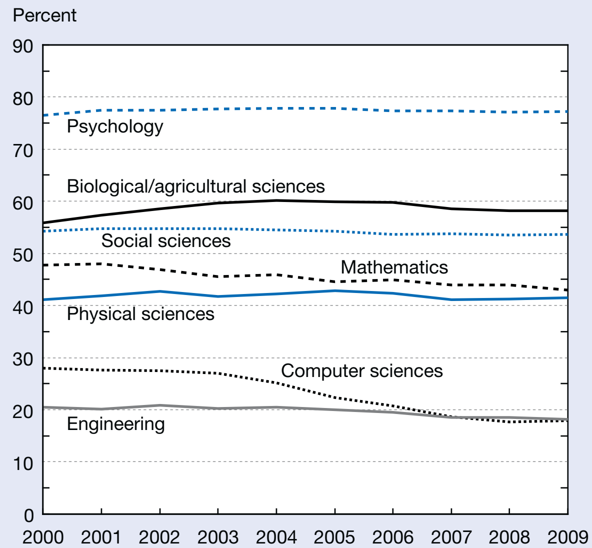
A sizeable gender gap in college enrollment emerged in the 1980s and has widened since. By 1980, women achieved parity with men, receiving half of all college degrees. By 1990, women received 54% of college degrees and by the end of the millennium, 58%. The latest update of the American Council on Education (ACE) publication *Gender Equity in Higher Education* (King 2010) reports that the gender gap in the United States has largely stabilized.

According to disaggregated data from ACE, the size of the gender gap varies with race, ethnicity, age, income, and the financial independence of students pursuing higher education. It is close to zero among affluent families with parents who pay for their children's higher education. It is much larger for blacks and Hispanics, for low income families, and for independent students who pay for their own education.

Several indicators point to the stabilization of the gender gap. First, the distribution of enrollment and undergraduate degrees by gender has remained consistent since around 2000. Second, the number of bachelor's degrees awarded to both men and women is on the rise. Third, for most racial/ethnic groups, the percentage of traditional-age, male undergraduates has been stable.

Hispanics are the exception. Despite a large increase in the number of degrees awarded to Hispanics of both genders in recent years, the bachelor's degree attainment rate for Hispanic males is the lowest of any major racial/ethnic group (10%) and has not changed much since the mid-1990s. This is due to immigration. Foreign-born Hispanics complete high school and college at much lower rates than their native-born peers, in particular male immigrants, who represent one out of every three Hispanic young adults.

Figure 2-14
Women's share of S&E bachelor's degrees, by field: 2000–09

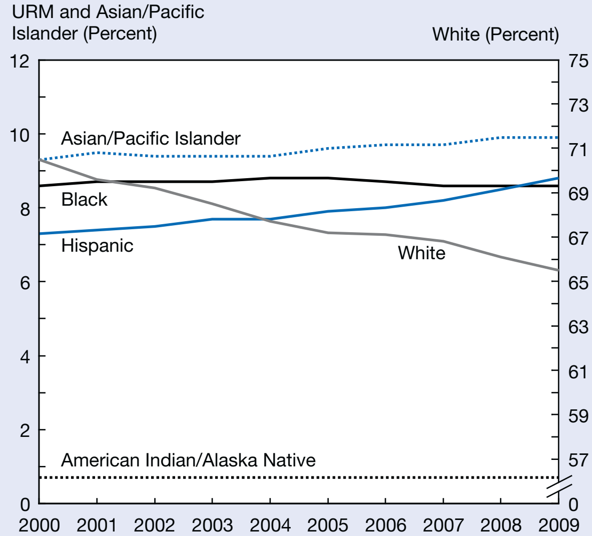


NOTE: Physical sciences include earth, atmospheric, and ocean sciences.

SOURCES: National Center for Education Statistics, Integrated Postsecondary Education Data System, Completions Survey; and National Science Foundation, National Center for Science and Engineering Statistics, WebCASPAR database, http://webcaspar.nsf.gov. See appendix table 2-18.

Science and Engineering Indicators 2012

Figure 2-15
Share of S&E bachelor's degrees, by race/ethnicity: 2000–09



URM = underrepresented minorities (black, Hispanic, and American Indian/Alaska Native)

SOURCES: National Center for Education Statistics, Integrated Postsecondary Education Data System, Completions Survey; and National Science Foundation, National Center for Science and Engineering Statistics, WebCASPAR database, http://webcaspar.nsf.gov. See appendix table 2-19.

Science and Engineering Indicators 2012

bachelor's degrees in any field, the gap in educational attainment between young minorities and whites continues to be wide. The percentage of the population ages 25–29 with bachelor's or higher degrees was 19% for blacks, 12% for Hispanics, and 37% for whites in 2009. These figures changed from 13%, 10%, and 26%, respectively, in 1989 (NCES 2010a). Differences in completion of bachelor's degrees in S&E by race/ethnicity reflect differences in high school completion rates, college enrollment rates, and college persistence and attainment rates. In general, blacks, Hispanics, and American Indian/Alaska Natives are less likely than whites and Asians/Pacific Islanders to graduate from high school, to enroll in college, and to graduate from college. (For information on immediate post-high school college enrollment rates, see chapter 1, "Transition to Higher Education.") Among those who do enroll in or graduate from college, blacks, Hispanics, and American Indians/Alaska Natives are about as likely as whites to choose S&E fields; and Asians/Pacific Islanders are more likely than members of other racial/ethnic groups to choose these fields. For Asians/Pacific Islanders, almost half of all bachelor's degrees received are in S&E, compared with about one-third of all bachelor's degrees earned by each of the other racial/ethnic groups. However, the proportion of Asians/Pacific Islanders earning degrees in the social sciences is similar to other racial/ethnic groups (appendix table 2-19).

The contrast in field distribution among whites, blacks, Hispanics, and American Indians/Alaska Natives on the one hand and Asians/Pacific Islanders on the other is apparent within S&E fields as well. White, black, Hispanic, and American Indian/Alaska Native S&E baccalaureate recipients share a similar distribution across broad S&E fields. In 2009, between 9% and 11% of all baccalaureate recipients in each of these racial/ethnic groups earned their degrees in the natural sciences,[18] 3%–4% in engineering, and 15%–18% in the social and behavioral sciences. Asian/Pacific Islander baccalaureate recipients earned 20% of their bachelor's degrees in natural sciences and 8% in engineering (appendix table 2-19).

For all racial/ethnic groups, the total number of bachelor's degrees, the number of S&E bachelor's degrees, and the number of bachelor's degrees in most S&E fields (with the exception of computer sciences) has generally increased since 2000 (appendix table 2-19). Across all racial/ethnic groups, the number of degrees in computer sciences increased considerably through 2003–04 and then sharply declined through 2008. Except for Asians/Pacific Islanders, whose numbers in computer sciences continued to fall in 2009, the decline in other racial/ethnic groups stabilized. In the case of Hispanics, the number of computer science degrees awarded increased.

Bachelor's Degrees by Citizenship. Since 2000, students on temporary visas in the United States have consistently earned a small share (3%–4%) of S&E degrees at the bachelor's level. These students earned a larger share of bachelor's degrees awarded in economics and in electrical and industrial engineering in 2009 (about 9%). The number of S&E bachelor's degrees awarded to students on temporary visas increased from about 15,200 in 2000 to about 18,800 in 2004, and then declined to 17,100 in 2009 (appendix table 2-19).

Persistence and Retention in Undergraduate Education (S&E Versus Non-S&E Fields)

Many students who start out in undergraduate programs drop out before completing a degree. This section examines differences between S&E and non-S&E students in persistence and completion of higher education.

S&E students persist and complete undergraduate programs at a higher rate than non-S&E students. Six years after enrollment in a 4-year college or university in the 2003–04 academic year, 63% of S&E students had completed a bachelor's degree by spring 2009, compared to 55% of non-S&E students. About 12% of both S&E and non-S&E students were still enrolled and about 24% had not completed any degree and were no longer enrolled. Within S&E fields, persistence and completion is higher in agricultural, biological, and social sciences than in mathematics, and physical and computer sciences (table 2-8).

The number of undergraduates who switch out of S&E fields is lower than entry into S&E fields as a whole. Because many students begin college in the large pool of non-S&E and undeclared majors, even the relatively small proportion who later switch to S&E constitutes a large number. Among postsecondary students who began at 4-year

Table 2-8
Persistence and outcome of postsecondary students beginning 4-year colleges or universities in 2004: 2009

		Cumulative persistence outcome, 2009 (%)			
Major in 2004	Number	Bachelor's	Associate's or certificate	Still enrolled	No longer enrolled
All majors	1,657,800	57.8	6.2	12.2	23.7
S&E	397,500	63.3	4.5	11.7	20.5
Agricultural/biological sciences	80,600	71.4	3.1	10.2	15.3
Physical/math/computer sciences	85,300	51.7	7.4	11.3	29.5
Engineering	107,300	60.8	4.5	14.2	20.5
Social/behavioral sciences	124,300	62.4	3.4	14.7	19.1
Non-S&E	790,900	55.2	7.3	13.0	24.5
Missing/undeclared	469,400	57.5	5.9	11.3	25.3

NOTE: Physical sciences include earth, atmospheric, and ocean sciences. Social sciences include history.

SOURCE: U.S. Department of Education, National Center for Education Statistics, 2003–04 Beginning Postsecondary Students Longitudinal Study, Second Follow-Up (BPS:04/09), http://nces.ed.gov/datalab/index.aspx.

Science and Engineering Indicators 2012

colleges or universities in 2003–04, 25% reported an S&E major, 47% reported a non-S&E major, and 28% were missing data on major or had not declared a major. In cases where data on major were available, 35% reported an S&E major. Six years later, among those who had attained a bachelor's degree, 34% were S&E majors. Although about 28% of agricultural/biological sciences majors, 31% of mathematics/physical/computer sciences majors, 22% of engineering majors, and 32% of social sciences majors eventually switched to non-S&E majors before earning a bachelor's degree, 35% of those with initially missing or undeclared majors and 15% of those with initial non-S&E majors switched into S&E fields before earning their bachelor's degrees (table 2-9).

Within S&E fields, undergraduate attrition out of agricultural/biological sciences, mathematics/physical/computer sciences, and engineering is greater than transfers into those fields, but transfers into social/behavioral sciences are greater than attrition. One in ten engineering majors switched into a mathematics/physical/computer sciences major.

Among postsecondary students who began at 4-year colleges or universities in 2003–04 for whom data are available and who reported a major, 7% reported an agricultural/biological sciences major or a mathematics/physical/computer sciences major respectively, 10% reported an engineering major, 11% reported a social/behavioral sciences major, and 65% reported a non-S&E major. Six years later, among those who had attained a bachelor's degree, 7% were agricultural/biological sciences majors, 6% were mathematics/physical/computer sciences majors, 6% were engineering majors, 16% were social/behavioral sciences majors, and 64% were non-S&E majors.

Table 2-9
Field switching among postsecondary students beginning 4-year colleges and universities in 2004: 2009

		Major when last enrolled in 2009 (%)					
Major in 2004	Number	Agricultural/ biological sciences	Physical/math/ computer sciences	Engineering	Social and behavioral sciences	Non-S&E	Undeclared/ not in degree program
All majors	1,387,700	6.8	5.7	5.8	15.5	60.7	5.6
S&E							
Agricultural/biological sciences	71,300	53.7	3.6	1.3	10.9	28.3	2.2
Physical/math/computer sciences	68,900	5.0	43.0	5.6	8.2	31.1	7.1
Engineering	95,500	2.7	10.1	55.9	3.5	22.3	5.4
Social/behavioral sciences	108,600	2.2	1.1	1.0	60.7	31.8	3.3
Non-S&E	651,500	3.5	2.5	1.5	7.7	79.4	5.4
Missing/undeclared	391,900	6.2	5.0	2.9	20.8	58.0	7.1

NOTES: Data excludes students who were not enrolled after July 2006, including those who had obtained their degree by that date. Physical sciences include earth, atmospheric, and ocean sciences. Social sciences include history.

SOURCE: U.S. Department of Education, National Center for Education Statistics, 2003–04 Beginning Postsecondary Students Longitudinal Study, Second Follow-Up (BPS:04/09), http://nces.ed.gov/datalab/index.aspx.

Science and Engineering Indicators 2012

Graduate Education, Enrollment, and Degrees in the United States

Graduate education in S&E contributes to global competitiveness, producing the highly skilled workers of the future and the research needed for a knowledge-based economy. In 2009, the Council of Graduate Schools and the Educational Testing Service formed a joint commission to investigate how graduate education can meet the challenges of the 21st century (see sidebar "The Path Forward: The Future of Graduate Education in the United States").

This section includes indicators related to graduate enrollment, recent trends in the number of earned degrees in S&E fields, and participation by women, minorities, and foreign students in graduate education in U.S. academic institutions.

Graduate Enrollment in S&E

There were 611,600 S&E graduate students enrolled in the United States in fall 2009; 48% of them were women (appendix table 2-20). The proportions of women graduate students enrolled in S&E differed considerably by field, with the lowest proportions in engineering (22%), computer sciences (26%), and physical sciences (33%). Women constituted the majority of graduate students in psychology (76%), medical/other life sciences (76%), biological sciences (57%), and social sciences (54%), and were close to half of graduate students in agricultural sciences (49%) and earth, atmospheric, and ocean sciences (46%). Among the social sciences, economics has an unusually low proportion of women (37%).

In 2009, underrepresented minority students (blacks, Hispanics, and American Indians/Alaska Natives) accounted for 12% of students enrolled in graduate S&E programs (appendix table 2-21). As a group, blacks, Hispanics, and American Indians/Alaska Natives made up 6%–7% of graduate enrollment in many S&E fields (engineering; mathematics; physical sciences; earth, atmospheric, and ocean sciences; and computer sciences), 9%–10% of graduate enrollment in agricultural and biological sciences, 15% in medical/other life sciences, 17% in social sciences, and 19% in psychology. Whites accounted for about 48% of S&E graduate enrollment in 2009 and Asians/Pacific Islanders for 6%.

Enrollment in engineering has been rising steadily in the last 20 years;[19] the number of full-time engineering students reached a new peak of 114,600 in 2009 (figure 2-12; appendix table 2-22). According to more recent data from the Engineering Workforce Commission and the American Society for Engineering Education (Gibbons 2009), graduate engineering enrollment continued to rise in 2009.

In 2009, approximately 130,000 full-time students were enrolled for the first time in S&E graduate programs—23% in engineering, 49% in the natural sciences, and 27% in the social and behavioral sciences (appendix table 2-23).

Foreign Student Enrollment

In 2009, 168,900 foreign students were enrolled in S&E graduate programs (appendix table 2-21). The concentration of foreign enrollment was highest in computer sciences, engineering, physical sciences, mathematics, and economics.[20] Those were also the fields with the highest share of enrollment of first-time, full-time S&E foreign graduate students (appendix table 2-23).

According to data collected by the Institute of International Education (IIE 2010), the overall number of

The Path Forward: The Future of Graduate Education in the United States

According to a 2010 report from the Commission on the Future of Graduate Education in the United States (Wendler et al. 2010), the main challenges facing graduate education and the U.S. educational system as a whole are as follows:

- In the future, larger numbers of children entering schools will come from families with less education. Consequently, fewer domestic students may have the levels of math and reading skills that will enable them to pursue higher education.
- Population growth by the year 2015 will result for the most part from international migration, according to estimates by the Census Bureau. This will result in a growing number of first generation college students, many of whom are likely to require additional educational preparation.
- The number of nontraditional students (students who are older, working adults) is growing. This population may see graduate education as a way to improve their employability rather than as a way to prepare for a first career.
- The level of degree attrition is high and time to degree is long, particularly for doctoral students.
- At the doctorate level, the decline in the availability of tenure track positions, which used to be an incentive for students who decided to pursue a doctorate, may result in many doctoral recipients looking for careers outside academia.

All of these changes indicate the need to reconsider how graduate students are financially supported and what kinds of additional resources they may need for success in graduate school. The changing demographics also may require a reconsideration of traditional time to degree expectations and career pathway opportunities.

foreign graduate students in all fields increased 4% from academic year 2008–09 to 2009–10. The number of new foreign graduate students declined slightly. India, China, South Korea, Taiwan, and Canada were the top countries/economies of origin for foreign graduate students.

More recent data from the Bureau of Citizenship and Immigration Services show a continuing increase in foreign graduate students from November 2009 to November 2010, with all of the increase occurring in S&E fields (table 2-7). About 60% of all foreign students in graduate programs at U.S. institutions were enrolled in S&E fields. In fall 2010, the number of foreign graduate students enrolled in S&E fields increased 2% over the previous year (appendix table 2-24). In absolute numbers, most of the growth was in computer sciences and engineering, but the increase in computer sciences was proportionately higher than in engineering. India and China accounted for nearly two-thirds of the foreign S&E graduates in the United States in November 2010. South Korea, Taiwan, and Turkey also sent large numbers of S&E graduate students, although South Korea and Taiwan sent far larger numbers of graduate students in non-S&E fields (primarily business and humanities).

S&E Master's Degrees

In some fields, such as engineering and geology, a master's degree is often the terminal degree for students. In other fields, master's degrees are a step toward doctoral degrees. Professional master's degree programs, which stress interdisciplinary training, are a relatively new direction in graduate education (for details on professional science master's degrees, see NSB 2010, page 2–22).

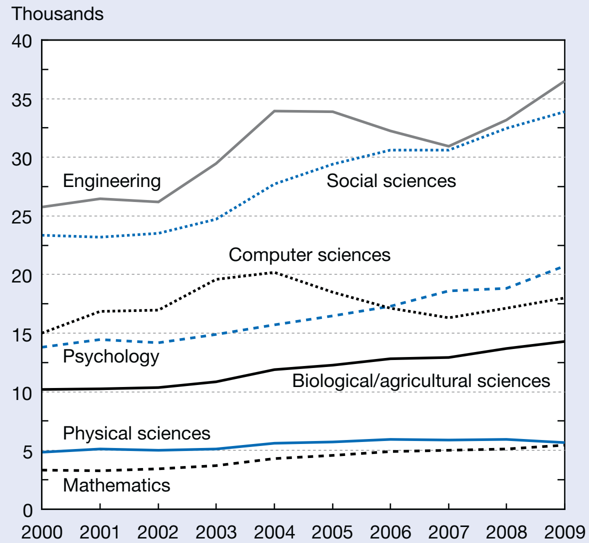
Master's degrees awarded in S&E fields increased from 96,200 in 2000 to about 120,900 in 2005, remained fairly consistent through 2007, but increased 12% in the years 2008–09 (appendix table 2-25). Since 2000, increases occurred in all major science fields. Master's degrees awarded in engineering and computer sciences declined between 2004 and 2007, but have since increased (figure 2-16).

Master's Degrees by Sex

The number of S&E master's degrees earned by both men and women rose between 2000 and 2009, but the number for women grew slightly faster (figure 2-17). In 2000, women earned 43% of all S&E master's degrees; by 2009, they earned 45% (appendix table 2-25). Among U.S. citizens and permanent residents, women earned about half of all S&E bachelor's degrees (NSF/NCSES 2011).

Women's share of S&E master's degrees varies by field. As with bachelor's degrees, in 2009, women earned a majority of master's degrees in psychology, biological sciences, social sciences, and agricultural sciences and a smaller share of master's degrees in engineering. Women's share of master's degrees in engineering in 2009, however, was slightly higher than their share in 2000 (appendix table 2-25). The number of master's degrees awarded to women in most major S&E fields increased fairly consistently throughout the last decade. In earth, atmospheric, and ocean sciences, and in the physical sciences, the numbers increased through 2006 but have since declined. In computer sciences, the numbers increased through 2004, declined sharply through 2007, but increased 14% in the years 2008–09.

Figure 2-16
S&E master's degrees, by field: 2000–09

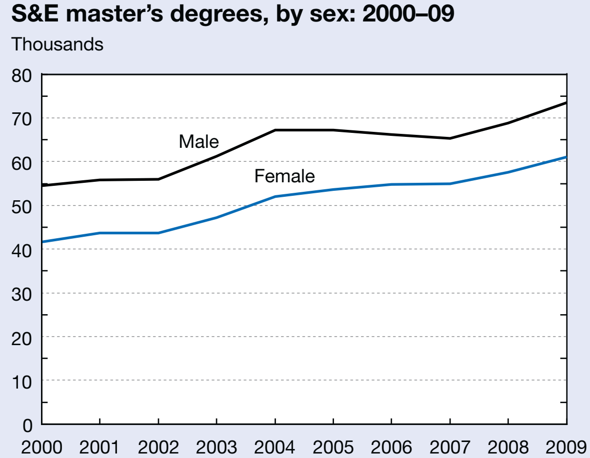


NOTE: Physical sciences include earth, atmospheric, and ocean sciences.

SOURCES: National Center for Education Statistics, Integrated Postsecondary Education Data System, Completions Survey; and National Science Foundation, National Center for Science and Engineering Statistics, WebCASPAR database, http://webcaspar.nsf.gov. See appendix table 2-25.

Science and Engineering Indicators 2012

Figure 2-17
S&E master's degrees, by sex: 2000–09



SOURCES: National Center for Education Statistics, Integrated Postsecondary Education Data System, Completions Survey; and National Science Foundation, National Center for Science and Engineering Statistics, WebCASPAR database, http://webcaspar.nsf.gov. See appendix table 2-25.

Science and Engineering Indicators 2012

Master's Degrees by Race/Ethnicity

The number of S&E master's degrees awarded to U.S. citizens and permanent residents increased for all racial/ethnic groups between 2000 and 2009 (figure 2-18; appendix table 2-26).[21]

The proportion of master's degrees in S&E fields earned by U.S. citizens and permanent residents from underrepresented racial and ethnic minorities increased slightly over the 10 years studied. Blacks accounted for 10% of master's degree recipients in 2009, up from 8% in 2000, Hispanics from 5% in 2000 to 7% in 2009, and American Indians/Alaska Natives from 0.5% to 0.6%. The proportion of Asian/Pacific Islander recipients remained flat in this period.

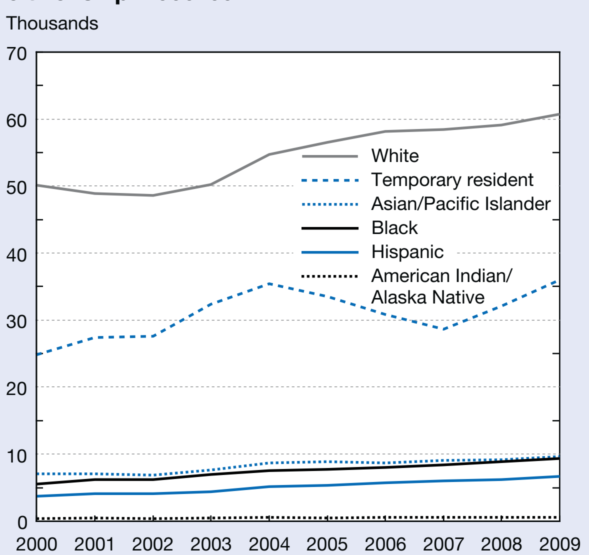
The percentage of S&E master's degrees earned by white students fell from 52% in 2000 to 45% in 2009, as the percentage of degrees earned by blacks, Hispanics, and temporary residents increased. The proportion of S&E master's degrees with other/unknown race increased from 5% to 9% between 2000 and 2009 (appendix table 2-26).

Master's Degrees by Citizenship

Foreign students make up a much higher proportion of S&E master's degree recipients than of bachelor's or associate's degree recipients. In 2009, foreign students earned 27% of S&E master's degrees. Their degrees were heavily concentrated in computer sciences, economics, and engineering, where they earned 46%, 45%, and 43%, respectively, of all master's degrees awarded in 2009 (appendix table 2-26). Within engineering, students on temporary visas earned more than half of the master's degrees in electrical and chemical engineering.

The number of S&E master's degrees awarded to students on temporary visas reached its highest point in the decade in 2009 (36,000), after a sharp decline between 2004 and 2007. Most of the drop during this time period was accounted for by decreases of temporary residents in the computer sciences and engineering fields, both of which rebounded by about one-third in the following 2 years.

Figure 2-18
S&E master's degrees, by race/ethnicity and citizenship: 2000–09



NOTE: Data on race/ethnicity include U.S. citizens and permanent residents.

SOURCES: National Center for Education Statistics, Integrated Postsecondary Education Data System, Completions Survey; and National Science Foundation, National Center for Science and Engineering Statistics, WebCASPAR database, http://webcaspar.nsf.gov. See appendix table 2-26.

Science and Engineering Indicators 2012

S&E Doctoral Degrees

Doctoral education in the United States prepares a new generation of faculty and researchers in academia, as well as a highly skilled workforce for other sectors of the economy. It also generates new knowledge important for the society as a whole and for U.S. competitiveness in a global knowledge-based economy. Over the years, numerous attempts have been made to measure the quality of doctoral education in the United States (Berelson 1960; Cartter 1966; NRC 1982; NRC 1995; Roose and Andersen 1970). For information on the latest assessment, see sidebar "The National Research Council Ratings: Measuring Scholarly Quality of Doctoral Programs."

The National Research Council Ratings: Measuring Scholarly Quality of Doctoral Programs

The National Research Council's *A Data-Based Assessment of Research Doctorate Programs in the United States* (NRC 2010), released in September 2010, is the latest attempt to measure the quality of U.S. doctoral education. The assessment sought to rely more heavily than past ratings on objective performance measures and to give less weight to faculty reputation. The study collected a wealth of data during the 2005–06 academic year, covering more than 5,000 programs in 62 fields at 212 universities.

Despite differences in the methodologies and the individual disciplines over time, the same universities—Harvard, Princeton, Stanford, University of California–Berkeley, MIT, and the California Institute of Technology—tend to have the top ranked departments (Jaschik 2010).

Not all observers agree that the latest ratings methodology is a clear improvement over past ratings. Major objections include (1) age of the data at the time of the release, (2) exclusion of books from the measure of faculty publication in some fields but not in others, and (3) disregard for the quality of the journals in which articles were published (Glenn 2010; Jaschik 2011).

The number of S&E doctorates conferred annually by U.S. universities increased rapidly between 2003 and 2007, but growth slowed in 2008, and the number declined slightly to 41,100 in 2009 (appendix table 2-27).[22] The growth through 2008 occurred among both U.S. citizens/permanent residents and temporary residents, although, in 2009, the number of temporary residents earning an S&E doctoral degree declined by about 4% (appendix table 2-28). The largest increases during the 2000–09 period were in engineering, biological/agricultural sciences, and medical/other life sciences (figure 2-19).

Time to Doctoral Degree Completion

The time required to earn a doctoral degree and the success rates of those entering doctoral programs are concerns for those pursuing a degree, the universities awarding the degree, and the agencies and organizations funding graduate study. Longer times to degree mean lost earnings and a higher risk of attrition. Time to degree (as measured by time from graduate school entry to doctorate receipt) increased through the mid-1990s but has since decreased in all S&E fields from 7.7 to 7.0 years (appendix table 2-29). The physical sciences, mathematics, biological sciences, and engineering had the shortest time to degree, while the social sciences and medical/other life sciences had the longest.

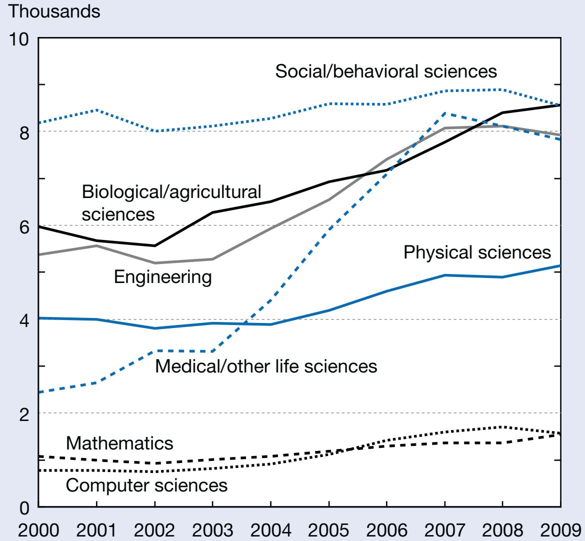
Between 1995 and 2009, time to degree for doctorate recipients decreased in each of the Carnegie types of academic institutions awarding doctoral degrees (see sidebar "Carnegie Classification of Academic Institutions"). Time to degree was shortest at research universities with very high research activity (6.9 years in 2009, down from 7.7 years in 1995). Doctorate recipients at medical schools also finished quickly (6.8 years in 2009). Time to degree was longer at universities less-strongly oriented toward research (table 2-10).

Doctoral Degrees by Sex

Among U.S. citizens and permanent residents, the proportion of S&E doctoral degrees earned by women grew consistently between 2000 and 2007 (from 45% to 55%), but decreased slightly in 2008 and 2009 (appendix table 2-27). During this decade, women made gains in most major fields, but considerable differences continued in certain fields. In 2009, women earned half or more of doctorates in non-S&E fields, in social/behavioral sciences, and in medical/other life sciences. However, they earned considerably fewer than half of the doctorates awarded in physical sciences (33%), mathematics/computer sciences (26%), and engineering (25%) (appendix table 2-27). Although the percentages of degrees earned by women in physical sciences and engineering are low, they are higher than those earned in 2000 (26% and 19% respectively).

The number of S&E doctoral degrees earned by women grew faster than that of men. The number of U.S. citizen and permanent resident women earning doctorates in S&E increased from 8,700 in 2000 to 15,000 in 2009, while the number earned by men increased from 10,700 to 12,800 in the same time interval (appendix table 2-27). The increase in the number of S&E doctorates earned by women occurred in most major S&E fields. For example, the number of engineering doctorates earned by U.S. citizen and permanent resident women increased from approximately 500 in 2000 to 900 in 2009, biological sciences doctorates from 1,700 to 2,800, physical sciences doctorates from 600 to 800, and medical and other life sciences doctorates from 1,300 to 5,300. A decrease in the number of doctorates earned by men in the early years of the decade occurred in non-S&E fields and in most S&E fields (except for medical/other life sciences). Since 2005, the number of doctorates earned by U.S. citizen and permanent resident men has increased in all major S&E fields except for agricultural sciences and psychology.

Figure 2-19
S&E doctoral degrees earned in U.S. universities, by field: 2000–09



NOTES: Physical sciences include earth, atmospheric, and ocean sciences. Data differ from doctoral degree data in other tables and figures in this report that are based on NSF Survey of Earned Doctorates and that refer to research doctorates only. Greatest differences are in psychology and medical/other life sciences.

SOURCES: National Center for Education Statistics, Integrated Postsecondary Education Data System, Completions Survey; and National Science Foundation, National Center for Science and Engineering Statistics, Integrated Science and Engineering Resources Data System (WebCASPAR), http://webcaspar.nsf.gov. See appendix table 2-27.

Science and Engineering Indicators 2012

Doctoral Degrees by Race/Ethnicity

The number and proportion of doctoral degrees in S&E fields earned by underrepresented minorities increased between 2000 and 2009. In 2009, blacks earned 1,451, Hispanics earned 1,335, and American Indians/Alaska Natives earned 154—accounting for 7% of all S&E doctoral degrees earned that year, up from 6% in 2000 (appendix table 2-28).[23] Their share of the S&E doctorates earned by

Table 2-10
Median number of years from entering graduate school to receipt of S&E doctorate, by 2010 Carnegie classification of doctorate-granting institution: 1995–2009

Year of doctorate	All institutions	Research universities (very high research activity)	Research universities (high research activity)	Doctoral/research universities	Medical schools and medical centers	Other/ not classified
1995	7.7	7.7	8.3	9.9	7.7	8.7
1996	7.7	7.7	8.6	9.2	7.7	8.7
1997	7.7	7.2	8.2	9.7	7.7	8.2
1998	7.3	7.2	8.2	9.2	6.9	7.7
1999	7.2	7.2	7.9	8.9	6.7	7.7
2000	7.5	7.2	8.2	9.2	7.2	7.9
2001	7.2	7.2	8.2	9.7	6.9	7.7
2002	7.5	7.2	8.2	9.9	6.9	7.7
2003	7.6	7.2	8.2	9.9	6.9	8.7
2004	7.2	7.0	8.0	9.2	6.9	7.6
2005	7.3	7.2	7.9	9.3	7.0	7.7
2006	7.2	7.0	7.9	9.0	6.9	7.5
2007	7.0	6.9	7.7	8.9	6.9	7.4
2008	7.0	6.9	7.7	8.9	6.7	7.4
2009	7.0	6.9	7.7	9.2	6.8	7.3

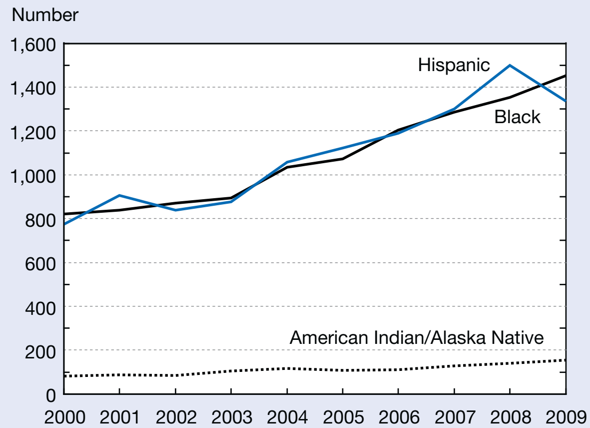
SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2010) of Survey of Earned Doctorates.

Science and Engineering Indicators 2012

U.S. citizens and permanent residents rose from 9% to 11% in the same period. Gains by all groups contributed to this rise, although the number of S&E degrees earned by blacks and Hispanics rose considerably more than the number earned by American Indians/Alaska Natives (figure 2-20). Asian/Pacific Islander U.S. citizens and permanent residents earned 6% of all S&E doctorates in 2009, similar to 2000.

The number of S&E doctorates earned by white U.S. citizens and permanent residents increased between 2000 and 2009. The number of S&E doctoral degrees earned by white U.S. citizen and permanent resident men declined through 2003, then gradually increased (figure 2-21). The number of degrees earned by white U.S. citizen and permanent resident women increased through 2007, but declined somewhat in 2008 and 2009. As the number of S&E doctorates awarded to minorities and temporary residents increased, the proportion of S&E doctoral degrees earned by white U.S. citizens and permanent residents decreased from 54% in 2000 to 49% in 2009 (appendix table 2-28).

Figure 2-20
S&E doctoral degrees earned by U.S. citizen and permanent resident underrepresented minorities, by race/ethnicity: 2000–09



NOTES: Data differ from doctoral degree data in other tables and figures in this report that are based on NSF Survey of Earned Doctorates and that refer to research doctorates only. Greatest differences are in psychology and medical/other life sciences.

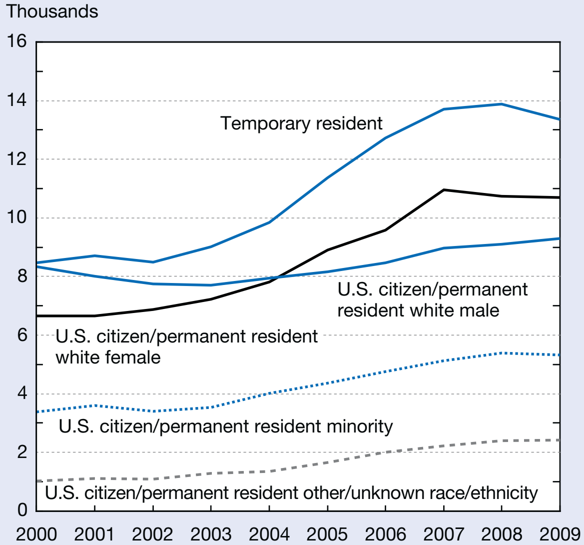
SOURCES: National Center for Education Statistics, Integrated Postsecondary Education Data System, Completions Survey; and National Science Foundation, National Center for Science and Engineering Statistics, Integrated Science and Engineering Resources Data System (WebCASPAR), http://webcaspar.nsf.gov. See appendix table 2-28.

Science and Engineering Indicators 2012

Foreign S&E Doctorate Recipients

Temporary residents earned approximately 13,400 S&E doctorates in 2009, up from 8,500 in 2000. Foreign students on temporary visas earned a larger proportion of doctoral degrees than master's, bachelor's, or associate's degrees (appendix tables 2-17, 2-19, 2-26, and 2-28). The temporary residents' share of S&E doctorates rose from 30% in 2000 to 33% in 2009. In some fields, foreign students earned sizeable shares of doctoral degrees. In 2009, foreign students on temporary visas earned half or more of doctoral degrees awarded in engineering, physics, computer sciences, and economics. They earned considerably lower proportions of doctoral degrees in other S&E fields, for example, 29% in biological sciences, 8% in medical/other life sciences, and 7% in psychology (appendix table 2-28).

Figure 2-21
S&E doctoral degrees, by sex, race/ethnicity, and citizenship: 2000–09



NOTES: Minority includes Asian/Pacific Islander, black, Hispanic, and American Indian/Alaska Native. Data differ from doctoral degree data in other tables and figures in this report that are based on NSF Survey of Earned Doctorates and that refer to research doctorates only. Greatest differences are in psychology and medical/other life sciences.

SOURCES: National Center for Education Statistics, Integrated Postsecondary Education Data System, Completions Survey; and National Science Foundation, National Center for Science and Engineering Statistics, Integrated Science and Engineering Resources Data System (WebCASPAR), http://webcaspar.nsf.gov. See appendix tables 2-27 and 2-28.

Science and Engineering Indicators 2012

Table 2-11
Foreign recipients of U.S. S&E doctorates, by country/economy of origin: 1989–2009

Country/economy	Number	Percent
All foreign recipients	223,245	100.0
Top 10 total	149,774	67.1
China	57,705	25.8
India	24,809	11.1
South Korea	21,846	9.8
Taiwan	17,848	8.0
Canada	7,193	3.2
Turkey	5,391	2.4
Thailand	4,003	1.8
Japan	3,806	1.7
Mexico	3,589	1.6
Germany	3,584	1.6
All others	73,471	32.9

NOTE: Foreign doctorate recipients include permanent and temporary residents.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2010) of Survey of Earned Doctorates.

Science and Engineering Indicators 2012

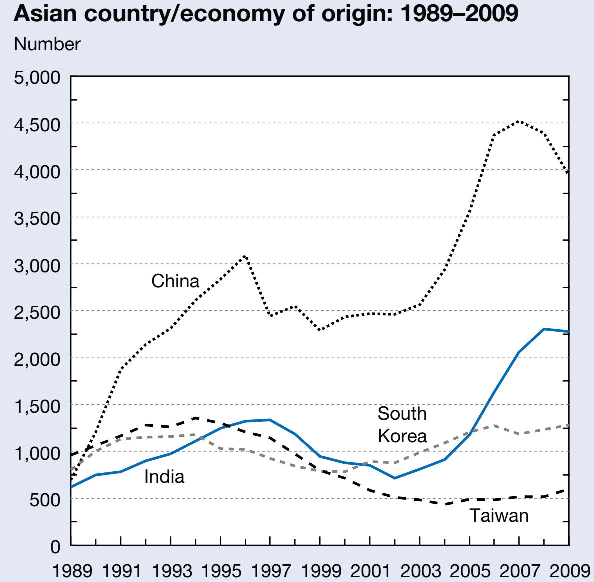
Countries/Economies of Origin

The top 10 foreign countries/economies of origin of foreign S&E doctorate recipients together accounted for 67% of all foreign recipients of U.S. S&E doctoral degrees from 1989 to 2009 (table 2-11). Six out of those top 10 locations are in Asia. The Asian countries/economies sending the most doctoral degree students to the United States have been, in descending order, China, India, South Korea, and Taiwan.

Asia. From 1989 to 2009, students from four Asian countries/economies (China, India, South Korea, and Taiwan) earned more than half of U.S. S&E doctoral degrees awarded to foreign students (122,200 of 223,200)—almost 4 times more than students from Europe (30,000). Most of these degrees were awarded in engineering, biological sciences, and physical sciences (table 2-12).

Students from China earned the largest number of U.S. S&E doctorates awarded to foreign students during the 1989–2009 period (57,700), followed by those from India (24,800), South Korea (21,800), and Taiwan (17,800) (table 2-11). The number of S&E doctorates earned by students from China dropped in the late 1990s, increased through 2007, but declined nearly 13% in the following 2 years (figure 2-22). Over the 20-year period, however, the number of S&E doctorates earned by Chinese nationals increased nearly 6 times.[24] The number of S&E doctorates earned by students from India also declined in the late 1990s, but has

Figure 2-22
U.S. S&E doctoral degree recipients, by selected Asian country/economy of origin: 1989–2009



NOTE: Degree recipients include permanent and temporary residents.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2010), Survey of Earned Doctorates.

Science and Engineering Indicators 2012

Table 2-12
Asian recipients of U.S. S&E doctorates, by field and country/economy of origin: 1989–2009

Field	Asia	China	India	South Korea	Taiwan
All fields	183,457	61,888	27,981	28,079	22,095
S&E	157,306	57,705	24,809	21,846	17,848
Engineering	58,557	38,903	13,847	13,356	9,992
Science	98,749	18,802	10,962	8,490	7,856
Agricultural sciences	5,905	1,726	632	838	678
Biological sciences	26,526	13,107	3,998	2,613	2,730
Computer sciences	8,462	2,831	2,147	937	916
Earth/atmospheric/ocean sciences	3,132	1,627	273	371	301
Mathematics	7,534	3,677	709	977	677
Medical/other life sciences	5,267	1,174	1,071	591	893
Physical sciences	22,581	11,220	2,851	2,627	1,867
Psychology	2,423	422	300	413	320
Social sciences	16,919	3,119	1,866	3,989	1,610
Non-S&E	26,151	4,183	3,172	6,233	4,247

NOTE: Includes permanent and temporary residents.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2010) of Survey of Earned Doctorates.

Science and Engineering Indicators 2012

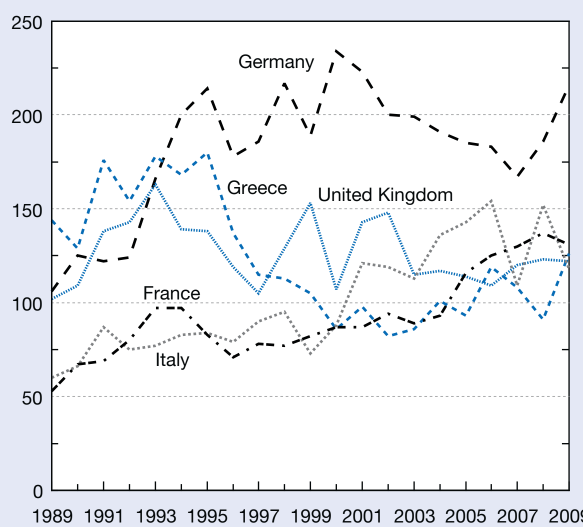
increased almost every year since 2002; over the last two decades it more than tripled. The number of S&E doctoral degrees earned by South Korean students also dipped in the late 1990s and then rose, but the number did not rise as dramatically as those for China and India. In 1989, students from Taiwan earned more U.S. S&E doctoral degrees than students from China, India, or South Korea. However, as universities in Taiwan increased their capacity for advanced S&E education in the 1990s, the number of students from Taiwan earning S&E doctorates from U.S. universities declined.

Europe. European students earned far fewer U.S. S&E doctorates than Asian students between 1989 and 2009, and they tended to focus less on engineering than did their Asian counterparts (tables 2-12 and 2-13). Western European countries whose students earned the largest number of U.S. S&E doctorates from 1989 to 2009 were Germany, the United Kingdom, Greece, Italy, and France, in that order. Individual country trends and patterns vary (figure 2-23).

The number of Central and Eastern European students earning S&E doctorates at U.S. universities increased from 74 in 1989 to more than 800 in 2009, approaching the number of those from Western Europe (figure 2-24). A higher proportion (87%) of Central and Eastern European doctorate recipients than of Western European or Scandinavian doctorate recipients (73% and 76% respectively) earned their doctorates in S&E fields, particularly in mathematics and physical sciences (table 2-13).

North America. Despite the proximity of Canada and Mexico to the United States, the shares of U.S. S&E doctoral degrees awarded to residents of these countries were

Figure 2-23
U.S. S&E doctoral degree recipients, by selected Western European country: 1989–2009



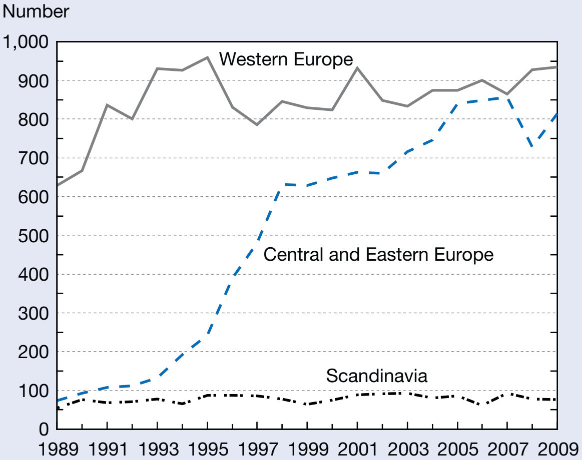
NOTE: Degree recipients include permanent and temporary residents.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2010), Survey of Earned Doctorates.

Science and Engineering Indicators 2012

small compared with those awarded to students from Asia and Europe. The number of U.S. S&E degrees earned by students from Canada doubled between 1989 and 2009, from about 240 to nearly 500. The number of doctoral degree recipients from Mexico increased through 2003, but has generally remained stable since then. In 2009, 193 S&E

Figure 2-24
U.S. S&E doctoral degree recipients from Europe, by region: 1989–2009



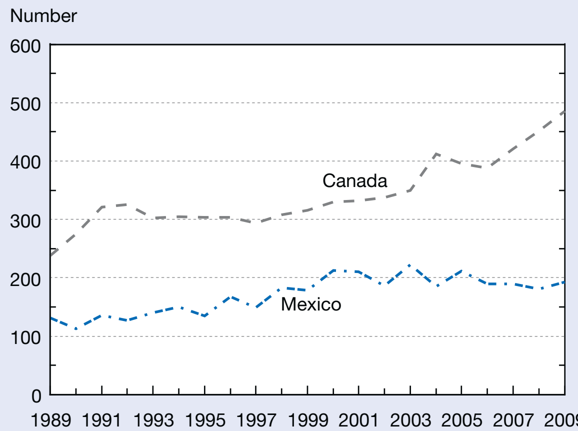
NOTES: Degree recipients include permanent and temporary residents. Western Europe includes Andorra, Austria, Belgium, France, Germany, Greece, Ireland, Italy, Liechtenstein, Luxembourg, Malta, Monaco, Netherlands, Portugal, San Marino, Spain, Switzerland, and United Kingdom. Central and Eastern Europe includes Albania, Armenia, Azerbaijan, Belarus, Bosnia-Herzegovina, Bulgaria, Croatia, Czech Republic, Estonia, Georgia, Hungary, Kazakhstan, Kosovo, Kyrgyzstan, Latvia, Lithuania, Macedonia, Moldova, Poland, Romania, Russia, Serbia-Montenegro, Slovakia, Slovenia, Tadjikistan, Turkmenistan, Ukraine, Uzbekistan, and Yugoslavia. Scandinavia includes Denmark, Finland, Iceland, Norway, and Sweden.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2010), Survey of Earned Doctorates.

Science and Engineering Indicators 2012

doctorate recipients from Mexico earned their degree in the United States (figure 2-25). A higher proportion of Mexican students (84%) than Canadian students (66%) earned U.S. doctorates in S&E fields (table 2-13). In particular, higher percentages of Mexican students than of Canadian students received U.S. doctoral degrees in engineering and agricultural sciences.

Figure 2-25
U.S. S&E doctoral degree recipients from Canada and Mexico: 1989–2009



NOTE: Degree recipients include permanent and temporary residents.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2010), Survey of Earned Doctorates.

Science and Engineering Indicators 2012

Table 2-13
European and North American recipients of U.S. S&E doctorates, by field and region/country of origin: 1989–2009

	Europe[a]				North America		
Field	All countries	Western	Scandinavia	Central/Eastern	All countries	Canada	Mexico
All fields	38,644	24,433	2,151	12,060	15,275	10,943	4,283
S&E	29,988	17,852	1,632	10,504	10,802	7,193	3,589
Engineering	5,876	3,741	291	1,844	1,859	1,035	824
Science	24,112	14,111	1,341	8,660	8,943	6,158	2,765
Agricultural sciences	828	606	59	163	854	266	588
Biological sciences	4,534	2,753	258	1,523	2,109	1,513	589
Computer sciences	1,621	868	75	678	337	235	101
Earth/atmospheric/ocean sciences	1,075	720	80	275	375	236	138
Mathematics	2,957	1,305	105	1,547	526	330	195
Medical/other life sciences	700	531	76	93	638	540	96
Physical sciences	6,068	2,956	220	2,892	1,164	873	289
Psychology	1,124	823	114	187	962	873	84
Social sciences	5,205	3,549	354	1,302	1,978	1,292	685
Non-S&E	8,656	6,581	519	1,556	4,473	3,750	694

[a]See figure 2-20 notes for countries included in Western Europe, Scandinavia, and Central/Eastern Europe.

NOTE: Includes permanent and temporary residents.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2010) of Survey of Earned Doctorates.

Science and Engineering Indicators 2012

International S&E Higher Education

In the 1990s, many countries expanded their higher education systems and access to higher education. At the same time, flows of students worldwide increased. More recently, a number of countries have adopted policies to encourage the return of students who studied abroad, to attract foreign students, or both.

Higher Education Expenditures

Increasingly, governments around the world have come to regard movement toward a knowledge-based economy as key to economic progress. Realizing that this requires a well-trained workforce, they have invested in upgrading and expanding their higher education systems and broadening participation. In most instances, government spending underwrites these initiatives. One indicator of the importance of higher education is the percentage of a nation's resources devoted to higher education, as measured by expenditures on tertiary education (education beyond high school) as a percentage of gross domestic product (GDP). In 2007, U.S. expenditures on tertiary education as a percentage of GDP were double the OECD average. The United States, Canada, and Korea spent the highest percentage of GDP on higher education (appendix table 2-30).

Another indicator of the growing importance of higher education is the change in expenditures for higher education over time. Expenditures for tertiary education rose more in the United States than in many other OECD countries between 1995 and 2000, but less in the United States than in other OECD countries between 2000 and 2007. From 1995 to 2000, educational expenditures in the United States increased faster than the OECD average and faster than most OECD countries. From 2000 to 2007, educational expenditures in the United States increased at a rate similar to the OECD average. During this period, several countries, including the United Kingdom and Poland, exceeded the OECD average increase in expenditures (appendix table 2-30).

Higher education funding data can vary between countries for reasons unrelated to actual expenditures, such as changes in measurement, prevalence of public versus private institutions (private institutions are much more prevalent in the United States than in other countries), types and levels of government funding included, and types and levels of education included. In several European countries, governments plan to cut their investments in higher education as a result of the global recession and fiscal crisis; the results of these policies remain to be seen.

Educational Attainment

Higher education in the United States expanded greatly after World War II and, for several decades, the United States' population led the world in educational attainment. In the 1990s, many countries in Europe and Asia also began to expand their higher education systems. Although the United States continues to be among those countries with the highest percentage of the population ages 25–64 with a bachelor's degree or higher, several other countries have surpassed the United States in the percentage of the younger population (ages 25–34) with a bachelor's degree or higher (figure 2-26; appendix table 2-31).[25]

First University Degrees in S&E Fields

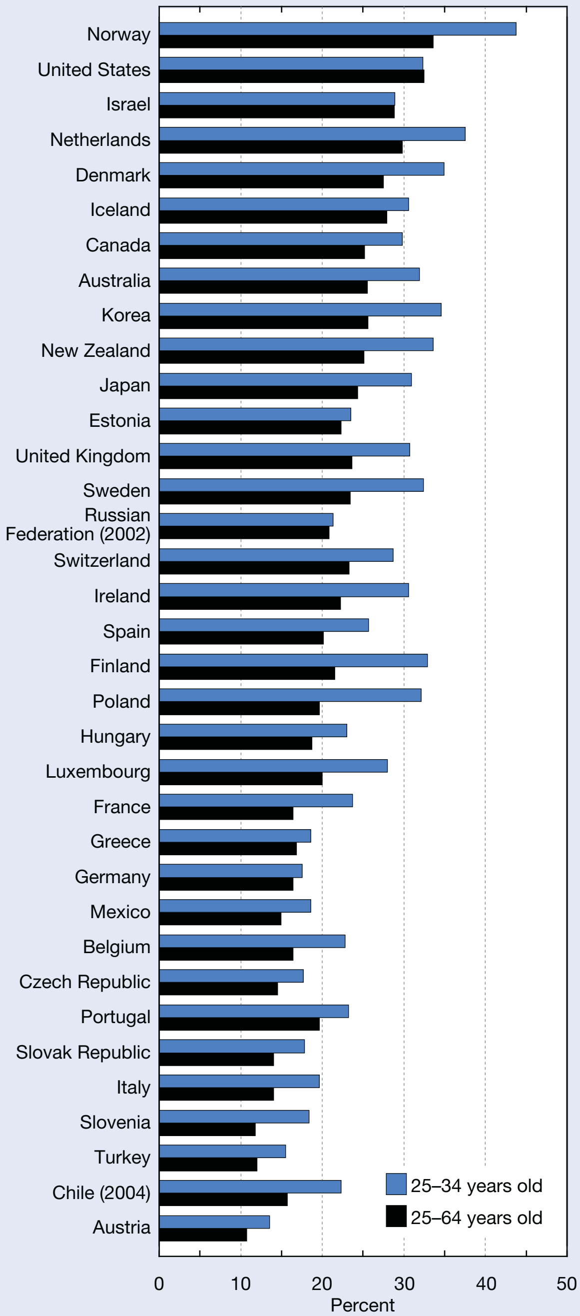
More than 14 million students worldwide earned first university degrees[26] in 2008, with about 5 million of these in S&E fields (appendix table 2-32). These worldwide totals include only countries for which relatively recent data are available (primarily countries in Asia, Europe, and the Americas) and are, therefore, an underestimation. Asian universities accounted for 2.4 million of the world's S&E first university degrees in 2008, more than 1 million of these in engineering. Students across Europe (including Eastern Europe and Russia) earned more than 1.2 million S&E degrees, and students in North and Central America earned nearly 700,000 in 2008.

In several countries/economies around the world, the proportion of first university degrees in S&E fields was higher than in the United States. More than half of first university degrees in Japan and China were in S&E fields, compared with about one-third in the United States. The disparity was especially large in engineering.[27] China has traditionally awarded a large proportion of its first university degrees in engineering, although the percentage has declined in recent years (appendix table 2-33). In the United States, about 4% of all bachelor's degrees are in engineering, compared with 19% in Asia, and approximately one-third in China (appendix table 2-32). About 11% of all bachelor's degrees awarded in the United States and worldwide are in natural sciences (physical, biological, computer, and agricultural sciences, and mathematics).

The number of S&E first university degrees awarded in China and Taiwan more than doubled between 2000 and 2008, and those in the United States and many other countries generally increased. Those awarded in Japan, France, and Spain decreased in recent years (appendix table 2-33). Natural sciences and engineering degrees account for most of the increase in S&E first university degrees in China. The number of natural sciences and engineering first university degrees in China rose sharply from 2002 to 2008, and more than tripled between 2000 and 2008 (figure 2-27). In comparison, the number awarded in Germany, Japan, South Korea, the United Kingdom, and the United States remained relatively flat. In China, degrees awarded increased faster than the population, which is also growing. In Japan and Europe degree trends may be influenced by declining populations.

In 1999, 29 European countries, through the Bologna Declaration, initiated a system of reforms in higher education in Europe. The goal of the Bologna Process is to harmonize certain aspects of higher education within participating countries so that degrees are comparable, credits

Figure 2-26
Attainment of tertiary-type A and advanced research programs, by country and age group: 2008

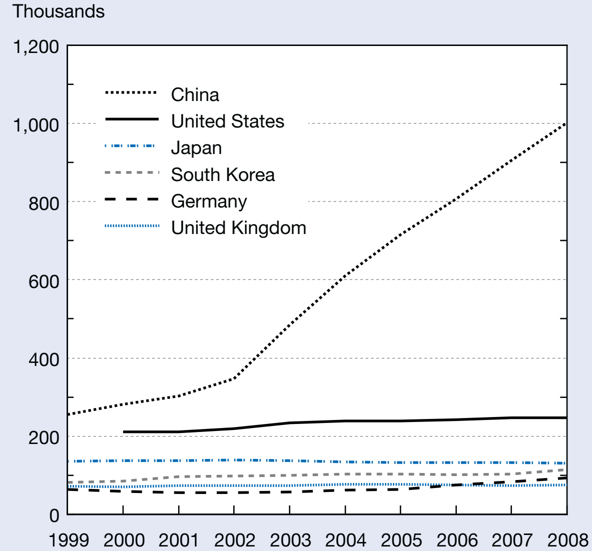


NOTES: Tertiary-type A programs (International Standard Classification of Education [ISCED] 5A) are largely theory-based and designed to provide sufficient qualifications for entry to advanced research programs and professions with high skill requirements such as medicine, dentistry, or architecture and have minimum duration of 3 years' full-time equivalent, although typically last ≥4 years. In the United States, they correspond to bachelor's and master's degrees. Advanced research programs are tertiary programs leading directly to award of an advanced research qualification, e.g., doctorate. See appendix table 2-33.

SOURCE: Organisation for Economic Co-operation and Development (OECD), Education at a Glance 2010: OECD Indicators (2010).

Science and Engineering Indicators 2012

Figure 2-27
First university natural sciences and engineering degrees, by selected countries: 1999–2008



NOTES: Natural sciences include physical, biological, earth, atmospheric, ocean, and agricultural sciences; computer science; and mathematics. Data for U.S. not available for 1999.

SOURCES: China—National Bureau of Statistics of China, China Statistical Yearbook, annual series (Beijing) various years; Japan—Government of Japan, Ministry of Education, Culture, Sports, Science and Technology, Higher Education Bureau, Monbusho Survey of Education; South Korea and Germany—Organisation for Economic Co-operation and Development, Education Online Database, http://www.oecd.org/education/database; United Kingdom—Higher Education Statistics Agency; and United States—National Center for Education Statistics, Integrated Postsecondary Education Data System, Completions Survey; and National Science Foundation, National Center for Science and Engineering Statistics, WebCASPAR database, http://webcaspar.nsf.gov. See appendix table 2-33.

Science and Engineering Indicators 2012

are transferable, and students, teachers, and researchers can move freely from institution to institution across national borders (for information on reforms affecting degree awards in Europe, see sidebar "An Update on the Bologna Process"). The Bologna Process is also stimulating discussions about higher education in the United States (Adelman 2009).

S&E First University Degrees by Sex

Women earned half or more of first university degrees in S&E in many countries around the world in 2008, including the United States and a number of smaller countries. Several large countries in Europe are not far behind, with more than 40% of first university S&E degrees earned by women. In many Asian and African countries, women generally earn about one-third or less of the first university degrees awarded in S&E fields (appendix table 2-34).

In Canada, Japan, the United States, and many smaller countries, more than half of the S&E first university degrees earned by women were in the social and behavioral sciences. In South Korea, nearly half of the S&E first university degrees earned by women were in engineering, a much higher proportion than in Europe and the United States.

An Update on the Bologna Process

Ten years after the Bologna Declaration, the European Higher Education Area (EHEA) was launched and higher education reform in Europe had been extended to more than 45 participating countries. The *Trends 2010* report, published by the European University Association (Sursock and Smidt 2010), analyzes the implementation of the Bologna Process and its impact on higher education based on questionnaire responses from 821 universities, 27 university associations, and site visits to 16 countries.

Some of the key findings indicate that—

- ♦ The vast majority of the institutions had implemented the three degree cycles (bachelor's, master's, and doctorate). However, implementation of degree structures had been more difficult in certain regulated professions such as medicine, law, and engineering.
- ♦ At the bachelor's level there has been greater emphasis on increasing and widening access, on student-centered learning, and on flexible learning paths. The master's degree was introduced as a new, separate qualification across Europe, and so far it seems to be a very flexible degree, but one that is defined differently by different countries and institutions. At the doctorate level, schools have been expanding rapidly and more attention has been focused on the supervision and training of doctoral students.
- ♦ A growing majority of the universities used the credit-transfer system for all bachelor's and master's degrees.
- ♦ Bologna was a catalyst to improve the quality of teaching and move toward student-centered learning. The majority of the universities had reviewed curricula in all departments under the Bologna Process.
- ♦ Institutions identified internationalization as an important driver of change. More institutions are developing integrated internationalization approaches to teaching and research through strategic partnerships.
- ♦ Despite efforts to promote mobility across institutions and national borders, not much data were available on how mobility flows had changed during the Bologna Process.

Global Comparison of S&E Doctoral Degrees

About 194,000 S&E doctoral degrees were earned worldwide in 2008. The United States awarded the largest number of S&E doctoral degrees of any country (about 33,000),[28] followed by China (about 28,000), Russia (almost 15,000), Germany (about 11,000), and the United Kingdom (about 9,500) (appendix table 2-35). About 55,000 S&E doctoral degrees were earned in the European Union.

Women earned 41% of S&E doctoral degrees awarded in the United States in 2008, about the same percentage earned by women in Australia, Canada, the European Union, and Mexico. In the United States, women earned nearly half of the S&E doctoral degrees awarded to U.S. citizens and permanent residents.[29] Women earned more than half of S&E doctoral degrees in Portugal and less than one-quarter of S&E doctoral degrees in the Netherlands, South Korea, and Taiwan (appendix table 2-36).

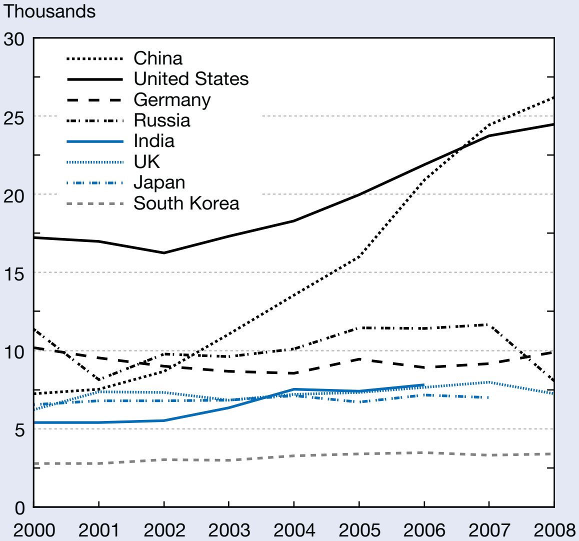
The number of S&E doctoral degrees awarded in China, Italy, and the United States has risen steeply in recent years; the number awarded in Russia increased considerably between 2002 and 2007, but decreased sharply in 2008 (appendix tables 2-37 and 2-38). Until 2006, the United States awarded the largest number of natural sciences and engineering doctoral degrees but, in 2007, China surpassed the United States (figure 2-28). In the United States, as well as in France, Germany, Italy, Spain, Switzerland, and the United Kingdom, the largest numbers of S&E doctoral degrees were awarded in the physical and biological sciences. The number of doctoral degrees awarded in S&E stagnated or declined in many of these countries between 2000 and 2004, although that number increased in later years in Italy, Switzerland, and the United States (appendix table 2-37).

In Asia, China was the largest producer of S&E doctoral degrees. As China's capacity for advanced S&E education increased, the number of S&E doctorates awarded rose from about 2,700 in 1994 to almost 28,500 in 2008 (appendix table 2-38), a substantially faster rate of growth when compared to the number of doctorates earned by Chinese citizens in the United States during the same period (figure 2-29). In 2007, the Chinese State Council Academic Degrees Committee announced that China would begin to limit admissions to doctoral programs and would focus more on quality of graduates (Mooney 2007). The number of S&E doctorates awarded in India, Japan, South Korea, and Taiwan also rose from 1994 to 2008, but at a lower rate. In China, Japan, South Korea, and Taiwan, more than half of S&E doctorates were awarded in engineering. In India, almost three-quarters of the S&E doctorates were awarded in the physical and biological sciences (appendix table 2-38).

Global Student Mobility

International migration of students has expanded in the past two decades, and countries are increasingly competing for foreign students. According to UNESCO, the number of internationally mobile students more than tripled between

Figure 2-28
Natural sciences and engineering doctoral degrees, by selected country: 2000–08



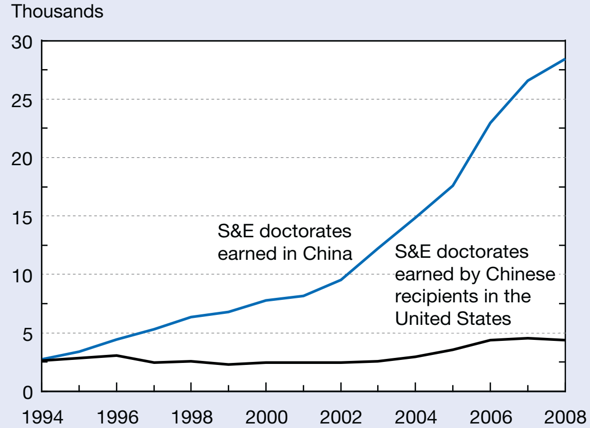
UK = United Kingdom

NOTES: Natural sciences and engineering include physical, biological, earth, atmospheric, ocean, and agricultural sciences; computer science; mathematics; and engineering. Data for India not available for 2007 and 2008; data for Japan not available for 2008.

SOURCES: China—National Bureau of Statistics of China; Japan—Government of Japan, Ministry of Education, Culture, Sports, Science and Technology, Higher Education Bureau, Monbusho Survey of Education; South Korea—Organisation for Economic Co-operation and Development, Education Online database, http://www.oecd.org/education/ database/; United Kingdom—Higher Education Statistics Agency; and Germany—Federal Statistical Office, Prüfungen an Hochschulen, and Organisation for Economic Co-operation and Development, Education Online database, http://www.oecd.org/education/ database/; and United States—National Center for Education Statistics, Integrated Postsecondary Education Data System, Completions Survey; and National Science Foundation, National Center for Science and Engineering Statistics, Integrated Science and Engineering Resources Data System (WebCASPAR), http://webcaspar.nsf.gov. See appendix tables 2-37 and 2-38.

Science and Engineering Indicators 2012

Figure 2-29
S&E doctoral degrees earned by Chinese students at home universities and U.S. universities: 1994–2008



NOTE: Degree recipients in the United States include permanent and temporary residents.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2010) of the Survey of Earned Doctorates; China—National Research Center for Science and Technology for Development and *Education Statistics Yearbook of China* (various years).

Science and Engineering Indicators 2012

1980 and 2009, to 3.4 million (UNESCO 2011).[30] In general, students migrate from developing countries to the more developed countries and from Europe and Asia to the United States. However, a few countries have emerged as regional hubs in their geographic regions, e.g., Australia, China, and South Korea for East Asia and South Africa for sub-Saharan Africa (UNESCO 2009).

Some students migrate temporarily for education, whereas others remain permanently. Some factors influencing the decision to seek a degree abroad include the policies of the countries of origin regarding sponsoring their citizens' study abroad; the tuition fee policies of countries of destination; the financial support the countries of destination offer to international students; and the cost of living and exchange rates that impact the cost of international education. The long-term return from international education also depends on how international degrees are recognized by the labor market in the country of origin (OECD 2010). In recent years, many countries, particularly English-speaking countries such as Australia, Canada, the United Kingdom, and the United States, have expanded their provision of transnational education, i.e., programs for foreign students in their home countries (see sidebar "Transnational Higher Education"). The influence of the worldwide economic and monetary crises that began in 2008 on future international flows of students is uncertain.

Some countries expanded recruitment of international students as their own populations of college-age students decreased, both to attract highly skilled workers and increase revenue for colleges and universities (OECD 2010). The population of individuals ages 20–24 (a proxy for the college-age population) decreased in China, Europe, Japan, and the United States in the 1990s and is projected to continue decreasing in China, Europe (mainly Eastern Europe), Japan, South Korea, and South America (appendix table 2-39). The U.S. population of 20–24-year-olds is projected to increase.

The United States remains the destination of the largest number of internationally mobile students (both undergraduate and graduate) of all countries (figure 2-30), although its share declined in recent years. In 2009, the United States received 20% of international students, down from 25% in 2000 (UNESCO 2011). Other top destinations for international students include the United Kingdom (12%), Germany (9%), and France (9%). Together with the U.S.,

Transnational Higher Education

Although transnational higher education is not entirely new, the nature and scale of its global expansion are changing substantially (Naidoo 2009). Two growing trends are the establishment of branch campuses and collaborative programs such as joint/dual degrees.

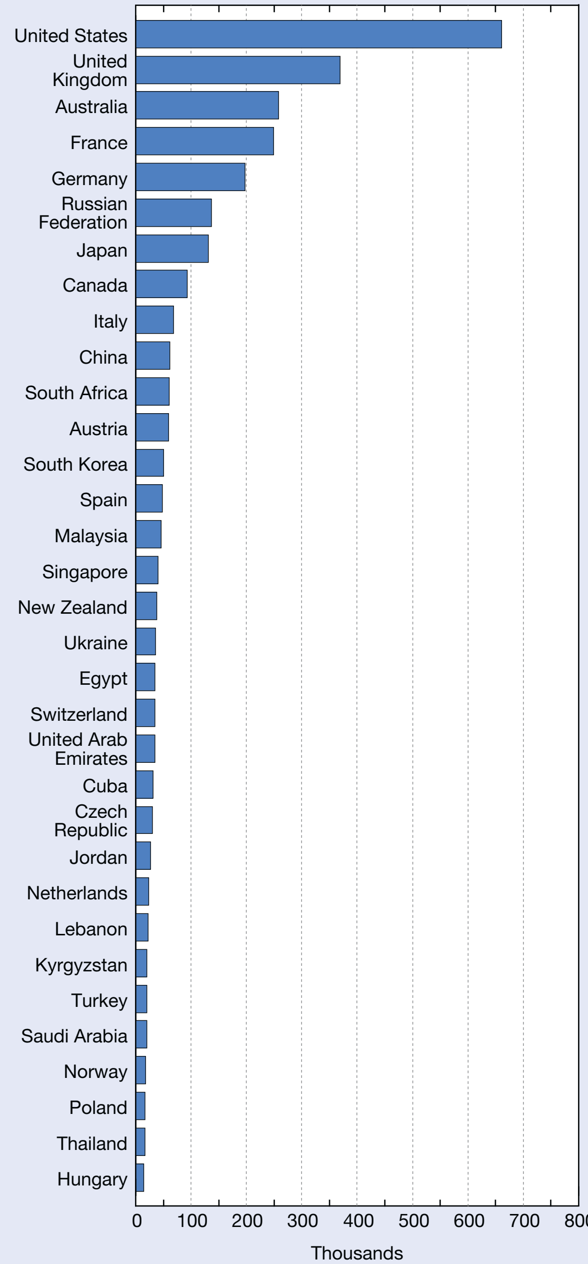
According to research by the Observatory on Borderless Higher Education, between 2006 and 2009 the number of branch campuses increased by 43%, to 162 (Becker 2010). English-speaking countries dominate, led by U.S. institutions with 78 international branch campuses, followed by Australia (14), the United Kingdom (13), and France and India (11 each). The United States also led in campus growth between 2006 and 2009; American institutions sponsored 15 of the 49 branch campuses created during that time. The United Arab Emirates was the top host country, with 40 international branch campuses, two-thirds of which are located in Dubai International Academic City. China hosts 15 branch campuses, followed by Singapore and Qatar.

Branch campuses give foreign students the opportunity to earn a Western degree without leaving their home country. For the institution venturing into a new country, meeting enrollment and financial goals without diluting quality standards is often a challenge. Following the closures of several branch campuses, higher education institutions have become more aware of the long-term risks involved and more frequently look for sponsors or partners to share and reduce such risks.

Recent data on joint and dual degree programs are scarce. In these programs, students study at two or more institutions. After successfully completing the requirements, in dual degree programs they receive a separate diploma from each institution and in joint degree programs they receive a single diploma representing both institutions (CGS 2010). Two member surveys conducted by the Council of Graduate Schools in 2007 and 2008 show that, at the graduate level in the United States, dual degrees are more prevalent than joint degrees and that these collaborative programs are more common in universities with high international student enrollment. U.S. graduate schools are more likely to have established dual/joint degree programs with higher education institutions in Europe, with China and India in second place. The most common fields for dual degrees at the master's level are business, engineering, and the social sciences; at the doctoral level, they are engineering and physical sciences.

Figure 2-30

Internationally mobile students enrolled in tertiary education, by country: 2009



NOTES: Data based on the number of students who have crossed a national border and moved to another country with the objective of studying (i.e., mobile students). Data for Canada for 2007 exclude private institutions. Data for Netherlands and Germany exclude advanced research programs, e.g., doctorate. Data for Belgium exclude social advancement education. Data for Russia exclude tertiary-type B programs (e.g., associate's) in private institutions and advanced research programs (e.g., doctorate). Data for United Kingdom, United States, and Australia based on country of residence; data for Germany and Switzerland based on country of prior education; data from other countries based on country of citizenship.

SOURCE: UNESCO Institute for Statistics, *Global Education Digest* (2011).

Science and Engineering Indicators 2012

these countries receive more than half of all internationally mobile students worldwide.

Although Australia has a higher percentage (21%) of foreign higher education students (undergraduate and graduate) than the United States (3%), it has a lower share (7%) of foreign students worldwide.[31] Other countries with relatively high percentages of foreign higher education students include Austria (16%), the United Kingdom (15%), Switzerland (14%), and New Zealand (13%). In Switzerland and the United Kingdom, more than 40% of doctoral students are foreign. A number of other countries, including New Zealand, Austria, Australia, Belgium, Canada, and the United States, have relatively high percentages (more than 20%) of doctoral students who are foreign[32] (OECD 2010).

The United Kingdom has been actively expanding its position in international education, both by recruiting foreign students to study in the country and expanding its provision of transnational education (British Council 2011). Foreign student enrollment in the United Kingdom has been increasing, especially at the graduate level, with increasing flows of students from China and India (appendix table 2-40). In 2008, foreign students made up 47% of all graduate students studying S&E in the United Kingdom (an increase from 32% in 1998). Foreign students now account for nearly 60% of graduate students in mathematics, computer sciences, and engineering. Students from China and India accounted for most of the increase, but the number of graduate students from Nigeria, Pakistan, Germany, and the United States also increased. The percentage of foreign undergraduate students increased little.

Japan has increased its enrollment of foreign students in recent years and in 2008 announced plans to triple foreign enrollment in 12 years (McNeil 2008). In 2010, almost 70,000 foreign students were enrolled in S&E programs in Japanese universities, up from 57,000 in 2004. Foreign S&E student enrollment in Japan is concentrated at the undergraduate level, accounting for 67% of all foreign S&E students. Foreign nationals accounted for 3% of undergraduate and 16% of graduate S&E students in Japan. The vast majority of the foreign students were from Asian countries. In 2010, Chinese students accounted for 69% of the foreign S&E undergraduate students and 57% of graduate S&E students in Japan. South Koreans comprised 19% of the foreign undergraduates and 10% of the graduates. Indonesia, Vietnam, Malaysia, Thailand, Mongolia, and Nepal were among the top 10 countries of origin for both undergraduates and graduate students (appendix table 2-41).

Foreign students constitute an increasing share of enrollment in Canadian universities. Foreign S&E students accounted for about 7% of undergraduate and 22% of graduate S&E enrollment in Canada in 2008, up from 4% and 14% in 1999. In 2008, at both the undergraduate and graduate levels, the highest percentages of foreign S&E students were in mathematics/computer sciences and engineering. China was the top country of origin of foreign S&E students in Canada, accounting for 15% of foreign S&E graduate and 15% of undergraduate students. The United States was also among the top countries of origin of foreign students, accounting for 7% of foreign S&E graduate students and 10% of foreign S&E undergraduate students in Canada. About 10% of foreign S&E graduate students in Canada were from France and 9% from Iran. At the undergraduate level, 8% of Canada's foreign S&E undergraduate population was from France (appendix table 2-42).

Although foreign students make up a large share of U.S. higher education, U.S. students constitute a relatively small share of foreign students worldwide. About 52,328 U.S. students (in all fields) were reported as foreign students by OECD and OECD-partner countries in 2008, far fewer than the number of foreign students from China, France, Germany, India, Japan, or South Korea. The main destinations of U.S. students were the United Kingdom (13,900), Canada (9,900), Germany (3,300), France (3,200), Australia (3,100), New Zealand (2,900), Ireland (2,800)—mainly English-speaking countries (OECD 2010).

About 260,000 U.S. students from U.S. universities enrolled in study-abroad programs in the 2008–09 academic year, down slightly from 2007–08 (1%), but up 81% in the last 10 years (IIE 2010). Just over one-third enrolled in programs lasting one semester, a similar proportion in the summer term, and 12% in short-term programs (2–8 weeks). About 12% were graduate students; the rest were undergraduates, primarily juniors or seniors. About one-third were studying in S&E fields: 21% in social sciences, 7% in physical or life sciences, 3% in engineering, 2% in mathematics or computer sciences, and 1% in agricultural sciences.

Conclusion

S&E higher education in the United States is attracting growing numbers of students. The number of bachelor's and master's degrees awarded in all fields and in S&E fields continues to rise, having reached new peaks in 2009. Most of the growth in undergraduate S&E education occurred in science fields, in particular in the social and behavioral sciences. In engineering, bachelor's degrees increased since 2002 but have not yet reached the record high levels attained in the 1980s. Computer sciences degree awards dropped precipitously between 2004 and 2007, but have began to rebound since then. A growth in the number of master's degrees awarded occurred in all major S&E fields. The number of doctoral degrees awarded in all fields and in S&E increased between 2000 and 2008 and remained stable in 2009. In the last decade, growth in doctoral degrees awarded occurred mostly in the natural sciences and engineering fields.

Foreign graduate student enrollment in S&E recovered since early in the decade when the number of entering foreign students dropped after 11 September 2001.

Globalization of higher education continues to expand. Although the United States continues to attract the largest number and fraction of foreign students worldwide, its share of foreign students has decreased in recent years.

Universities in several other countries have expanded their enrollment of foreign S&E students.

Notes

1. The physical sciences include earth, atmospheric, and ocean sciences.

2. In this NCES report, distance education courses include live, interactive audio- or videoconferencing; prerecorded instructional videos; webcasts; CD-ROMs or DVDs; or computer-based systems accessed over the Internet. Distance education does not include correspondence courses.

3. For information on site traffic statistics at the MIT OpenCourseWare, see http://ocw.mit.edu/about/site-statistics.

4. In May 2010, an ad hoc committee of the National Academy of Sciences began a 2-year project to report on the top 10 actions that Congress, the federal government, state governments, research universities, and others could take to assure the ability of the American research university to maintain excellence in research and doctoral education. Among other areas, the committee is focusing on the financial capacity of public research universities in the United States.

5. 2010 data are preliminary.

6. Clinical psychology programs and programs that emphasize professional practice (professional schools and Psy.D. programs) are associated with higher debt, but even in the more research-focused subfields of psychology, lower percentages of doctorate recipients were debt free and higher percentages had high levels of debt than those in other S&E fields. For information on debt levels of clinical versus nonclinical psychology doctorates in 1993–96, see *Psychology Doctorate Recipients: How Much Financial Debt at Graduation?* (NSF 00-321) at http://www.nsf.gov/statistics/issuebrf/sib00321.htm (accessed 20 June 2011).

7. In table 2-6, the difference in the average amount owed in constant 2000 dollars by S&E master's recipients between 2000 and 2008 was not statistically significant.

8. Household income is a measure of ability to pay and age-specific unemployment rates is a measure of opportunity costs.

9. Based on previous projections, NCES estimated that the mean absolute percentage error for enrollment in degree-granting institutions projected 9 years out was 10.1 (NCES 2011c).

10. These data are from sample surveys and are subject to sampling error. Information on estimated standard errors can be found in appendix E of the annual report *The American Freshman: National Norms Fall 2010,* published by The Cooperative Institutional Research Program of the Higher Education Research Institute, University of California–Los Angeles (http://gseis.ucla.edu/heri/pr-display.php?prQry=55, accessed 15 February 2011). Data reported here are significant at the .05 level.

11. The number of S&E degrees awarded to a particular freshmen cohort is lower than the number of students reporting such intentions and reflects losses of students from S&E, gains of students from non-S&E fields after their freshman year, and general attrition from bachelor's degree programs.

12. The data in this section come from the Institute for International Education (IIE) and the Student and Exchange Visitor Information System (SEVIS). IIE conducts an annual survey of institutions during the fall of a specific year and the spring and summer of the following year. An international student in this survey is anyone studying at an institution of higher education in the United States on a temporary visa that allows academic coursework, primarily F and J visas. SEVIS collects administrative data, including all foreign national students enrolled in colleges and universities in the United States. SEVIS collects data for the fall and the spring of each year. Data on exchange visitors are not included in this chapter.

13. These data include foreign students pursuing both bachelor's and associate's degrees. Comparable data for U.S. citizen/permanent resident students do not exist. However, the proportion of S&E associate's and bachelor's degree awards for U.S. citizens and permanent residents is considerably lower.

14. About 14% of S&E bachelor's degree recipients who earned their degree between 1 July 1 2002 and 30 June 2005 had previously earned an associate's degree (National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System [SESTAT] 2006, special tabulation).

15. Data for racial/ethnic groups are for U.S. citizens and permanent residents only.

16. For longer trends in degrees, see NSB 2010. For more detail on enrollment and degrees by sex and by race/ethnicity, see *Women, Minorities, and Persons with Disabilities in Science and Engineering: 2011* (NSF/NCSES 2011).

17. Data for racial/ethnic groups are for U.S. citizens and permanent residents only.

18. The natural sciences include agricultural; biological; computer; earth, atmospheric, and ocean; and physical sciences and mathematics.

19. The reason for the differences in the number of engineering students in appendix table 2-21 and appendix table 2-22 is because the Engineering Workforce Commission includes in its engineering counts computer science students enrolled in engineering schools. Data on graduate enrollment from the Survey of Graduate Students and Postdoctorates in Science and Engineering counts such students as computer science students.

20. See *Women, Minorities, and Persons with Disabilities in Science and Engineering: 2011* (NSF/NCSES 2011) for more detail on enrollment of foreign students by sex.

21. Data for racial/ethnic groups are for U.S. citizens and permanent residents only.

22. At the doctorate level, the data on degrees awarded in the United States includes health fields because they

are research-oriented and not professional fields (as health fields are at the bachelor's and master's level). However, health fields at the doctorate level are not included in international comparisons because international sources cannot separate the MD degrees from the health fields, and the MDs are professional and not research degrees.

23. For the corresponding proportions in the 1990s see NSB 2008.

24. The number of S&E doctoral degrees earned by students in Chinese universities continued to increase throughout this period, from 1,894 in 1993 to 28,439 in 2008.

25. These data are based on national labor force surveys and are subject to sampling error; therefore, small differences between countries may not be meaningful. The standard error for the U.S. percentage of 25- to 64-year-olds with a bachelor's or higher degree is roughly 0.1, and the standard error for the U.S. percentage of 25- to 34-year-olds with a bachelor's or higher degree is roughly 0.4.

26. A first university degree refers to the completion of a terminal undergraduate degree program. These degrees are classified as level 5A in the International Standard Classification of Education, although individual countries use different names for the first terminal degree (e.g., *laureata* in Italy, *diplome* in Germany, *maîtrise* in France, and bachelor's degree in the United States and Asian countries).

27. Differences in the taxonomies of engineering programs and level of reporting detail across countries make exact comparisons difficult.

28. In international comparisons, S&E fields do not include medical or health fields.

29. This proportion excludes medical/other life sciences doctorate awards in the United States because international sources cannot separate the MD degrees from the health fields, and the MDs are professional and not research degrees.

30. Internationally mobile students are students who have crossed a national or territorial border for the purposes of education and are now enrolled outside their country of origin.

31. Foreign students are those who do not hold the citizenship of the country for which the data were collected.

32. In many OECD countries, students in S&E fields make up a considerable proportion of international students. No data are available by degree level and field of study.

Glossary

Distance education: Formal education process in which the student and instructor are not in the same place.

First university degree: A terminal undergraduate degree program; these degrees are classified as level 5A in the International Standard Classification of Education, which is developed by the United Nations Educational, Scientific and Cultural Organization, although individual countries use different names for the first terminal degree (e.g., *laureata* in Italy, *diplome* in Germany, *maîtrise* in France, and *bachelor's degree* in the United States and in Asian countries).

Internationally mobile students: Students who have crossed a national or territorial border for the purposes of education and are now enrolled outside their country of origin.

Net price: The published price of an undergraduate college education minus the average grant aid and tax benefits that students receive.

Online education: A type of distance education where the medium of instruction is computer technology via the Internet.

Tertiary type A programs: Higher education programs that are largely theory-based and designed to provide sufficient qualifications for entry to advanced research programs and to professions with high skill requirements, such as medicine, dentistry, or architecture. These programs have a minimum duration of 3 years, although they typically last 4 or more years and correspond to bachelor's or master's degrees in the United States.

Tertiary type B programs: Higher education programs that focus on practical, technical, or occupational skills for direct entry into the labor market and have a minimum duration of 2 years. These programs correspond to associate's degrees in the United States.

Underrepresented minorities: Blacks, Hispanics, and American Indians/Alaska Natives are considered to be underrepresented minorities in S&E.

References

Adelman C. 2009. *The Bologna Process for U.S. Eyes: Relearning Higher Education in the Age of Convergence.* Washington, DC: Institute for Higher Education Policy. http://www.ihep.org/assets/files/EYESFINAL.pdf. Accessed 23 March 2011.

Allen I, Seaman J. 2010. *Class Differences: Online Education in the United States, 2010.* Needham, MA: The Sloan Consortium.

Becker R. 2010. International branch campuses: New trends and directions. *International Higher Education* 58(Winter):2–3.

Berelson B. 1960. *Graduate Education in the United States.* New York: McGraw-Hill.

British Council. 2011. The Prime Minister's Initiative for International Education. http://www.britishcouncil.org/eumd-pmi2.htm. Accessed 20 June 2011.

Cartter AM. 1966. *An Assessment of Quality in Graduate Education.* Washington, DC: American Council on Education.

College Board. 2010a. *Trends in College Pricing: 2010.* New York.

College Board. 2010b. *Trends in Student Aid: 2010*. New York.

Commonfund Institute. 2010. 2010 Update: Higher Education Price Index. http://www.commonfund.org/CommonfundInstitute/HEPI/HEPI%20Documents/2010/CF_HEPI_2010.pdf. Accessed 27 January 2011.

Council of Graduate Schools (CGS) 2010. *Joint Degrees, Dual Degrees, and International Research Collaborations.* Washington DC.

Engineering Workforce Commission (EWC). 2010. *Engineering & Technology Enrollments, Fall 2009*. Washington, DC: American Association of Engineering Societies.

Gibbons MT. 2009. *Engineering by the Numbers.* Washington, DC: American Society for Engineering Education. http://www.asee.org/papers-and-publications/publications/college-profiles/2009-profile-engineering-statistics.pdf. Accessed 23 February 2011.

Glenn D. 2010. An elaborate ranking of doctoral programs makes its long-awaited debut. *Chronicle of Higher Education*. http://chronicle.com/article/An-Elaborate-Ranking-of/124633/?sid=at&utm_source=at&utm_medium=en/. Accessed 21 March 2011.

Institute of International Education (IIE). 2010. *Open Doors 2010: A Report on International Education Exchange.* http://www.iie.org/Research-and-Publications/Open-Doors/Data.aspx. Accessed 27 June 2011.

Jaschik S. 2010. You're not No. 1. *Inside Higher Ed.* http://www.insidehighered.com/layout/set/print/news/2010/09/29/rankings/. Accessed 21 March 2011.

Jaschik S. 2011. Sociologists blast doctoral rankings. *Inside Higher Ed*. http://www.insidehighered.com/layout/set/print/news/2011/03/21/sociologists_blast_rankings_of_doctoral_programs/. Accessed 21 March 2011.

Karp M. 2008. Towards a community college research agenda. Summary of the National Community College Symposium; June 19. Washington, DC. http://www.ed.gov/about/offices/list/ovae/pi/cclo/cc-sympsm-smmry10-29-08-final.pdf. Accessed 3 February 2011.

King J. 2010. *Gender Equity in Higher Education.* Washington, DC: American Council on Education.

McNeil D. 2008. Japan announces plan to enroll more foreign students. *Chronicle of Higher Education News Blog*, 28 July 2008. http://chronicle.com/news/article/4899/japan-announces-plan-to-enroll-more-foreign-students?utm_source=at&utm_medium=en. Accessed 17 January 2011.

Mooney P. 2007. China limits growth of universities. *Chronicle of Higher Education*. http://chronicle.com/article/China-Limits-Growth-of-Univ/11420/. Accessed 4 March 2011.

Naidoo V. 2009. Transnational higher education: A stock take of current activity. *Journal of Studies in International Education* 13(3): 310–330.

National Center for Education Statistics (NCES). 2009a. *Enrollment in Postsecondary Institutions, Fall 2007; Graduation Rates, 2003 & 2006 Cohorts; and Financial Statistics, Fiscal Year 2007.* NCES 2009-155. Washington, DC.

National Center for Education Statistics (NCES) 2009b. *Web Tables: Undergraduate Financial Aid Estimates by Type of Institution in 2007–2008.* NCES 2009-201. Washington, DC.

National Center for Education Statistics (NCES). 2010a. *The Condition of Education: 2010.* NCES 2010-031. Washington, DC.

National Center for Education Statistics (NCES). 2010b. *Postsecondary Institutions and Price of Attendance in the United States: Fall 2009, Degrees and Other Awards Conferred: 2008-2009, and 12-Month Enrollment: 2008–09*. NCES 2010-161. Washington, DC.

National Center for Education Statistics (NCES). 2010c. *Digest of Education Statistics: 2009.* NCES 2010-020. Washington, DC.

National Center for Education Statistics (NCES). 2011a. *Enrollment in Postsecondary Institutions, Fall 2009; Graduation Rates, 2003 & 2006 Cohorts; and Financial Statistics, Fiscal Year 2009.* NCES 2011-230. Washington, DC.

National Center for Education Statistics (NCES). 2011b. *The Condition of Education: 2011*. NCES 2011-033. Washington, DC.

National Center for Education Statistics (NCES). 2011c. *Projections of Education Statistics to 2019.* NCES 2011-017. Washington, DC. http://nces.ed.gov/pubs2011/2011017.pdf. Accessed 14 March 2011.

National Center for Public Policy and Higher Education (NCPPHE). 2008. *Measuring Up 2008: The National Report Card on Higher Education.* San Jose, CA. http://measuringup2008.highereducation.org/print/NCPPHEMUNationalRpt.pdf. Accessed 1 March 2011.

National Research Council 1982. *An Assessment of Research-Doctorate Programs in the United States.* Washington, DC: National Academies Press.

National Research Council 1995. *Research-Doctorate Programs in the United States: Continuity and Change.* Washington, DC: National Academies Press.

National Research Council 2010. *A Data-Based Assessment of Research-Doctorate Programs in the United States*. Washington, DC: National Academies Press.

National Science Board (NSB). 2003. The Science and Engineering Workforce: Realizing America's Potential. Special Report NSB 03-69. Arlington, VA: National Science Foundation.

National Science Board (NSB). 2008. *Science and Engineering Indicators 2008.* Two volumes (volume 1, NSB 08-01; volume 2, NSB 08-01A). Arlington, VA: National Science Foundation.

National Science Board (NSB). 2010. *Science and Engineering Indicators 2010*. NSB 10-01. Arlington, VA: National Science Foundation.

National Science Foundation, National Center for Science and Engineering Statistics (NSF/NCSES). 2000. Modes of Financial Support in the Graduate Education of Science and Engineering Doctorate Recipients. Special Report NSF 00-319. Arlington, VA.

National Science Foundation, National Center for Science and Engineering Statistics (NSF/NCSES). 2008. Baccalaureate Origins of S&E Doctorate Recipients. Special Report NSF 08-311. Arlington, VA.

National Science Foundation, National Center for Science and Engineering Statistics (NSF/NCSES). 2010a. *Characteristics of Recent Science and Engineering Graduates: 2006*. Detailed Statistical Tables NSF 10-318. Arlington, VA. Available at http://www.nsf.gov/statistics/nsf10318/. Accessed 25 February 2011.

National Science Foundation, National Center for Science and Engineering Statistics (NSF/NCSES). 2010b. Doctorate Recipients From U.S. Universities: 2009. Special Report NSF 11-306. Arlington, VA. Available at http://nsf.gov/statistics/nsf11306/. Accessed 4 January 2011.

National Science Foundation, National Center for Science and Engineering Statistics (NSF/NCSES). 2011. *Women, Minorities, and Persons with Disabilities in Science and Engineering: 2011*. Special Report NSF 11-309. Arlington, VA. Available at http://www.nsf.gov/statistics/wmpd/. Accessed 3 March 2011.

Organisation for Economic Co-operation and Development (OECD). 2008. *Education at a Glance: 2008*. Paris, France.

Organisation for Economic Co-operation and Development (OECD). 2010. *Education at a Glance: 2010*. Paris, France.

Project on Student Debt. 2009. *Student Debt and the Class of 2009*. http://projectonstudentdebt.org/files/pub/classof2009.pdf. Accessed 20 June 2011.

Roose KD, Andersen CJ. 1970. *A Rating of Graduate Programs*. Washington, DC: American Council on Education.

Sursock A, Smidt H. 2010. *Trends 2010: A Decade of Change in European Higher Education.* Brussels, Belgium: European University Association. http://www.eua.be/publications/eua-reports-and-studies.aspx Accessed March 1 2011.

United Nations Educational, Scientific and Cultural Organization (UNESCO) 2009. *Global Education Digest 2009: Comparing Education Statistics Across the World*. http://unesdoc.unesco.org/=images/0018/001832/183249e.pdf. Accessed June 14 2011.

United Nations Educational, Scientific and Cultural Organization (UNESCO) 2011. *Global Education Digest 2011*. Forthcoming.

Wendler C, Bridgeman B, Cline F, Millett C, Rock J, Bell N, McAllister P. 2010. *The Path Forward: The Future of Graduate Education in the United States*. Princeton, NJ: Educational Testing Service.

Chapter 3
Science and Engineering Labor Force

List of Sidebars

List of Tables

List of Figures

Highlights

Scope of the S&E Workforce

The S&E workforce has shown sustained growth for more than half a century.

- ♦ The number of workers in S&E occupations grew from about 182,000 in 1950 to 5.4 million in 2009. This represents an average annual growth rate of 5.9%, much greater than the 1.2% growth rate for the total workforce older than age 18 during this period.
- ♦ Workforce growth in S&E occupations from 2000 to 2009 was slower than in the two preceding decades. Nonetheless, at 1.4% annually, it exceeded the rate (0.2%) for the general workforce, which barely grew at all.

Many workers outside S&E occupations have S&E training or use related knowledge and skills in their jobs.

- ♦ Individuals with an S&E bachelor's degree or higher (17.2 million in 2008) or whose highest degree was in S&E (12.6 million in 2008) substantially outnumbered those working in S&E occupations.
- ♦ In 2008, about two-thirds of those with an S&E highest degree but not working in an S&E occupation reported that their job was either closely or somewhat related to their degree.

S&E Workers in the Economy

Scientists and engineers work for all types of employers.

- ♦ For-profit firms employed 59% of all individuals whose highest degree was in S&E but only 35% of those holding S&E doctorates.
- ♦ Academic institutions employed about 41% of individuals with S&E doctorates, including those in postdoc or other temporary positions.
- ♦ About 19% of workers whose highest degree was in S&E reported they were self-employed in 2008, with two-thirds in incorporated businesses.
- ♦ Small firms are important employers of those with S&E highest degrees. Firms with fewer than 100 persons employ 36% of them.

S&E Labor Market Conditions

Workers with S&E degrees or occupations tend to earn more than other comparable workers.

- ♦ Half of the workers in S&E occupations earned $73,290 or more in 2010, more than double the median earnings ($33,840) of the total U.S. workforce.
- ♦ Workers with S&E degrees, regardless of their occupations, earn more than workers with comparable-level degrees in other fields.
- ♦ Industries with above-average proportions of S&E jobs tend to pay higher average salaries to both their S&E and non-S&E workers.

People whose work is associated with S&E are less often exposed to unemployment.

- ♦ Unemployment rates for those in S&E occupations tend to be lower than those for all college-degreed individuals and much lower than those of persons with less than a bachelor's degree.
- ♦ Unemployment rates for S&E doctorate holders are generally much lower than for those at other degree levels.

Demographics of the S&E Workforce

Women remain underrepresented in the S&E workforce, although to a lesser degree than in the past.

- ♦ Women constituted 38% of employed individuals with a highest degree in an S&E field in 2008, but their proportion is smaller in most S&E occupations.
- ♦ From 1993 through 2008, growth occurred in both the share of workers with a highest degree in an S&E field who are women (increasing from 31% to 38%) and the share of women in S&E occupations (increasing from 21% to 26%).
- ♦ Female scientists and engineers are concentrated in different occupations than are men, with relatively high shares of women in the social sciences (53%) and biological and medical sciences (51%) and relatively low shares in engineering (13%) and computer and mathematical sciences (26%).

Race and ethnicity are salient factors in rates of participation in the S&E workforce.

- ♦ Hispanics, blacks, and American Indians/Alaska Natives make up a smaller share of the S&E workforce, with 9% of workers in S&E occupations and 11% of S&E degree holders in 2008, than their proportion in the general population, with 26% of U.S. residents from ages 20 to 70.
- ♦ Asians work in S&E occupations at higher rates (17%) than their representation in the U.S. working-age population (5%). Asians are particularly highly concentrated in computer and information science occupations (22% Asian).
- ♦ Within every S&E occupation, more than half of all workers are non-Hispanic whites.

A variety of indicators point to a decline during the recent economic downturn in the immigration of foreign scientists and engineers.

- ♦ After an upward trend in the number of temporary work visas issued to scientists and engineers for most of the decade, the number fell sharply in 2009. H-1B visas fell to 2003 levels, dropping to 72% of the number issued in 2007.

- Both the number and percentage of S&E doctoral degree recipients with temporary visas reporting plans to stay in the United States peaked in 2007 and declined in 2009 after rising since 2002.
- The proportion of S&E doctoral degree recipients with temporary visas who remained in the United States 5 years after receiving their degrees rose from 45% to 67% between 1989 and 2005 but fell to 62% in 2009.

The baby boom portion of the S&E workforce continues to age, nearing retirement.

- From 1993 to 2008, the median age of scientists and engineers in the U.S. workforce rose from 37 to 41. The proportion over age 50 increased from 18% to 27%.
- Between 1993 and 2008, increasing percentages of scientists and engineers in their 60s reported that they were still in the labor force. Whereas 59% of S&E degree holders between the ages of 60 and 64 were employed in 1993, the comparable percentage rose to 66% in 2006 before declining slightly in 2008.

Global S&E Labor Force

Worldwide, the number of workers engaged in research has been growing since at least 1995.

- Among countries with large numbers of researchers, growth has been most rapid in China, where the number of researchers tripled, and South Korea, where it doubled.
- The United States and the European Union experienced steady growth but at a lower rate than in China or South Korea; both increased from about 1 million in 1995 to nearly 1.5 million in 2007.
- Japan and Russia were exceptions to the worldwide trend: in Japan, the number of researchers remained essentially unchanged, and in Russia the number declined.

Among businesses located in the United States, R&D employment is disproportionately domestic.

- Although about one-third of total employment in these firms is located abroad, only one-quarter of R&D employment is in foreign locations.
- In manufacturing, the disparity between overall employment in foreign locations (41%) and R&D employment in these locations (25%) is substantial; for nonmanufacturing employment, the comparable proportions—24% for overall employment and 23% for R&D employment—are similar.

Preliminary 2009 data indicate a substantial shift in the balance between R&D employment by U.S. firms abroad and R&D employment by foreign firms in the United States.

- Whereas R&D employment abroad by U.S. multinational companies (MNCs) nearly doubled between 2004 and 2009, domestic R&D employment by these firms increased by less than 5% in the same period.
- U.S. MNCs employed many more R&D workers in foreign locations in 2009 than foreign firms employed in the United States. In contrast, these two numbers had been similar in 2004.

Introduction

Chapter Overview

Policymakers and researchers have increasingly emphasized the importance of skilled people—what social scientists refer to as human capital—to both innovation and economic growth. As technical content spreads throughout our knowledge-based economy, the knowledge and skills associated with science and engineering (S&E) are increasingly necessary for workers with formal training in S&E who work in non-S&E jobs as well as for those in occupations traditionally classified as part of the S&E labor force.

Chapter Organization

The chapter is divided into five sections. The first section defines the S&E labor force and reports on its size and growth. It analyzes the interplay among occupational roles, educational credentials, and use of S&E expertise on the job. This section also includes a chart describing the main sources of data on the U.S. S&E labor force.

Section two explores the distribution of S&E workers in the economy. It describes employment patterns by sector and industry, with some special emphasis on the role private-sector firms play as employers of scientists and engineers. This section also reports data on federal workers in S&E occupations, thereby showing the roles of scientists and engineers in both scientific and other federal agencies.

Section three looks at recent and long-term trends in the economic rewards of participating in the S&E labor force. It includes data on recent labor market conditions, earnings, unemployment, and workers unable to find jobs in their field. Where possible, it contrasts S&E and non-S&E degree holders at comparable degree and experience levels. The section also includes broader measures of labor underutilization that go beyond long- and short-term unemployment rates.

Labor force demographics are covered in section four, including the growing role of women, minorities, and immigrants in the S&E labor force. This section also examines the distribution of S&E workers across occupations, sectors, and industries by degree levels and fields. Data on the aging of the S&E labor force and on its retirement patterns also appear in this section.

In addition, section four features a detailed analysis of salary differences among different demographic groups. This analysis explores the role of factors that are relevant to a worker's productivity (e.g., years of experience) and factors that are not directly related to job skill (e.g., demographic or personal background characteristics, such as race/ethnicity and sex). Trends in salary differences are also considered.

The final section of the chapter deals with the global S&E labor force. Although there are indications that the global S&E labor force has grown, there is little solid worldwide data on this broader labor force or its characteristics. Several U.S. and international data sources are used in this section to present indicators of worldwide R&D employment, international employment by multinational companies, and international engagement by U.S. S&E workers.

Scope of the S&E Workforce

Measures of the S&E Workforce

The terms *scientist* and *engineer* can include very different sets of workers. This section presents three types of measures that can be used to estimate the size and describe the characteristics of the U.S. S&E labor force.[1] Different categories of measures are better adapted for addressing some questions than others, and not all general population and workforce surveys include questions in each category (table 3-1).

Occupation

U.S. federal occupation data classify workers by the activities or tasks they primarily perform in their jobs. The Occupational Employment Statistics (OES) survey administered by the Bureau of Labor Statistics (BLS) relies on employers to classify their workers using standard occupational definitions. National Science Foundation (NSF) and Census Bureau occupational data in this chapter come from surveys in which individuals (NSF) or members of their household (Census Bureau) supplied information about job titles and work activities. With this information, jobs can be coded into standard occupational categories. Differences between employer- and employee-provided information can affect the content of occupational data.

NSF has developed a widely used set of occupational categories that it calls *S&E occupations*. These occupations are generally associated with a bachelor's degree level of knowledge and education in S&E fields. A second category of occupations, *S&E-related occupations*, also requires some S&E knowledge or training, but not necessarily as a required credential for being hired or at the bachelor's degree level. Examples of such occupations are S&E technicians or managers of the S&E enterprise who may supervise people working in S&E occupations. Other occupations, although classified as *non-S&E*, may include individuals who use their S&E technical expertise in their work. Examples include technical writers who edit scientific publications and salespeople who sell specialized research equipment to chemists and biologists. The NSF occupational classification of S&E, S&E-related, and non-S&E occupations appears in table 3-2.

Other general terms, including science, technology, engineering, or mathematics (STEM), science and technology (S&T), and science, engineering, and technology (SET), are often used to designate the part of the labor force that works with S&E. These terms are broadly equivalent and have no standard definition.

In this chapter, the narrow classification of S&E occupations is sometimes expanded to include S&E technicians, computer programmers, and S&E managers. This broader grouping is referred to here as *STEM occupations*.

Education

The pool of S&E workers can also be identified by educational credentials. Individuals who possess an S&E degree, whose highest degree is in S&E, or whose most recent degree is in S&E may be qualified to hold jobs that require S&E knowledge and skills and may seek such jobs if they do not currently hold them. However, a focus on people with relevant educational credentials also includes individuals who hold jobs that are not generally identified with S&E and who are not likely to seek S&E jobs in the future. Furthermore, workers with degrees in S&E may not have kept up to date with the fields in which they were trained, may lack interest in working in jobs that require skills associated with S&E education, or may have advanced in their careers to a point where other skills have become more important.

S&E Technical Expertise

The S&E workforce may also be defined by the expertise required to perform a job or the extent to which job requirements are related to formal training in S&E. Many people, including some outside S&E occupations or without S&E degrees, report that their jobs require at least a bachelor's degree level of technical expertise in engineering, computer sciences, mathematics, the natural sciences, or social sciences, which we refer to in this report as *S&E technical expertise*. Unlike defining the S&E workforce by occupational groupings or educational credentials, defining it by the use of technical knowledge, skills, or expertise involves assessing the content and characteristics of individual jobs. However, it also involves asking survey respondents to make a complex judgment about their jobs and apply a criterion that they are likely to interpret differently.[2] A recent survey provides clues to how college-educated Americans understand job-related technical expertise. (See sidebar, "Technical Expertise on the Job.")

Table 3-1
Major sources of data on the U.S. labor force

Data source	Data collection agency	Data years	Major topics	Respondent	Coverage
Occupational Employment Statistics (OES)	Department of Labor, Bureau of Labor Statistics	Through 2010	Employment status Occupation Salary Industry Employer location (national, state, metropolitan statistical area)	Employing organizations	All full-time and part-time wage and salary workers in non-farm industries. Does not cover self-employed, unincorporated firms, household workers, or unpaid family workers.
Scientists and Engineers Statistical Data System (SESTAT)—comprises Survey of Doctorate Recipients, National Survey of College Graduates, National Survey of Recent College Graduates	National Science Foundation, National Center for Science and Engineering Statistics	Through 2008	Employment status Occupation Job characteristics (work activities, technical expertise) Salary Detailed educational history Demographic characteristics	Individuals	Individuals with bachelor's degree or higher in S&E or S&E-related field, or with non-S&E bachelor's but working in S&E or S&E-related occupation.
American Community Survey (ACS)	Department of Commerce, Census Bureau	Through 2009	Employment status Occupation First bachelor's degree field Educational attainment Demographic characteristics	Households	U.S. population
Current Population Survey (CPS)	Department of Labor, Bureau of Labor Statistics	Through 2010	Employment status Occupation Educational attainment Demographic characteristics	Households	U.S. population

Science and Engineering Indicators 2012

Table 3-2
Classification of degree fields and occupations

Classification	Degree field	Occupation	Occupation classification STEM	Occupation classification S&T
S&E	Biological, agricultural, and environmental life sciences	Biological, agricultural, and environmental life scientists	X	X
	Computer and mathematical sciences	Computer and mathematical scientists	X	X
	Physical sciences	Physical scientists	X	X
	Social sciences	Social scientists	X	X
	Engineering	Engineers	X	X
		S&E postsecondary teachers	X	X
S&E-related	Health fields	Health-related occupations		
	Science and math teacher education	S&E managers	X	
	Technology and technical fields	S&E precollege teachers		
	Architecture	S&E technicians and technologists	X	X
	Actuarial science	Architects		
		Actuaries		
		S&E-related postsecondary teachers		
Non-S&E	Management and administration	Non-S&E managers		
	Education (except science and math teacher education)	Management-related occupations		
		Non-S&E precollege teachers		
	Social services and related fields	Non-S&E postsecondary teachers		
	Sales and marketing	Social services occupations		
	Arts and humanities	Sales and marketing occupations		
	Other fields	Arts and humanities occupations		
		Other occupations		

S&T = science and technology; STEM = science, technology, engineering, and mathematics

NOTES: Designations STEM and S&T refer to occupations only. For more detailed classification of occupations and degrees by S&E, S&E-related, and non-S&E, see National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT), http://sestat.nsf.gov/docs/occ03maj.html and http://sestat.nsf.gov/docs/ed03maj.html.

Science and Engineering Indicators 2012

Technical Expertise on the Job

The Joint Program on Survey Methodology (JPSM) provides advanced education for survey research professionals through a collaboration among the University of Maryland, the University of Michigan, and Westat, a survey research firm. As part of their training, JPSM students take a course in which they design and analyze a survey on a topic of interest to a federal statistical agency.

In 2009, JPSM's survey probed the meaning of SESTAT data indicating that many college-educated Americans who are not employed in S&E occupations say their jobs require the technical expertise of an S&E bachelor's degree. The survey asked a nationally representative group of college graduates who are members of the Knowledge Networks Internet survey panel about the knowledge and skills they use on the job and the education and experience through which they acquired them. The survey also collected various additional information about the survey respondents—the colleges they attended; their major fields of study; and the characteristics of their current and previous jobs, including respondents' occupations, salaries, job satisfaction, and employer characteristics.

Preliminary analyses suggest that asking about either "knowledge and skills" or "technical expertise" produces roughly equivalent response patterns; if anything, a higher percentage of respondents claim that "knowledge and skills" associated with a degree are required on the job than make the equivalent claim about "technical expertise." In addition, the data suggest that graduates in different major fields vary in how often they claim that their jobs require bachelor's level competency in a field. Along with education majors, people who major in natural sciences and engineering appear to more frequently view their jobs as requiring bachelor's degree level competency in some field of study. Those who major in health-related fields and social sciences rank somewhat below them. College graduates with degrees in arts, humanities, business administration, communications, and other fields outside the sciences less often report that their jobs need this kind of competency. However, these data offer numerous opportunities for further analysis of the relationships among knowledge, skills, and job activities, and such analyses might cast these preliminary findings in a different light.

Size of the S&E Workforce

In the most recent estimates, the U.S. S&E workforce (defined by occupation) totaled between 4.8 million and 6.4. million people (table 3-3). Those in S&E occupations who also had bachelor's degrees were estimated at between 4.8 million (Census Bureau 2009) and 4.9 million (NSF, National Center for Science and Engineering Statistics [NCSES], Scientists and Engineers Statistical Data System [SESTAT]).[3] SESTAT's 2008 estimates for individuals with an S&E degree at the bachelor's level or higher (17.2 million) or whose highest degree was in S&E (12.6 million) were substantially higher than the number of current workers in S&E occupations. Many of those whose highest degree is in S&E reported that their job, although not in an occupation classified as S&E, was closely (2.2 million) or somewhat (2.1 million) related to their highest degree. Counting these people, along with those in S&E occupations, as part of the S&E workforce increases the SESTAT S&E workforce estimate from 4.9 million to 9.1 million, an 84% increase.

The 2003 SESTAT surveys provide a recent estimate for a different assessment of S&E work—whether workers believe their jobs require technical expertise at the bachelor's degree level or higher in S&E fields. According to these surveys, 12.9 million bachelor's degree holders reported that their jobs required at least this level of expertise in one or more S&E fields. This contrasts with 2003 SESTAT estimates of 4.8 million workers in S&E occupations and 11.9 million whose highest degree was in an S&E field.

Growth of the S&E Workforce

However defined, the S&E workforce has for decades grown faster than the total workforce. Defined by occupation, growth in the S&E workforce can be examined over nearly seven decades using Census Bureau data. The number of workers in S&E occupations grew from about 182,000 in 1950 to 5.4 million in 2009. This represents an average annual growth rate of 5.9%, much greater than the 1.2% growth rate for the total workforce older than age 18 during this period. The somewhat broader category of S&T occupations grew from 205,000 to 6.6 million (a 6.1% growth rate) (figure 3-1).

In each decade, the growth rate of S&E occupations exceeded that of the total workforce (figure 3-2). During the 1960s, 1980s, and 1990s, the difference in growth rates was very large (about 3 times the rate for the total labor force). It was smallest during the slower growth period of the 1970s. Between 2000 and 2007, the ratio of the S&E growth rate to the overall workforce was 1.6, which was comparable to the 1970s. The economic downturn at the end of this decade resulted in almost no overall workforce growth for the decade as a whole, well below the 1.4% growth rate for the S&E workforce for the same period. While both the total and S&E employment experienced smaller growth rates in the 2000s compared to the 1990s, the trend of higher growth rates in S&E occupations relative to other jobs continues, even through the recent economic downturn. S&E occupational employment has grown from 2.6% of the workforce in 1983 to 4.8% of all employment in 2010 (figure 3-3).

Table 3-3
Measures and size of employed S&E workforce: 2003, 2008, and 2009

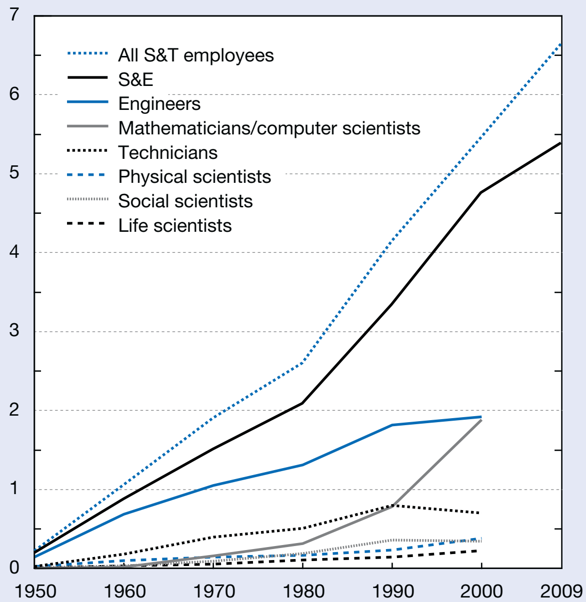
Measure	Education coverage	Data source	Workers
Occupation			
Employment in S&E occupations	All degree levels	2009 BLS OES	5,786,000
Employment in S&E occupations	Bachelor's and above	2008 NSF/NCSES SESTAT	4,874,000
Employment in S&E occupations	All degree levels	2009 Census Bureau ACS	6,416,000
Employment in S&E occupations	Bachelor's and above	2009 Census Bureau ACS	4,750,000
Education			
At least one degree in S&E field	Bachelor's and above	2008 NSF/NCSES SESTAT	17,214,000
Highest degree in S&E field	Bachelor's and above	2008 NSF/NCSES SESTAT	12,588,000
Job closely related to highest degree	Bachelor's and above	2008 NSF/NCSES SESTAT	4,802,000
S&E occupation	Bachelor's and above	2008 NSF/NCSES SESTAT	2,635,000
Other occupation	Bachelor's and above	2008 NSF/NCSES SESTAT	2,168,000
Job somewhat related to highest degree	Bachelor's and above	2008 NSF/NCSES SESTAT	3,101,000
S&E occupation	Bachelor's and above	2008 NSF/NCSES SESTAT	996,000
Other occupation	Bachelor's and above	2008 NSF/NCSES SESTAT	2,105,000
Job requires S&E technical expertise at bachelor's level			
In one or more S&E fields	Bachelor's and above	2003 NSF/NCSES SESTAT and NSCG	12,855,000
Engineering, computer science, mathematics, or natural sciences	Bachelor's and above	2003 NSF/NCSES SESTAT and NSCG	9,215,000
Social sciences	Bachelor's and above	2003 NSF/NCSES SESTAT and NSCG	5,335,000

ACS = American Community Survey; BLS = Bureau of Labor Statistics; OES = Occupational Employment Statistics Survey; NSF/NCSES = National Science Foundation, National Center for Science and Engineering Statistics; SESTAT = Scientists and Engineers Statistical Data System; NSCG = National Survey of College Graduates

SOURCES: BLS, 2009 OES; Census Bureau, 2009 ACS; NSF/NCSES, 2008 SESTAT integrated file and special analytic file comprising 2003 SESTAT integrated file and 2003 NSCG.

Science and Engineering Indicators 2012

Figure 3-1
Science and technology employment: 1950–2009



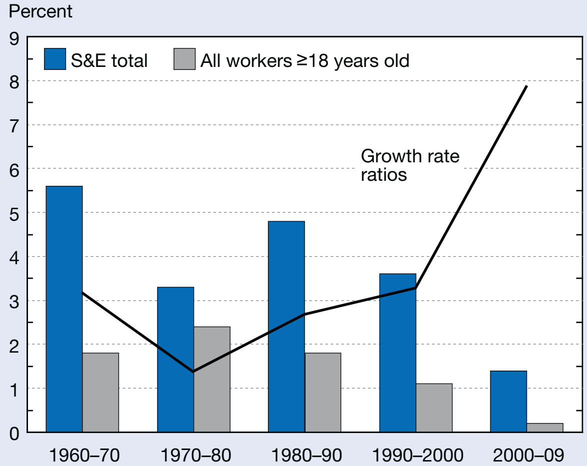
S&T = science and technology

NOTE: Data include bachelor's degrees or higher in science occupations, some college and above in engineering occupations, and any education level for technicians and computer programmers. No estimates were calculated below level of S&E and S&T from 2009 American Community Survey.

SOURCES: Adapted from Lowell BL, Regets MC, A Half-Century Snapshot of the STEM Workforce, 1950 to 2000, Commission on Professionals in Science and Technology (2006); with additional estimates from the Census Bureau, American Community Survey (2009).

Science and Engineering Indicators 2012

Figure 3-2
Average annual growth rates of S&E occupations and total workforce: 1960–2009



SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) from 1960–2000 Decennial Census, Public-Use Microdata Sample (PUMS), and American Community Survey (2009).

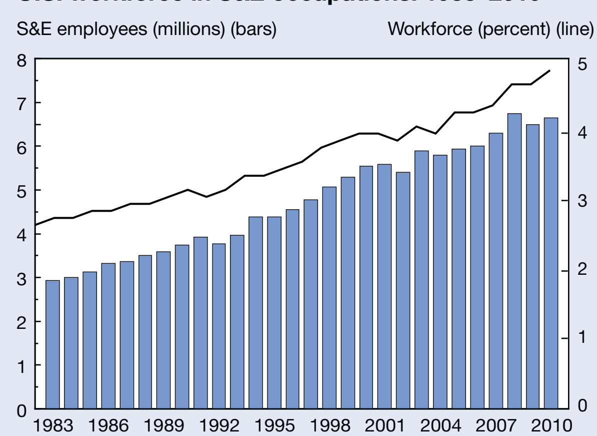
Science and Engineering Indicators 2012

Recent OES employment estimates for workers in S&E occupations indicate that the S&E workforce has remained steady while the total workforce has declined. The OES estimate was 5.5 million in May 2010, compared to 5.6 million in May 2007. The total workforce declined from 134 million to 127 million in this time frame. The broader STEM aggregate (including technicians, S&E managers, etc.) also remained relatively steady at 7.4 million in May 2010, compared to 7.6 million in May 2007. OES projections for 2008 to 2018 are that S&E occupations will grow at a faster rate than the total workforce. (See sidebar, "Projected Growth of Employment in S&E Occupations.")

Between 1980 and 2000, although the number of S&E degree holders in the workforce grew more than the number of people working in S&E occupations, degree production in all broad categories of S&E fields rose at a slower rate than employment in S&E jobs (figure 3-4). (See chapter 2 for a fuller discussion of S&E degrees.) During this period, S&E employment grew from 2.1 million to 4.8 million (4.2% average annual growth), while annual S&E degree production increased from 526,000 to 676,000 (1.5% average annual growth). Except for mathematics, computer sciences, and the social sciences, the growth rate for advanced degrees was higher than for bachelor's degrees.

This growth in the S&E labor force was possible largely because of three factors: (1) increases in U.S. S&E degrees earned by both native and foreign-born students who entered the labor force, (2) temporary and permanent migration to the United States of those with foreign S&E educations, and (3) the relatively small proportion of scientists and engineers retiring from the S&E labor force. Many have expressed concerns about the effects of changes in any or all of these factors on the future of the U.S. S&E labor force (see NRC 2010 and NSB 2003).

Figure 3-3
U.S. workforce in S&E occupations: 1983–2010



SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) from Bureau of Labor Statistics, Current Population Survey Monthly Outgoing Rotation files (1983–2010).

Science and Engineering Indicators 2012

Projected Growth of Employment in S&E Occupations

Projections of employment growth are plagued by uncertain assumptions and notoriously difficult to make. Many corporate and government spending decisions on R&D are impossible to anticipate. In addition, R&D funds increasingly cross borders in search of the best place to have particular research performed. Finally, it may be difficult to anticipate new products and industries that may be created via the innovation processes that are most closely associated with scientists and engineers.

The worldwide economic crisis and the dynamics of recovery from it compound the already difficult problem of making employment projections, because recent economic upheavals may produce long-term changes in employment patterns and trends. The reader is cautioned that the assumptions underlying projections such as those that follow, which rely on past empirical relationships, may no longer be valid.

The most recent Bureau of Labor Statistics (BLS) occupational projections, for the period 2008–18, suggest that total employment in occupations that NSF classifies as S&E will increase at more than double the overall growth rate for all occupations (figure 3-A). S&E occupations are projected to grow by 20.6% between 2008 and 2018, while employment in all occupations is projected to grow 10.1% over the same period (table 3-A, appendix table 3-1).* These projections involve only the demand for strictly defined S&E occupations and do not include the wider range of jobs in which S&E degree holders often use their training.

Approximately 58% of BLS's projected increase in S&E jobs is in computer and mathematical scientist occupations (table 3-A). Although life scientists account for a smaller number of job openings, they have a higher projected growth rate (26.7%) than computer and mathematical scientists (25.6%). The growth rates projected for physical scientists and social scientists are also above those for all occupations. Engineering occupations, with projected growth of 11.3%, are expected to grow at only slightly more than the rate for all jobs.

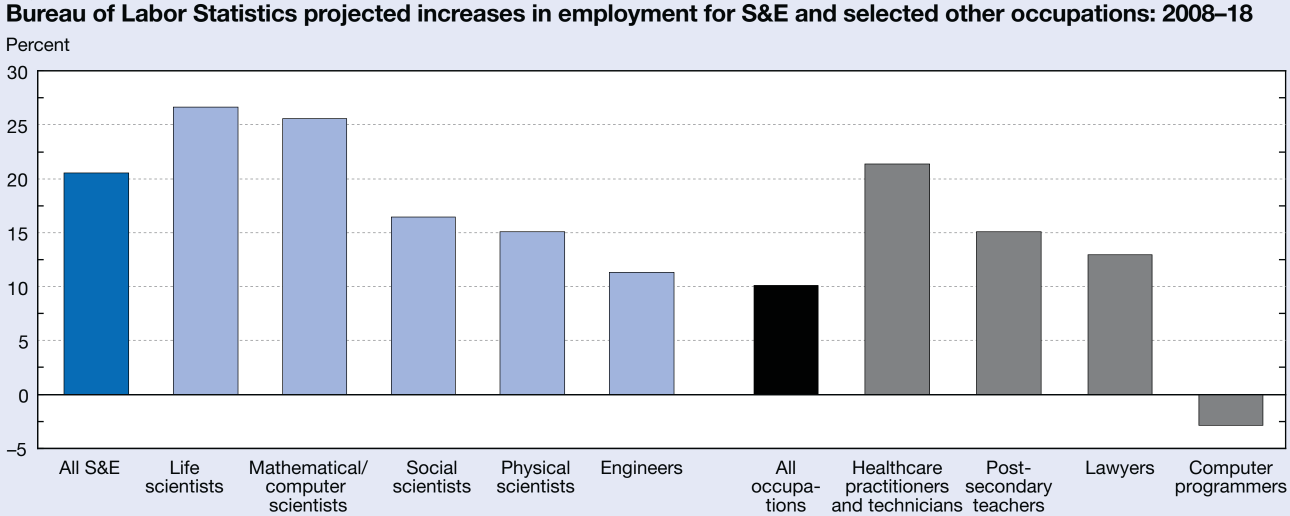
Table 3-A also shows occupations that either contain significant numbers of S&E-trained people or represent other career paths that are often chosen by S&E bachelor's degree holders who pursue graduate training. Among these, the occupation healthcare practitioners and technicians is projected to grow faster than all S&E occupations, from 7.5 million to 9.1 million workers over the decade between 2008 and 2018—an increase of 21.4%. Postsecondary teacher, which includes all fields of instruction, is projected to grow 15.1%. In contrast, BLS projects computer programmers to decrease by 2.9%.

BLS also projects that job openings in NSF-identified S&E occupations over the 2008–18 period will represent a greater proportion of current employment than openings in all other occupations—41.7% versus 33.7% (figure 3-B). Job openings include both growth in total employment and openings caused by attrition.

---

*Although BLS labor force projections do a reasonable job of forecasting employment in many occupations (see Alpert and Auyer 2003), the mean absolute percentage error in the 1988 forecast of employment in detailed occupations in 2000 was 23.2%.

Figure 3-A
Bureau of Labor Statistics projected increases in employment for S&E and selected other occupations: 2008–18



SOURCE: Bureau of Labor Statistics, Office of Occupational Statistics and Employment Projections, National Industry-Occupation Employment Projections 2008–18. See appendix table 3-1.

Science and Engineering Indicators 2012

Projected Growth of Employment in S&E Occupations—continued

Table 3-A
Bureau of Labor Statistics projections of employment and job openings in S&E and other selected occupations: 2008–18
(Thousands)

Occupation	BLS National Employment Matrix 2008 estimate	BLS projected 2018 employment	Job openings from growth and net replacements, 2008–18	10-year growth in total employment (%)	10-year job openings % of 2008 employment
All occupations	150,932	166,206	50,929	10.1	33.7
All S&E	5,571	6,717	2,321	20.6	41.7
Computer/mathematical scientists	3,101	3,895	1,353	25.6	43.6
Life scientists	279	354	144	26.7	51.4
Physical scientists	276	317	123	15.1	44.6
Social scientists/related occupations	343	400	170	16.5	49.4
Engineers	1,572	1,750	531	11.3	33.8
S&E-related occupations					
S&E managers	522	589	166	13.0	31.8
S&E technicians	855	925	298	8.2	34.9
Computer programmers	427	414	80	-2.9	18.8
Healthcare practitioners and technicians	7,491	9,091	3,139	21.4	41.9
Selected other occupations					
Postsecondary teachers	1,699	1,956	553	15.1	32.5
Lawyers	759	858	240	13.0	31.7

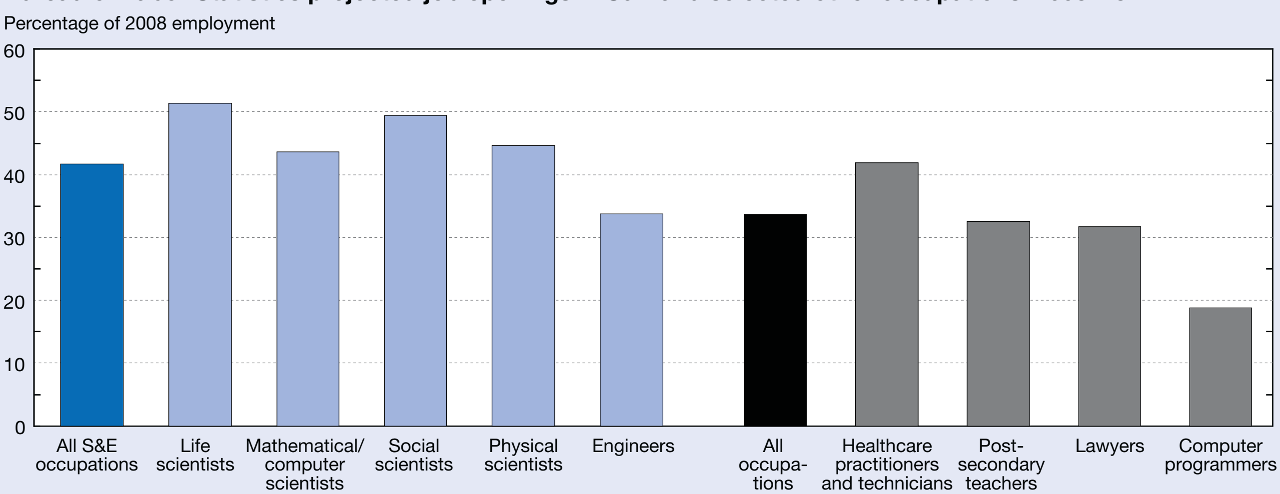
BLS = Bureau of Labor Statistics

NOTES: Estimates of current and projected employment for 2008–18 from BLS's National Employment Matrix. Data in matrix from Occupational Employment Statistics (OES) survey and Current Population Survey (CPS). Together, these sources cover paid workers, self-employed workers, and unpaid family workers in all industries, agriculture, and private households. Because data are derived from multiple sources, they can often differ from employment data provided by OES, CPS, or other employment surveys alone. BLS does not make projections for S&E occupations as a group; numbers in table based on sum of BLS projections in occupations that National Science Foundation considers as S&E.

SOURCE: BLS, Office of Occupational Statistics and Employment Projections, special tabulations (2011) of 2008–18 National Industry-Occupation Employment Projections.

Science and Engineering Indicators 2012

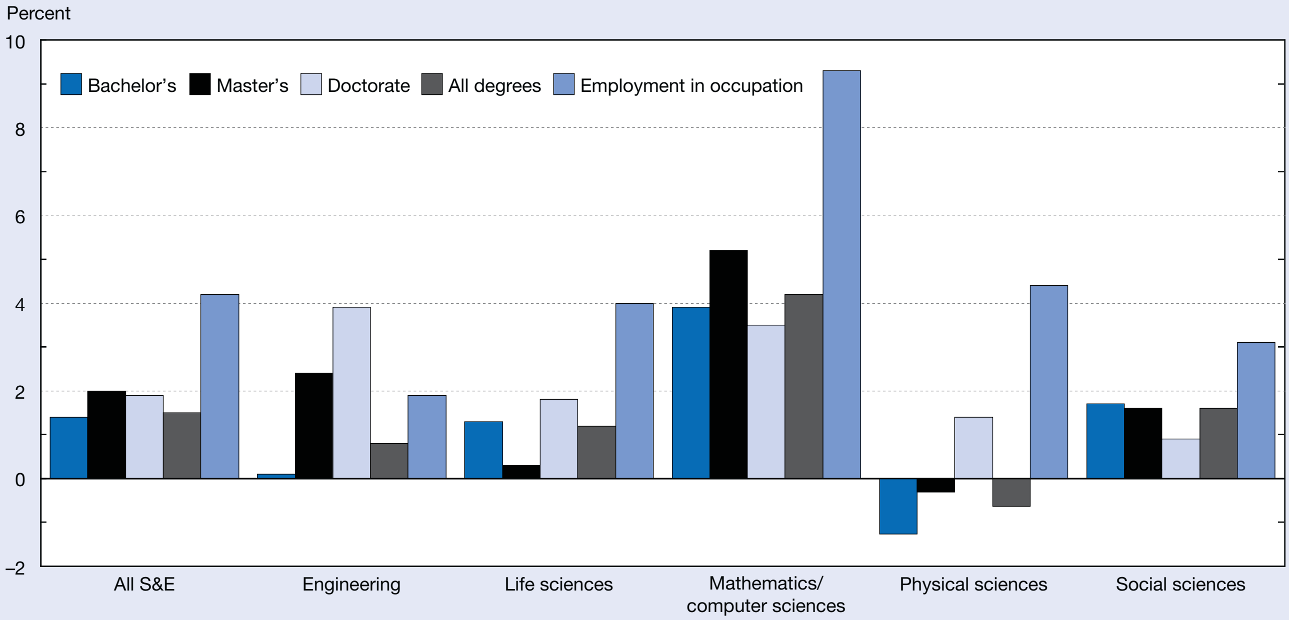
Figure 3-B
Bureau of Labor Statistics projected job openings in S&E and selected other occupations: 2008–18



SOURCE: Bureau of Labor Statistics, Office of Occupational Statistics and Employment Projections, National Industry-Occupation Employment Projections 2008–18. See appendix table 3-1.

Science and Engineering Indicators 2012

Figure 3-4
Annual average growth rate of degree production and occupational employment, by S&E field: 1980–2000



SOURCES: University of Michigan, Integrated Public Use Microdata Series, 1980–2000 Decennial Census files, http://usa.ipums.org/usa; and National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of WebCASPAR database, https://webcaspar.nsf.gov.

Science and Engineering Indicators 2012

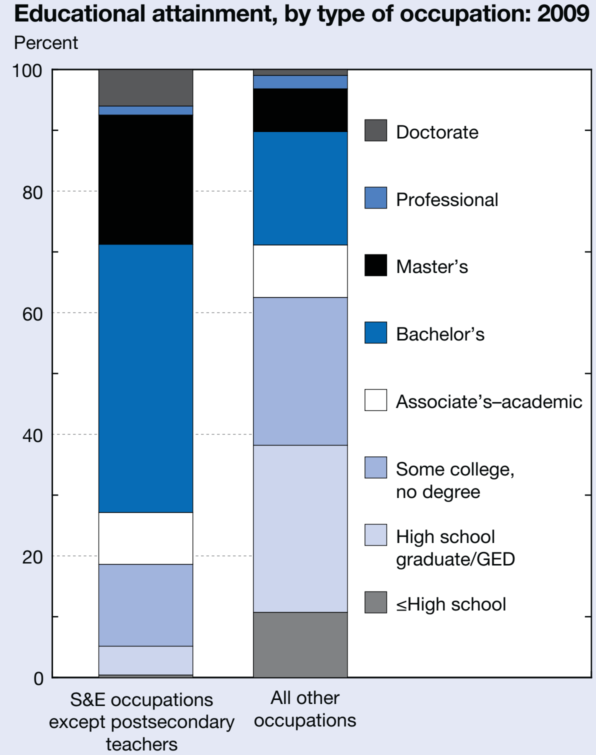
Educational Distribution of Those in S&E Occupations

Workers in S&E occupations have undergone more formal education than the general workforce (figure 3-5). Nonetheless, these occupations include workers with a range of educational qualifications. For all workers in S&E occupations except postsecondary teachers,[4] data from the 2009 U.S. Census Bureau's American Community Survey (ACS) indicate that slightly more than one-quarter had not earned a bachelor's degree. For an additional 44%, a bachelor's was their highest degree. The proportion of workers with advanced degrees was about equal to that of those without a bachelor's degree. Only about 6% of all S&E workers (except postsecondary teachers) had doctorates.

Technical issues related to occupational classification may inflate the estimated size of the nonbaccalaureate S&E workforce. Even so, these data indicate that many individuals enter the S&E workforce with marketable technical skills from technical or vocational schools (with or without earned associate's degrees) or college courses, and many acquire these skills through workforce experience or on-the-job training. In information technology, and to some extent in other occupations, employers frequently use certification exams, not formal degrees, to judge skills. (See "Who Performs R&D?" and the discussion in chapter 2.)

Among individuals with at least a bachelor's degree who work in S&E occupations, a large proportion (88%) have at least one S&E degree, and 75% have S&E degrees only

Figure 3-5
Educational attainment, by type of occupation: 2009



GED = General Equivalency Diploma

SOURCE: Census Bureau, American Community Survey (2009).

Science and Engineering Indicators 2012

(table 3-4). S&E workers who have both S&E and non-S&E degrees very likely earned their first bachelor's degree in S&E, even if their highest degree was not in an S&E field. Among workers in S&E occupations, the most common degrees are in engineering (38%) and computer sciences and mathematics (22%) (figure 3-6).

Table 3-4
Educational background of workers in S&E occupations: 2008

Educational background	Workers	Percent
S&E occupations	4,874,000	100.0
At least one S&E degree	4,275,000	87.7
First bachelor's degree in S&E field	4,022,000	82.5
Highest degree in S&E field	3,881,000	79.6
All degrees in S&E fields	3,644,000	74.8
At least one degree in field		
Computer and mathematical sciences	1,056,000	21.7
Biological, agricultural, and other life sciences	591,000	12.1
Physical sciences	479,000	9.8
Social sciences	675,000	13.9
Engineering	1,839,000	37.7
No S&E degrees but at least one S&E-related degree	217,000	4.4
No S&E or S&E-related degrees	382,000	7.8

NOTE: Detail may not add to total because of rounding.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2008), http://sestat.nsf.gov.

Science and Engineering Indicators 2012

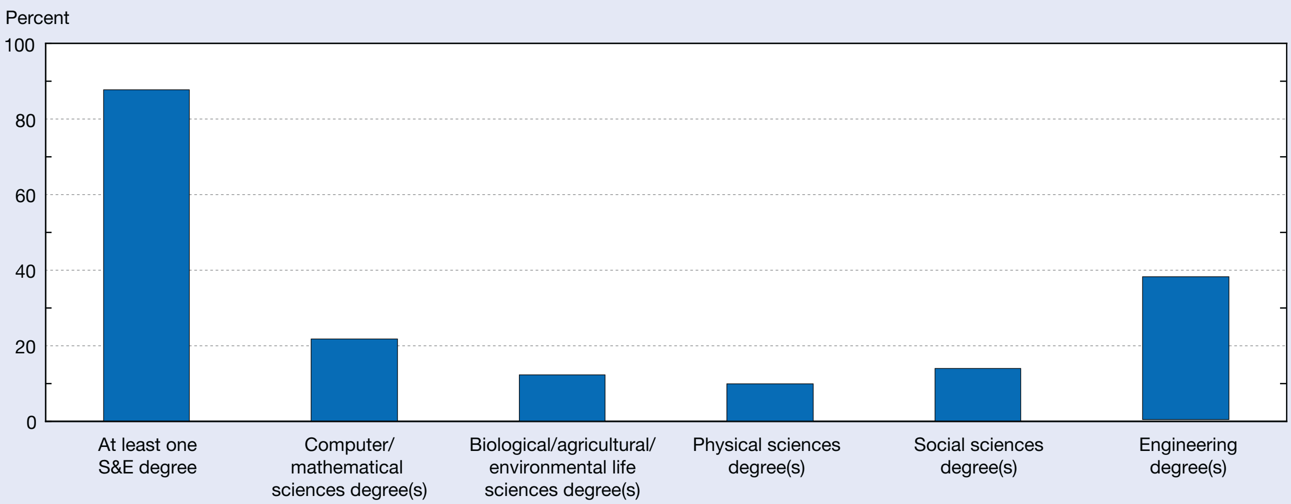
S&E Degree Holders in Non-S&E Occupations

S&E degree holders work in all manner of jobs. For example, they work in S&E-related jobs such as health occupations (1.4 million workers) or in S&E managerial positions (367,000 workers), but they also hold non-S&E jobs such as college and precollege teachers in non-S&E areas (655,000 workers) or work in social services occupations (634,000 workers) (appendix table 3-2).

In 2008, 6.3 million workers whose highest degree was in an S&E field did not work in an S&E occupation. Some 1.3 million worked in S&E-related occupations, while 5.1 million worked in non-S&E jobs. The largest category of non-S&E jobs was management and management-related occupations, with 1.5 million workers, followed by sales and marketing occupations, with 882,000 workers (appendix table 3-2).

Only about 38% of college graduates whose highest degree is in an S&E field work in S&E occupations (figure 3-7). The proportion is higher for those with more advanced degrees. The overall proportion varies substantially by field, ranging from engineering (64%) at the top, followed closely by computer sciences and mathematics (56%) and physical sciences (54%). Although a smaller percentage (31%) of biological/agricultural sciences degree holders work in S&E occupations, an additional 26% of persons with degrees in these fields work in S&E-related occupations (appendix table 3-2). Individuals with social science degrees (14%) are least likely to work in S&E occupations. This pattern of field differences generally characterizes individuals whose highest degree is either a bachelor's or a master's. At the doctoral level, the size of these field differences shrinks substantially.

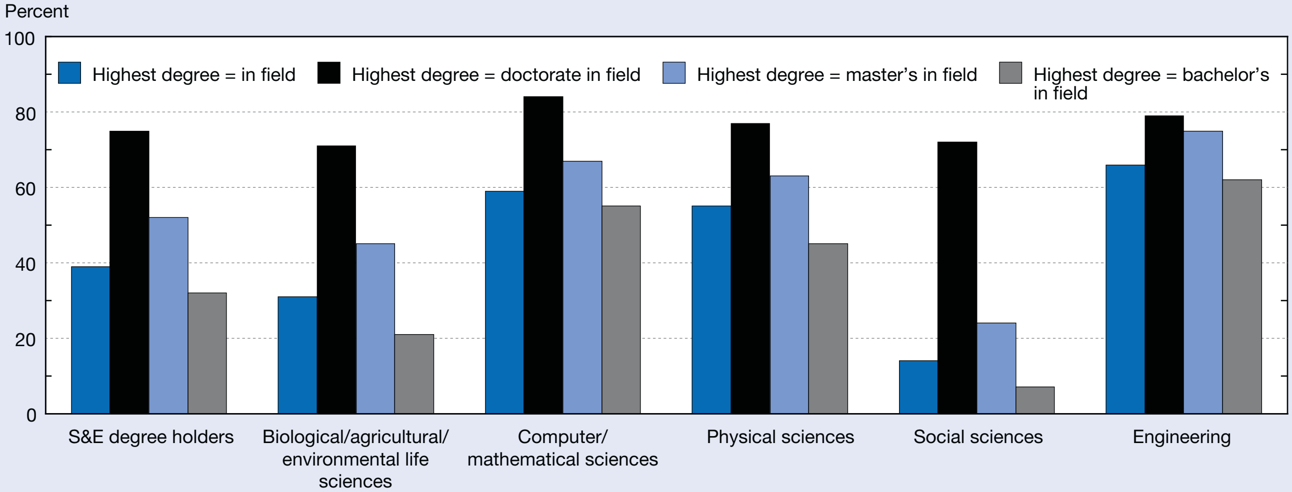
Figure 3-6
S&E degree background of workers in S&E occupations: 2008



SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2008), http://sestat.nsf.gov.

Science and Engineering Indicators 2012

Figure 3-7
S&E degree holders working in S&E occupations, by degree field: 2008



NOTE: Individuals may have degrees in more than one S&E degree field.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2008), http://sestat.nsf.gov.

Science and Engineering Indicators 2012

By field, holders of degrees in computer sciences and mathematics and engineering most often work in the broad occupation group in which they were trained (49% and 42%, respectively). S&E doctorate holders more often work in an S&E occupation similar to their doctoral field (55%) compared with individuals whose highest degree is an S&E bachelor's (23%) (appendix table 3-3).

Relationships Between Jobs and Degrees

Most individuals with S&E highest degrees who work in S&E-related or non-S&E occupations do not see themselves as working entirely outside their field of degree. Rather, most indicate that their jobs are either closely (34%) or somewhat (33%) related to their degree field (table 3-5). Among those in managerial and management-related occupations, for example, 33% characterize their jobs as closely related and 42% as somewhat related. More than half (52%) of workers in sales and marketing say their S&E degrees are closely or somewhat related to their jobs. Among S&E precollege teachers whose highest degree is in S&E, 72% say their jobs are closely related to their degrees.

Workers with more advanced S&E education more often do work that is at least somewhat related to their field of degree. Up to 5 years after receiving their degrees, 96% of S&E doctorate holders say that they have jobs closely or somewhat related to their degree field, compared with 92% of master's degree holders and 75% of bachelor's degree holders (figure 3-8). Even when the fit between an individual's job and degree is assessed using the stricter criterion of *closely related,* the data indicate that many S&E bachelor's degree holders who received their degree up to 5 years earlier are working in jobs that use skills developed during their college training (figure 3-9). In the natural sciences and engineering fields (i.e., S&E degree fields excluding the social sciences), half or more characterized their jobs as closely related to their field of degree: 58% in engineering, 57% in physical sciences, 60% in computer/mathematical sciences, and 46% in biological, agricultural, and environmental life sciences. The comparable figure for social science graduates (30%) was substantially lower.

Table 3-5
Relationship of highest degree to job among S&E highest degree holders not in S&E occupations, by degree level: 2008
(Percent)

		Degree related to job		
Highest degree	Workers	Closely	Somewhat	Not
All degree levels[a]	6,335,000	34.2	33.2	32.6
Bachelor's	5,108,000	30.8	33.6	35.6
Master's	1,027,000	49.3	30.6	20.1
Doctorate	193,000	45.1	36.9	18.0

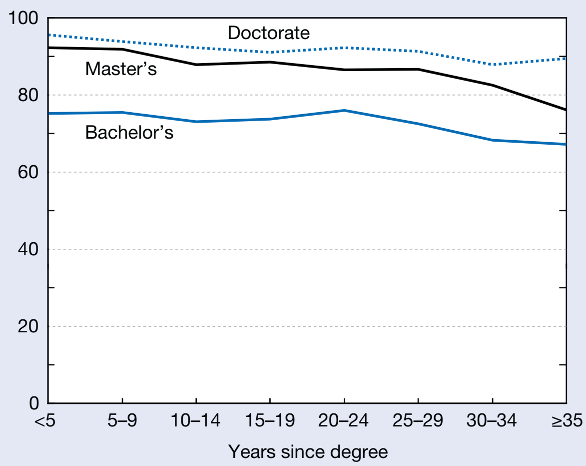
[a]Includes professional degrees not broken out separately.

NOTE: Detail may not add to total because of rounding.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2008), http://sestat.nsf.gov.

Science and Engineering Indicators 2012

Figure 3-8
S&E degree holders employed in jobs related to highest degree, by years since highest degree: 2008

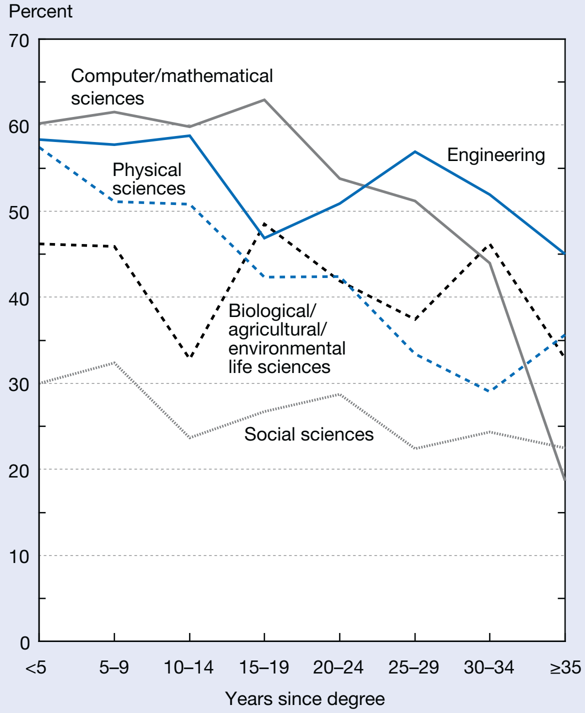


NOTE: Includes those who say their job is either closely related or somewhat related to field of their highest degree.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2008), http://sestat.nsf.gov.

Science and Engineering Indicators 2012

Figure 3-9
S&E bachelor's highest degree holders employed in jobs closely related to degree, by degree field and years since degree: 2008



SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2008), http://sestat.nsf.gov.

Science and Engineering Indicators 2012

The stronger relationship between S&E jobs and S&E degrees at higher degree levels holds at all career stages, as seen in comparisons among groups of bachelor's, master's, and doctoral degree holders at comparable numbers of years since receiving their degrees. However, for each group, the relationship between job and field of degree becomes weaker over time. There are many reasons for this decline: individuals may change their career interests, gain skills in different areas, take on general management responsibilities, forget some of their original college training, or even find that some of their original training has become obsolete. Against this background, the career-cycle decline in the relevance of an S&E degree appears modest.

The loose relationship among jobs, degrees, and individuals' perceptions of the expertise they need to do their work can be seen in figures 3-10 and 3-11. In figure 3-10, the intersecting area shows individuals whose highest degree is in S&E who are also working in S&E occupations. Less than one-third of SESTAT respondents fall in this area—the rest have one or the other attribute but not both. Figure 3-11 compares three groups of individuals who hold at least a bachelor's degree: those whose highest degree is in S&E and who say their job is at least somewhat related to their degree, those who say they need at least a bachelor's degree level of S&E expertise to perform their job, and those in S&E occupations. In 2008, about 13 million Americans had one or more of these characteristics.[5] Yet these three characteristics are not strongly associated with each other:

- Only 27% had all three characteristics, and 43% had only one.
- Even among those in S&E occupations, only about 71% also had S&E degrees, had jobs at least somewhat related to S&E, and believed they needed at least a bachelor's degree level of S&E expertise.
- Among the people who claimed they needed the technical expertise associated with an S&E bachelor's degree for their job, more than 40% said either that their job was unrelated to their actual degree or that their highest degree was not in S&E.

S&E Workers in the Economy

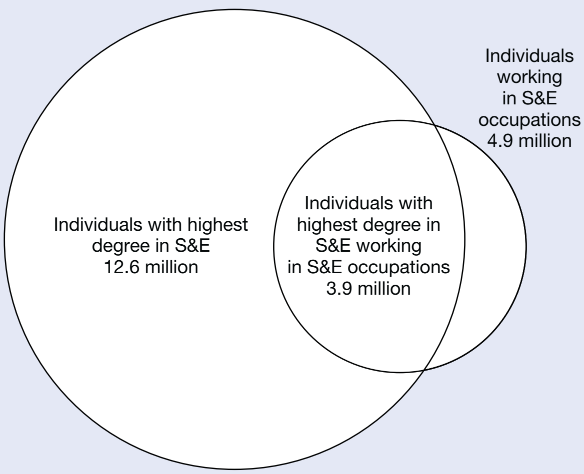
This section profiles how the S&E labor force is distributed across employment sectors in the U.S. economy. It shows that members of the S&E labor force work in all sectors, including for-profit businesses, nonprofit organizations, educational institutions, and government. The section begins with a brief description of patterns and trends in the proportions of the S&E labor force in these different employment sectors, and in the characteristics of organizations that employ S&E workers. The section looks at employment patterns in sectors and industries that have unusually high concentrations of S&E workers and variations among employers of different sizes. It then closes with a brief presentation of data on geographical areas with major concentrations of S&E workers. This includes data both on areas where workers in S&E occupations constitute a large percentage of the labor force and areas where large numbers of workers in these occupations are geographically concentrated.

The section then analyzes S&E employment in the different economic sectors. In the business/industry sector, it describes differences between for-profit and nonprofit organizations and in the proportion of S&E workers by industrial sector. The section also examines self-employed workers with S&E degrees and in S&E occupations. Throughout the section, the analysis distinguishes between employment sectors for individuals with S&E degrees and for those working in S&E occupations.

A brief analysis of the education sector, including all levels of education at both public and private institutions, and the government sector follows. In light of specialized scientific missions and the scope of scientific activities supported by the U.S. government, this section focuses on federal employment.

The S&E labor force is often seen as a major contributor to innovation. The section concludes, therefore, with data on various activities associated with innovation, such as performing R&D, patenting, and enhancing knowledge and skills through work-related training. This includes a description of data on job changes among S&E workers, which enable them to apply work-related learning in new contexts and may thereby spur innovation.

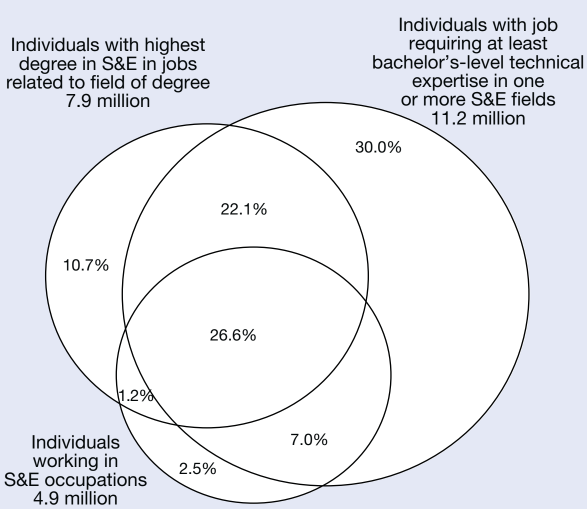
Figure 3-10
Intersection of individuals with highest degree in S&E and S&E occupation: 2008



SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2008), http://sestat.nsf.gov.

Science and Engineering Indicators 2012

Figure 3-11
Measures of the S&E workforce: 2008



SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2008), http://sestat.nsf.gov.

Science and Engineering Indicators 2012

Characteristics of Employers of Scientists and Engineers

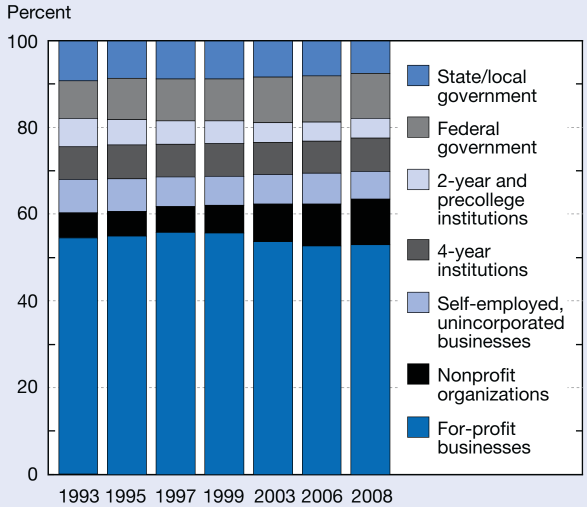
Employment Sector

In general, the labor market is divided into workers in the public sector and those in the private sector. This classification works awkwardly for analysis of the S&E labor force. Because educational institutions are significant employers of scientists and engineers in the United States, these institutions are better treated as a distinct sector, which spans public and private institutions and includes 4- and 2-year colleges and universities and precollege institutions. Employees in the business/industry sector work in for-profit businesses and nonprofit organizations, as well as being self-employed. The government sector includes local, state, and federal employees.

The S&E workforce includes both those working in S&E occupations and those trained in S&E fields. In 2008, approximately 70% of individuals trained or working in S&E worked in the business/industry sector, 12% in the government sector, and 18% in the education sector. This distribution has stayed relatively stable since the early 1990s (see figure 3-12), with some minor shifts. Although the overall percentage of scientists and engineers working in educational institutions has stayed at approximately 18% of overall employment, the relative proportion working in 4-year institutions versus other educational institutions has changed from about 50/50 in 1993 to 40/60 in 2008. Compared with 1993, a smaller proportion of scientists and engineers are working in the federal government in 2008 (6.4% versus 4.5%). The largest change has been within the nonprofit sector. In 1993, the proportion working in this sector was 5.8%; by 2008, it was 10.4%, an 80% increase.

The different sectors in which scientists and engineers are employed are shown in table 3-6. The sector distributions of scientists and engineers by highest degree in S&E versus any degree in S&E are very similar, and mirror the distributions found among all employed S&Es. Workers in different

Figure 3-12
Employed scientists and engineers, by employment sector: 1993–2008



NOTE: *Scientists and engineers* refers to all persons who work in an S&E occupation or who received a bachelor's degree or higher in an S&E degree field in 1993–99 or an S&E or S&E-related field in 2003–08.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (1993–2008), http://sestat.nsf.gov.

Science and Engineering Indicators 2012

broad occupational categories are concentrated in different employment sectors. Four-year educational institutions, for example, employ a higher percentage of workers in S&E occupations than other institutions in the education sector. A larger proportion of S&E-related workers are employed in nonprofit organizations, compared to those in S&E or non-S&E occupations.

Employer Size

Employer size can affect the breadth and depth of S&E employment concentration. Educational institutions and government entities that employ scientists and engineers are, primarily, larger employers. A large majority of these organizations have 100 or more employees (88% in the education sector, 91% in the government sector). Scientists and engineers working in the business/industry sector are more broadly distributed across firms of many sizes.

S&E degree holders who work in for-profit businesses are distributed particularly broadly. Moreover, within the business/industry sector, workers at different degree levels are distributed similarly across firms of different sizes (figure 3-13). Companies with fewer than 100 employees, for example, employ 36% of S&E highest degree holders who work in the business/industry sector, ranging from 32% of master's degree holders to 38% of doctorate holders. S&E doctorate holders in this sector, however, are concentrated at very small and very large firms. Some 23% work at the

Table 3-6
Employment sector of employed scientists and engineers, by broad occupation and degree field: 2008
(Number and percent)

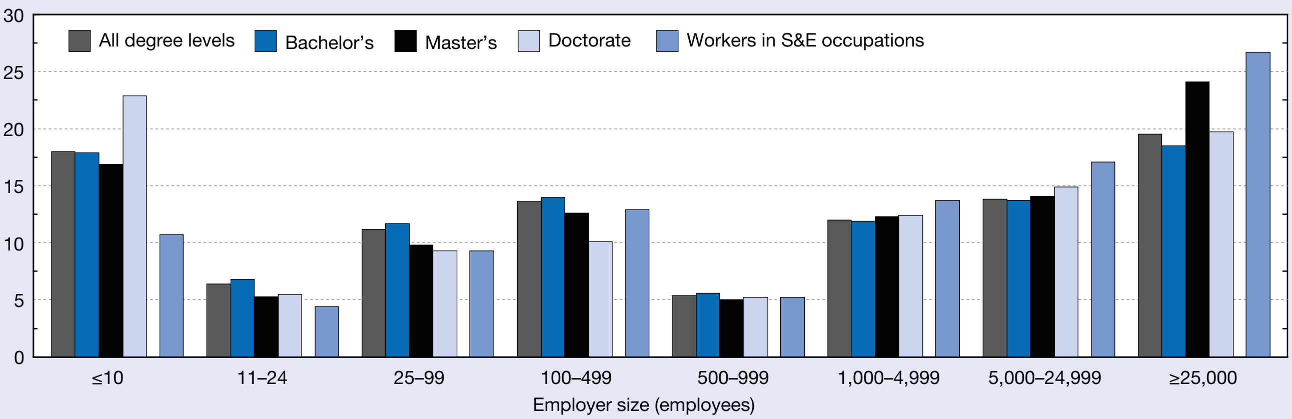
Employment sector	All employed scientists and engineers	Occupation			Education	
		S&E	S&E related	Non-S&E	Highest degree in S&E	Any degree in S&E
Total *(n)*	19,244,000	4,874,000	5,542,000	8,828,000	10,216,000	14,145,000
Business/industry (%)	69.8	70.9	69.6	69.3	71.3	69.8
For-profit businesses	53.0	63.2	45.0	52.4	58.9	55.5
Nonprofit organizations	10.4	4.4	18.4	8.6	6.9	7.8
Self-employed, unincorporated businesses	6.4	3.3	6.1	8.3	5.5	6.5
Education (%)	18.0	16.4	21.0	17.0	15.5	17.2
4-year institutions	7.5	13.3	7.1	4.5	8.3	8.0
2-year institutions	1.0	1.6	0.6	0.9	0.9	0.9
Precollege and other institutions	9.5	1.5	13.5	11.5	6.3	8.2
Government (%)	12.2	12.7	9.4	13.7	13.2	13.0
Federal	4.5	6.1	3.4	4.4	5.3	5.0
State	3.7	3.7	2.8	4.2	4.0	3.9
Local	4.0	3.0	3.2	5.1	3.9	4.2

NOTE: *Scientists and engineers* refers to all persons who have received a bachelor's degree or higher in a science or engineering (S&E) field or S&E-related field or occupation.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2008), http://sestat.nsf.gov.

Science and Engineering Indicators 2012

Figure 3-13
S&E highest degree holders and S&E workers employed in business/industry sector, by employer size: 2008



SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2008), http://sestat.nsf.gov.

Science and Engineering Indicators 2012

smallest firms (under 10 employees), but the proportion of them at firms with fewer than 500 employees is similar to that among S&E highest degree holders generally. At the other end of the spectrum, close to 20% of doctorate holders work at firms of 25,000 or more employees.

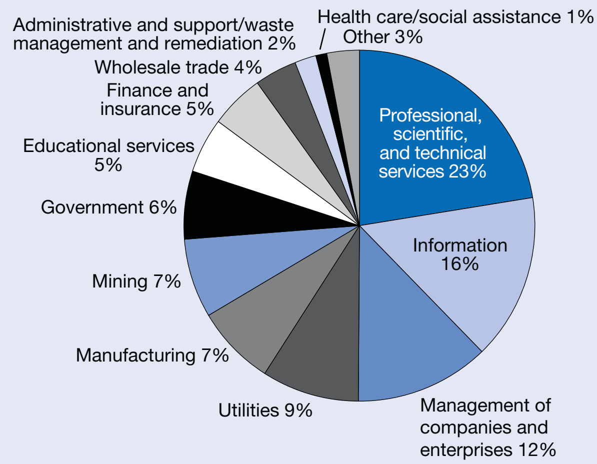
The distribution of employees in the business/industry sector in S&E occupations, however, shows a different pattern. Among this group, there is a greater concentration of employment in firms with more than 5,000 employees (44%), compared to those in smaller firms of 100 employees or fewer (25%).

S&E Occupation Density by Type of Industry

Industries vary in their proportions of S&E workers (table 3-6). The OES survey provides detailed estimates for employment by type of industry, although it excludes the self-employed and those employed in recent startups. OES classifies the government sector within the broad category "government," and educational institutions within the broad category of "educational services." In the for-profit sector, the industry with the highest percentage of S&E workers was "professional, scientific, and technical services" with 29%, followed by information with 16% (figure 3-14). The government (federal, state, and local) had 6% and the educational services sector had 5% of total employment in S&E occupations in 2010.

In 2010, slightly more than 1 million workers in S&E jobs were employed in industries whose S&E employment component was less than the national average of 4.4% (table 3-7). These industries employ 75% of all workers and 21% of all workers in S&E occupations. Examples include local government (at 3.0%, with 165,960 S&E jobs), hospitals (at 1.5%, with 77,890 S&E jobs), and plastic parts manufacturers (at 2.6%, with 13,000 S&E jobs).

Figure 3-14
Industries that employ workers in S&E occupations: May 2010



NOTE: Industries defined by North American Industry Classification System.

SOURCE: Bureau of Labor Statistics, Occupational Employment Statistics Survey (May 2010).

Science and Engineering Indicators 2012

Industries with higher proportions of individuals in S&E occupations tend to pay higher average salaries to both their S&E and non-S&E workers (table 3-7). The average salary of workers in non-S&E occupations employed in industries where more than 40% of workers are in S&E occupations is nearly double the average salary of workers in non-S&E occupations in industries with below-average proportions of workers in S&E occupations ($79,540 versus $29,970).

S&E Workers by Metropolitan Area

The availability of highly skilled workers can affect an area's economic competitiveness and its ability to attract business investment. The federal government uses standard definitions to describe geographical regions in the United States for comparative purposes. It designates very large metropolitan areas, sometimes dividing them into smaller metropolitan divisions that can also be substantial in size (Office of Management and Budget 2009).

Two measures indicate availability of workers in S&E occupations: (1) the number of these workers in a metropolitan area or division and (2) the proportion of the entire metropolitan workforce in S&E occupations. For both measures, estimates are affected by the geographic scope of a metropolitan area, which can vary significantly. Thus, comparisons between areas can be strongly affected by how much territory outside the urban core is included in the metropolitan area.

Table 3-8 presents the total number and proportion of workers in STEM and S&E occupations in the very large metropolitan areas with multiple metropolitan subdivisions. Metropolitan divisions with the largest estimated proportion of the workforce employed in S&E occupations are shown in table 3-9; those with the largest estimated number of workers employed in S&E occupations are listed in table 3-10. The metropolitan areas with the highest estimated

Table 3-7
Average annual salaries of workers, by industries' proportion of employment in S&E occupations: May 2010

				Average annual salary ($)		
Workers in S&E occupations (%)	All occupations	S&E occupations	Non-S&E occupations	All occupations	S&E occupations	Non-S&E occupations
All industries	127,097,160	5,549,980	121,547,180	44,410	80,170	42,770
>40.0	2,464,060	1,183,480	1,280,580	82,770	86,250	79,540
20.1–40.0	3,459,430	2,492,720	966,710	67,570	87,720	57,810
10.1–20.0	11,084,360	1,585,440	9,498,920	64,680	80,590	47,750
4.4–10.0	9,533,170	8,861,610	671,560	53,680	74,290	35,490
<4.4 (below national average)	95,119,520	1,139,620	93,979,900	40,480	70,320	29,970

SOURCE: Bureau of Labor Statistics, Occupational Employment Statistics Survey (May 2010).

Science and Engineering Indicators 2012

Table 3-8
Workers in S&E and STEM occupations in largest metropolitan statistical areas: May 2010

	Workers employed (*n*)			Percentage of workforce	
Metropolitan statistical area	All occupations	S&E occupations	STEM occupations	S&E occupations	STEM occupations
U.S. total	127,097,160	5,549,980	7,427,350	4.4	5.8
New York-Northern New Jersey-Long Island, NY-NJ-PA	8,101,890	S	443,200	S	5.5
Washington-Arlington-Alexandria, DC-VA-MD-WV	2,840,740	298,180	360,580	10.5	12.7
Los Angeles-Long Beach-Santa Ana, CA	5,191,880	237,430	308,090	4.6	5.9
Boston-Cambridge-Quincy, MA-NH	2,413,780	190,260	244,740	7.9	10.1
Chicago-Naperville-Joliet, IL-IN-WI	4,169,840	155,760	214,310	3.7	5.1
Dallas-Fort Worth-Arlington, TX	2,832,560	151,090	198,860	5.3	7.0
Seattle-Tacoma-Bellevue, WA	1,601,010	138,350	174,920	8.6	10.9
San Francisco-Oakland-Fremont, CA	1,900,110	138,280	177,380	7.3	9.3
Philadelphia-Camden-Wilmington, PA-NJ-DE-MD	2,619,360	129,910	168,720	5.0	6.4
Detroit-Warren-Livonia, MI	1,686,920	102,210	135,190	6.1	8.0
Miami-Fort Lauderdale-Pompano Beach, FL	2,143,470	63,060	83,940	2.9	3.9

S = suppressed for reasons of confidentiality and/or reliability

STEM = science, technology, engineering, and mathematics

NOTES: Includes only metropolitan statistical areas with multiple metropolitan divisions. Differences among employment estimates may not be statistically significant. For additional information see appendix table 3-4.

SOURCE: Bureau of Labor Statistics, Occupational Employment Statistics Survey (May 2010).

Science and Engineering Indicators 2012

Table 3-9
Metropolitan areas with largest proportion of workers in S&E occupations, by occupation category: May 2010

Metropolitan area	Percentage of workforce: S&E occupations	Percentage of workforce: STEM occupations	Workers employed (*n*): All occupations	Workers employed (*n*): S&E occupations	Workers employed (*n*): STEM occupations
U.S. total	4.4	5.8	127,097,160	5,549,980	7,427,350
San Jose-Sunnyvale-Santa Clara, CA	15.4	19.2	857,160	131,890	164,640
Huntsville, AL	13.7	17.5	202,410	27,780	35,500
Boulder, CO	13.6	15.9	152,100	20,640	24,220
Corvallis, OR	12.4	17.4	32,770	4,050	5,700
Durham, NC	11.8	15.1	266,990	31,590	40,260
Framingham, MA NECTA Division	11.4	14.8	154,760	17,710	22,960
Lowell-Billerica-Chelmsford, MA-NH NECTA Division	11.1	14.7	113,630	12,630	16,660
Washington-Arlington-Alexandria, DC-VA-MD-WV Metropolitan Division	10.6	12.7	2,289,200	243,350	291,730
Bethesda-Frederick-Gaithersburg, MD Metropolitan Division	9.9	12.5	551,550	54,820	68,860
Seattle-Bellevue-Everett, WA Metropolitan Division	9.7	12.3	1,346,300	131,130	164,980
Kennewick-Pasco-Richland, WA	9.2	12.6	96,390	8,830	12,100
Bloomington-Normal, IL	8.8	11.4	85,760	7,570	9,750
College Station-Bryan, TX	8.8	11.1	92,510	8,110	10,230
Palm Bay-Melbourne-Titusville, FL	8.6	11.3	189,730	16400	21,480
Boston-Cambridge-Quincy, MA NECTA Division	8.4	10.7	1,658,000	139,620	177,930
Olympia, WA	8.4	10.3	93,910	7,870	9,640
Kokomo, IN	8.4	10.9	37,790	3,160	4,120
Fort Collins-Loveland, CO	8.0	10.0	125,100	10,070	12,500
Austin-Round Rock, TX	8.0	10.4	759,910	60,600	79,210
Colorado Springs, CO	7.9	9.5	240,000	19,050	22,700

NECTA = New England City and Town Area; STEM = science, technology, engineering, and mathematics

NOTES: Excludes metropolitan statistical areas where S&E proportions were suppressed. Larger metropolitan areas broken into component metropolitan divisions. Differences among employment estimates may not be statistically significant. For additional details, see appendix table 3-4.

SOURCE: Bureau of Labor Statistics, Occupational Employment Statistics Survey (May 2010).

Science and Engineering Indicators 2012

proportion of S&E employment are mainly smaller and perhaps less economically diverse. However, some large areas, such as Washington, D.C.; Seattle; Boston; and San Jose, also appear on the list of metropolitan areas with the greatest intensity of S&E employment. Differences between estimates for different areas are not necessarily statistically significant. More detailed information on all metropolitan areas can be found in appendix table 3-4.

S&E Workers by Employment Sector

Education Sector

Overall, the education sector employs 18% of scientists and engineers and 16% of those in S&E occupations (table 3-6). Depending on the population, however, the proportion working within different parts of the education sector varies. For example, for workers with an S&E doctorate, 4-year colleges and universities are the most important employer (appendix table 3-5). However, only a minority (41%) of S&E doctorate holders work in this sector, and not all of these are tenured or tenure-track faculty. This figure also includes individuals holding postdoc and other temporary positions, working in various other S&E teaching and research jobs, performing administrative functions, and employed in a wide variety of non-S&E occupations. (See chapter 5 for additional details on academic employment of science, engineering, and health (SEH) doctorates.)

Within the education sector, the portion of the workforce in S&E occupations is concentrated in 4-year institutions (81%). In contrast, most education sector workers in S&E-related or non-S&E occupations are found in precollege or other institutions (63% and 68%, respectively). These workers are primarily teachers in these types of institutions.

Business/Industry Sector

For-profit businesses. For-profit businesses employ the greatest number of individuals with S&E degrees (figure 3-12). In 2008, they employed 59% of all individuals whose highest degree is in S&E and 35% of S&E doctorate holders (appendix table 3-5). By occupation, they employ 53% of those working in S&E occupations.

Table 3-10
Metropolitan areas with largest number of workers in S&E occupations, by occupation category: May 2010

Metropolitan area	Workers employed (*n*) All occupations	Workers employed (*n*) S&E occupations	Workers employed (*n*) STEM occupations	Percentage of workforce S&E occupations	Percentage of workforce STEM occupations
U.S. total	127,097,160	5,549,980	7,427,350	4.4	5.8
Washington-Arlington-Alexandria, DC-VA-MD-WV Metropolitan Division	2,289,200	243,350	291,730	10.6	12.7
New York-White Plains-Wayne, NY-NJ Metropolitan Division	4,982,650	182,350	250,050	3.7	5.0
Los Angeles-Long Beach-Glendale, CA Metropolitan Division	3,817,570	169,040	217,670	4.4	5.7
Houston-Sugar Land-Baytown, TX	2,497,880	135,170	184,640	5.4	7.4
Chicago-Naperville-Joliet, IL Metropolitan Division	3,542,180	131,980	182,380	3.7	5.1
Boston-Cambridge-Quincy, MA NECTA Division	1,658,000	139,620	177,930	8.4	10.7
Seattle-Bellevue-Everett, WA Metropolitan Division	1,346,300	131,130	164,980	9.7	12.3
San Jose-Sunnyvale-Santa Clara, CA	857,160	131,890	164,640	15.4	19.2
Dallas-Plano-Irving, TX Metropolitan Division	2,001,860	115,340	150,490	5.8	7.5
Atlanta-Sandy Springs-Marietta, GA	2,200,660	108,840	139,950	4.9	6.4
Minneapolis-St. Paul-Bloomington, MN-WI	1,678,090	99,380	132,040	5.9	7.9
Philadelphia, PA Metropolitan Division	1,804,600	93,760	120,330	5.2	6.7
San Diego-Carlsbad-San Marcos, CA	1,238,720	83,330	111,550	6.7	9.0
Denver-Aurora, CO	1,183,990	82,610	101,300	7.0	8.6
Phoenix-Mesa-Scottsdale, AZ	1,683,500	73,680	100,060	4.4	5.9
Baltimore-Towson, MD	1,238,860	72,670	93,740	5.9	7.6
San Francisco-San Mateo-Redwood City, CA Metropolitan Division	948,970	73,800	92,600	7.8	9.8
Santa Ana-Anaheim-Irvine, CA Metropolitan Division	1,374,310	68,390	90,420	5.0	6.6
Warren-Troy-Farmington Hills, MI Metropolitan Division	1,017,660	65,640	86,600	6.5	8.5
Oakland-Fremont-Hayward, CA Metropolitan Division	951,150	64,470	84,770	6.8	8.9

NECTA = New England City and Town Area; STEM = science, technology, engineering, and mathematics

NOTES: Larger metropolitan areas broken into component metropolitan divisions. Differences among employment estimates may not be statistically significant. For additional details see appendix table 3-4.

SOURCE: Bureau of Labor Statistics, Occupational Employment Statistics Survey (May 2010).

Science and Engineering Indicators 2012

Nonprofit organizations. Nonprofit organizations have shown substantial growth in the percentage of scientists and engineers that they employ (see figure 3-12). However, this is primarily driven by those working in S&E-related occupations (which include health-related jobs); 18.4% of the workers in S&E-related occupations work in nonprofit organizations (table 3-6). Among those in S&E occupations, the proportion is much smaller—4.4%.

Self-employment. More than 3.6 million individuals with S&E degrees or working in S&E occupations were self-employed in 2008—18.8% of all scientists and engineers in the United States (table 3-11; NSF/NCSES 2008). This SESTAT estimate of self-employment is much higher than others that have been published elsewhere because it includes those self-employed individuals who work in incorporated businesses. In contrast, most reports of federal data on self-employment are limited to individuals whose businesses are unincorporated.

Although only about one-third of all self-employed workers in the United States work in incorporated businesses (Census Bureau 2009), about two-thirds of self-employed scientists and engineers in the broad SESTAT population work in such businesses (table 3-11). The rate of incorporated self-employment is much higher for individuals with S&E degrees (12%), with S&E highest degrees (11%), or working in S&E occupations (8%) than for the U.S. workforce as a whole, where the comparable rate is 3% (Census Bureau 2009).

Scientists and engineers working in S&E-related or non-S&E occupations reported higher levels of self-employment (20% and 22%, respectively) than those working in S&E occupations. Some 16% of social scientists indicated that they are self-employed, but unlike the general pattern of higher

Table 3-11
Self-employed scientists and engineers, by education, occupation, and type of business: 2008
(Percent)

Characteristic	Total	Unincorporated business	Incorporated business
All self-employed scientists and engineers	18.8	6.4	12.4
S&E degree holders			
At least one degree in S&E field	18.7	6.5	12.2
Highest degree in S&E field	16.7	5.6	11.1
Computer and mathematical sciences	13.9	3.3	10.6
Biological, agricultural, and environmental life sciences	17.1	6.5	10.6
Physical sciences	15.1	5.7	9.4
Social sciences	18.0	7.4	10.6
Engineering	16.8	3.5	13.3
Occupation			
S&E occupation	11.1	3.3	7.8
Computer and mathematical scientists	10.3	2.4	7.9
Biological, agricultural, and environmental life scientists	5.7	1.6	4.1
Physical scientists	9.3	3.2	6.1
Social scientists	16.1	11.1	5.0
Engineers	12.3	2.4	9.9
S&E-related occupations	20.1	6.1	14.0
Non-S&E occupations	22.3	8.3	14.0

NOTE: Scientists and engineers include those with one or more S&E or S&E-related degrees at bachelor's level or higher or who have a non-S&E degree at bachelor's level or higher and were employed in an S&E or S&E-related occupation in 2008.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2008), http://sestat.nsf.gov.

Science and Engineering Indicators 2012

incorporated self-employment exhibited among scientists and engineers in general, this group reported higher rates of unincorporated self-employment. This is largely driven by psychologists, 30% of whom are self-employed, mostly in unincorporated businesses (NSF/NCSES 2008). Many scientists and engineers who are self-employed are working in small businesses. Some 81% of self-employed individuals in unincorporated businesses and 46% of self-employed people in incorporated businesses are working in businesses with 10 or fewer employees. Some proportion of these scientists and engineers are likely to be working as independent professionals, rather than in small businesses.

The proportion of self-employed workers generally decreases by level of degree and increases with age (figure 3-15). Across all ages, 18% of S&E bachelor's degree holders are self-employed, but the proportion falls to 12% for S&E doctorate holders. However, self-employment increases with age at all degree levels. By ages 60–64, self-employment reaches about 35% for bachelor's degree, 27% for master's degree, and 21% for doctorate holders.

Government Sector

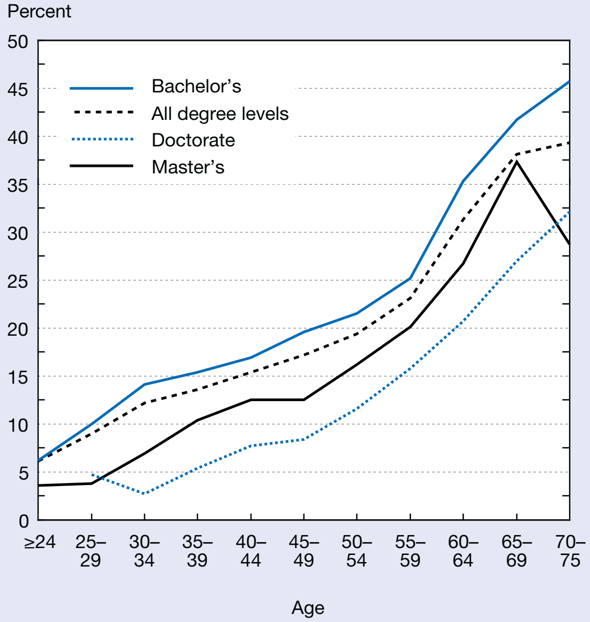
Federal government. The United States' federal government is a major employer of scientists and engineers. However, its employees are largely limited to those with U.S. citizenship.[6] According to data from the U.S. Office of Personnel Management, the federal government employed approximately 235,000 persons in S&E occupations in 2009. Many of these workers were in occupations that, nationwide, include relatively large concentrations of foreign-born persons, some of whom are not U.S. citizens, rendering them ineligible for many federal jobs. Among federal employees in S&E occupations, 60% were in science occupations and 40% were in engineering occupations.

The five federal agencies with the largest proportions of scientists and engineers among their workforce are those with strong scientific missions: the National Aeronautics and Space Administration (NASA), Nuclear Regulatory Commission (NRC), Environmental Protection Agency (EPA), National Science Foundation (NSF), and Department of Energy. The Department of Defense employed the largest number of scientists and engineers, with 43% of the federal S&E workforce (NSF/NCSES 2012b, forthcoming).[7]

Overall, scientists and engineers represent approximately 11.5% of the entire federal workforce. Among federal executives in the Senior Executive Service (SES),[8] 22% are scientists and engineers.

State and local government. Data from the 2010 OES survey show that there are approximately 7.89 million employees of state and local governments in the United States. In 2008, SESTAT estimated 1.48 million scientists and engineers working in this sector. Approximately 8% of

Figure 3-15
Self-employment rates of workers with highest degrees in S&E, by degree level and age: 2008



NOTE: Self-employment includes unincorporated self-employed and incorporated self-employed. All degree levels includes professional degrees not broken out separately.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2008), http://sestat.nsf.gov.

Science and Engineering Indicators 2012

individuals with highest degrees in S&E work in this sector; 7% of those with S&E occupations also work there (appendix table 3-5). Within S&E occupations, a larger proportion of biological and physical scientists work in state and local governments (11.3% and 10.5%, respectively), relative to other S&E occupations.

Scientists and Engineers and Innovation-Related Activities

Who Performs R&D?

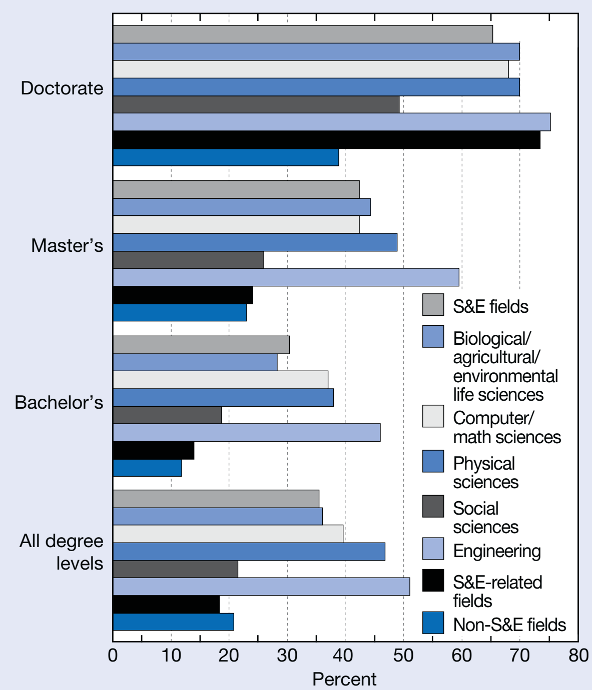
Because R&D creates new knowledge and new types of goods and services that can fuel economic growth, individuals with S&E expertise who use their knowledge in R&D attract special interest. Using SESTAT data, this section reports two broad indicators of R&D work. One involves whether performing R&D is a major work activity constituting at least 10% of the worker's job. The other is whether workers report R&D as a primary or secondary work activity—an activity ranking first or second in work hours from a list of 14 choices.

In 2008, just over 14.1 million employed individuals had one or more S&E degrees (NSF/NCSES 2008). Overall, 31% of S&E degree holders report R&D as a major work activity in their principal jobs. The majority of them have bachelor's (52%) or master's (32%) degrees, while individuals with doctorates, who constitute only 6% of all individuals with S&E degrees, represent 12% of individuals who report R&D as a major work activity.

R&D as a work activity varies among S&E degree holders depending on the field of their highest degree. Figure 3-16 shows the proportion of S&E degree holders who report R&D as their primary or secondary work activity, by their highest degree level and field (which may not be in S&E). Among S&E fields, the highest degree holders in engineering reported the highest aggregate R&D activity rate (51%), while those in the social sciences reported the lowest rate (22%).

In all fields, doctorate holders report higher R&D activity rates than those at lower levels of educational attainment. Engineering doctorate holders report the highest R&D rates, with other doctorate holders in natural and mathematical sciences fields having slightly lower rates. Social sciences and health doctorates report the lowest R&D rates (figure 3-16). This pattern of differences among fields is similar to that found among all degree holders.

Figure 3-16
R&D activity rate of employed S&E degree holders, by field and level of highest degree: 2008



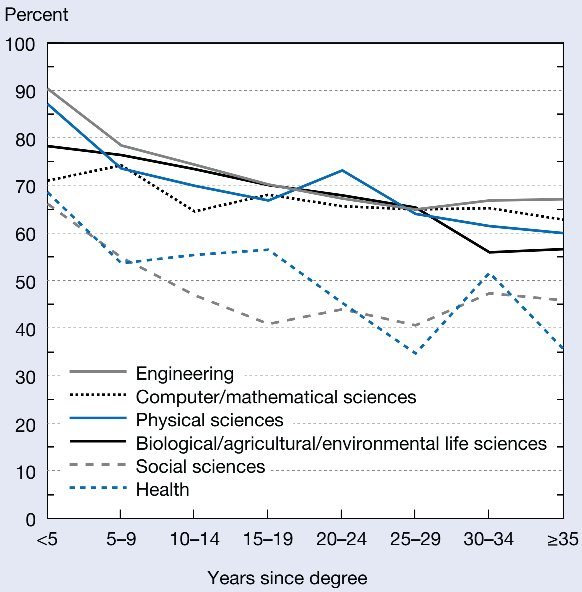
NOTES: "All degree levels" includes professional degrees not broken out separately. R&D activity rate is proportion of individuals who report that basic research, applied research, design, or development is primary or secondary work activity. For classification of degrees by S&E, S&E-related, and non-S&E, see table 3-1.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2008), http://sestat.nsf.gov.

Science and Engineering Indicators 2012

Doctorate holders in all fields engaged in declining amounts of R&D activity over the course of their careers (figure 3-17). The decline may reflect movement into management or other career interests. It may also reflect increased opportunity for more experienced scientists to perform functions involving the interpretation and use of, as opposed to the creation of, scientific knowledge.

Figure 3-17
SEH doctorate holders with R&D as major work activity, by field and years since degree: 2008



SEH = science, engineering, and health

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2008), http://sestat.nsf.gov.

Science and Engineering Indicators 2012

Many S&E degree holders subsequently earn degrees in other fields, such as medicine, law, or business. Figure 3-16 includes individuals who have at least one S&E degree, but then may have earned other degrees in S&E-related and non-S&E fields. These individuals report substantial R&D activity rates less often than workers whose highest degrees are in S&E fields. Nonetheless, the proportions who report R&D as their primary or secondary activity—18% for those whose highest degree is in an S&E-related field and 21% for those whose degree is in a non-S&E field—are still substantial and are similar to those for people with their highest degree in the social sciences.

R&D activity spans a broad range of occupations. Table 3-12 shows the occupational distribution of S&E degree holders who spend at least 10% of their time on R&D or report R&D as a major work activity. Among the former, 39% are in non-S&E occupations (lawyers or non-S&E managers, for example). Twenty-seven percent of those for whom R&D is a major work activity are in non-S&E occupations.

R&D Employment in the Business/Industry Sector

A large proportion (78%) of scientists and engineers who work in the business/industry sector report spending at least 10% of their work hours on R&D activities; this proportion is 80% for those employed in the for-profit sector (NSF/NCSES 2008). The 2009 Business R&D and Innovation Survey, which includes only U.S.-located companies that fund or perform R&D, allows for further examination of R&D employment in this sector.

Table 3-12
Employed S&E degree holders with R&D work activities, by occupation: 2008

Occupation	Employed S&E degree holders: Number	Employed S&E degree holders: Percent	R&D at least 10% of work time: Number	R&D at least 10% of work time: Percent	R&D at least 10% of work time: R&D activity rate (%)	R&D as major work activity: Number	R&D as major work activity: Percent	R&D as major work activity: R&D activity rate (%)
All occupations	14,145,000	100.0	7,670,000	100.0	54.2	4,403,000	100.0	31.1
S&E occupations	4,275,000	30.2	3,397,000	44.3	79.5	2,590,000	58.8	60.6
Biological, agricultural, environmental life scientists	455,000	3.2	399,000	5.2	87.8	338,000	7.7	74.3
Computer and mathematical scientists	1,577,000	11.1	1,163,000	15.2	73.7	811,000	18.4	51.4
Physical scientists	308,000	2.2	263,000	3.4	85.5	219,000	5.0	71.1
Social scientists	449,000	3.2	303,000	4.0	67.6	228,000	5.2	50.7
Engineers	1,487,000	10.5	1,268,000	16.5	85.3	994,000	22.6	66.8
S&E-related occupations	2,507,000	17.7	1,258,000	16.4	50.2	631,000	14.3	25.2
Non-S&E occupations	7,363,000	52.1	3,015,000	39.3	40.9	1,182,000	26.8	16.1

NOTE: Detail may not add to total because of rounding. R&D as major work activity includes those reporting basic research, applied research, design, or development as activities they spent the most or second-most hours engaged in during a typical work week.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2008), http://sestat.nsf.gov.

Science and Engineering Indicators 2012

The proportion of R&D employment relative to total employment, or R&D employment intensity, is one indicator of a company's involvement in R&D activity. Companies located in the United States that performed or funded research and development domestically or overseas employed an estimated 27.1 million workers worldwide in 2009 (NSF/NCSES 2012a, forthcoming). The domestic employment of these companies totaled 17.8 million workers, including 1.4 million domestic R&D employees. Thus, domestic R&D employment accounted for 8% of companies' total domestic employment (table 3-13).

Smaller companies reported higher proportions of domestic R&D employment than did larger companies, with companies of 250 or more reporting 10% or fewer of their domestic employees as R&D employees, and small companies reporting rates higher than 10% (table 3-13). The greatest proportion of R&D employment (27.0%) is among companies of 5–24 employees, whereas the smallest proportion (5.1%) is among very large companies of 25,000 or more.

R&D employment is found in both manufacturing and nonmanufacturing industries, but at different rates. R&D employment intensity is 8.6% in manufacturing industries and 7.3% in nonmanufacturing industries (figure 3-18). Examination of this indicator across industries shows the highest R&D employment intensity rates in scientific R&D services (36%), communications equipment (30%), software publishers (28%), semiconductor and other electronics equipment (27%), and pharmaceuticals and medicines (20%).

Table 3-13
Domestic industrial and R&D employment, by company size: 2009
(Thousands of employees)

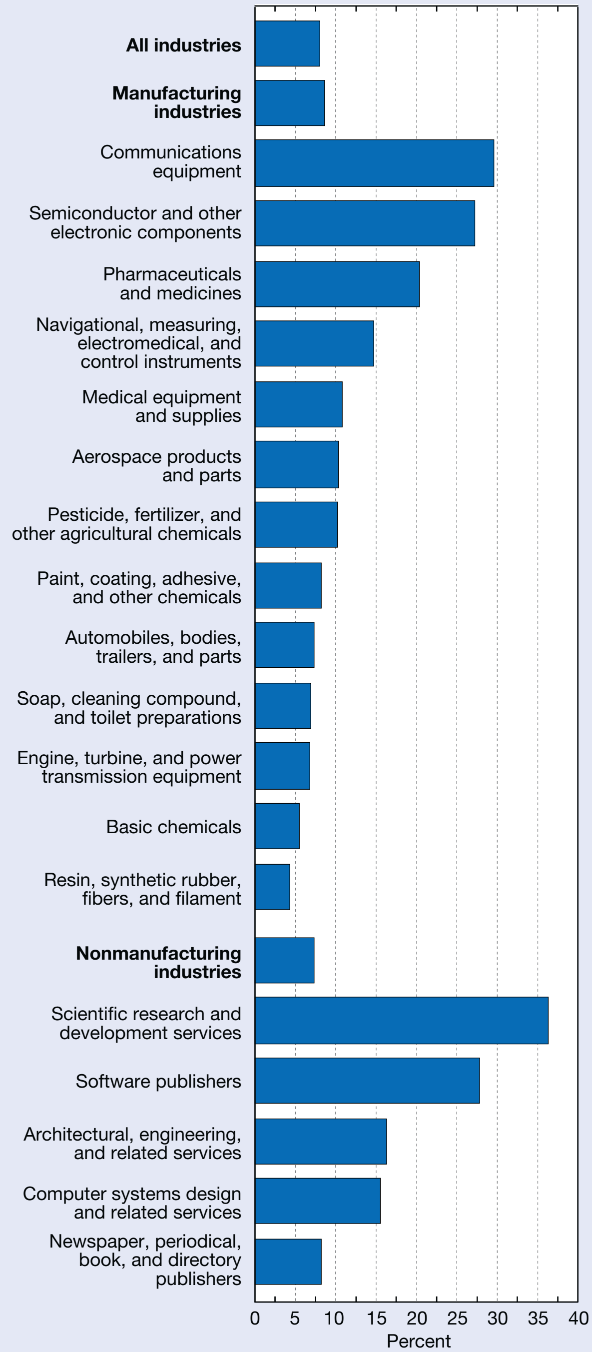
Company size	Domestic employees: All	Domestic employees: R&D	Domestic employees: % R&D employees
All companies	17,788	1,424	8.0
Small companies			
5–499	3,045	459	15.1
5–99	1,471	295	20.1
5–49	869	197	22.7
5–24	429	116	27.0
25–49	440	81	18.4
50–99	602	99	16.4
100–249	853	91	10.7
250–499	721	72	10.0
Medium and large companies			
500–999	795	64	8.1
1,000–4,999	2,349	204	8.7
5,000–9,999	1,603	112	7.0
10,000–24,999	2,679	212	7.9
≥25,000	7,316	374	5.1

NOTES: Data representative of companies where worldwide R&D expense plus worldwide R&D costs funded by others are greater than zero. Size based on number of domestic employees. Includes 2002 North American Industry Classification System (NAICS) codes 21–23, 31–33, and 42–81. Upper bound of "small company" classification based on U.S. Small Business Administration's definition of small business; Business R&D and Innovation Survey (BRDIS) does not include companies with fewer than 5 domestic employees. Detail may not add to total because of rounding.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, BRDIS (2009 preliminary).

Science and Engineering Indicators 2012

Figure 3-18
Domestic R&D employment in selected industries: 2009



SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Business R&D and Innovation Survey (2009 preliminary).

Science and Engineering Indicators 2012

Patenting Activity of Scientists and Engineers

The U.S. Patent and Trademark Office grants patents to inventions that are new, useful, and not obvious. Patenting is a limited but useful indicator of the inventive activity of scientists and engineers.

In its 2003 SESTAT surveys of the S&E workforce, NSF asked scientists and engineers to report on their recent patenting activities. Among those who had ever worked, 2.6% reported that from fall 1998 to fall 2003 they had been named as an inventor on a U.S. patent application (NSB 2010). Patenting activity rates were highest among those employed in the business/industry sector.

The patent office does not grant all patent applications, and not all granted patents produce useful commercial products or processes. NSF estimates that in the 5-year period for which data were collected, U.S. scientists and engineers filed 1.8 million patent applications. The patent office granted some 1 million patents (although applicants may have applied for some of these at an earlier period).

Of those patents granted between 1998 and 2003, about 54% resulted in a commercialized product, process, or license during the same period. Scientists and engineers employed in the business/industry sector reported the highest commercialization success rate (58%), much higher than the education (43%) and government (13%) sectors.[9] The overall commercialization rate varies by degree level, at 60%–65% for bachelor's and master's degree holders but 38% for doctorate holders (many of whom work in education, which has a low commercialization rate relative to other sectors).

In 2003, the patent activity rate of doctorate holders was 15.7%, compared with 0.7% among those whose highest degree was at the bachelor's level.[10] However, there are far fewer doctoral-level scientists and engineers, so they accounted for only about a quarter of all survey respondents named on a U.S. patent application. Bachelor's and master's degree holders accounted for 41% and 31%, respectively, of all patenting activity reported in the survey.

More recent data from 2008 on a subset of scientists and engineers—U.S.-trained science, engineering, and health (SEH) doctorates—show that the patent activity rate of this set of employed doctorate holders from 2003 to 2008 was 16.2% (table 3-14). The highest patenting activity rates were among doctorate holders in engineering (38.6%) and physical sciences (25.0%). Doctorate holders in these two fields also report the highest average number of applications per person (5.9 in both fields) and the highest average number granted (3.6 and 3.4, respectively). Doctorate holders in engineering and computer/information sciences report the highest average number commercialized (1.5 in both fields).

Table 3-14
Patenting indicators for employed U.S.-trained SEH doctorate holders, by field of doctorate: 2003–08

Indicator	All fields	Biological sciences	Computer/ information sciences	Mathematics/ statistics	Physical sciences	Psychology	Social sciences	Engineering	Health
Employed U.S. SEH doctorates	651,168	163,981	16,152	30,035	115,376	99,157	81,596	115,994	28,878
Patent applicants	105,196	26,159	4,780	2,034	30,621	1,010	591	38,368	1,632
Patent activity rate (%)	16.2	17.2	15.1	5.4	25.0	1.0	8.0	38.6	6.7
Patent grantees	73,169	16,905	3,064	1,367	22,664	677	343	27,047	1,099
Patent commercializers	40,365	7,779	1,787	692	12,256	349	255	16,593	653
Grantee's commercialization success rate (%)	55.2	46.0	58.3	50.6	54.1	51.6	74.3	61.3	59.4
Average number									
Applications	5.18	3.63	5.08	4.89	5.87	2.35	3.56	5.91	2.82
Patents granted	2.92	1.77	2.45	2.66	3.57	1.38	1.24	3.40	1.32
Commercialized products, processes, or licenses	1.16	0.69	1.49	1.06	1.14	0.66	0.79	1.50	0.69
Number of patents									
Applied for	545,058	95,080	24,312	9,940	179,737	2,378	2,113	227,002	4,609
Granted	307,583	46,199	11,682	5,405	109,389	1,395	729	130,686	2,160
Commercialized	122,182	18,055	7,114	2,147	34,914	673	464	57,700	1,131
Patent commercialization success rate (%)	39.7	39.1	60.9	39.7	31.9	48.2	63.6	43.9	52.4

SEH = science, engineering, and health

NOTES: Patenting indicators include activities between October 2003 and October 2008. Patenting indicators defined in Morgan R, Kruytbosch C, Kannankutty N, Patenting and invention activity of U.S. scientists and engineers in the academic sector: Comparisons to industry, *Journal of Technology Transfer* 26:173–83 (2001). Biological sciences includes agricultural and environmental life sciences.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Doctorate Recipients (2008), http://sestat.nsf.gov.

Science and Engineering Indicators 2012

Work-Related Training

In addition to formal education, scientists and engineers very often engage in work-related training. Such training can contribute to innovation in the economy by enhancing skills and knowledge within the S&E labor force. According to SESTAT, about three-fifths of scientists and engineers participated in work-related training in 2008. Among those who were employed, the rate was approximately 67%; for the unemployed, it was 32% (table 3-15). Among employed scientists and engineers, those in S&E-related occupations (health-related occupations, S&E managers, S&E precollege teachers, and S&E technicians and technologists) had the highest participation rate (79%).

Most who took training did so to improve skills or knowledge in their current occupational field (53%) (appendix table 3-6). Others did so for licensure/certification in their current occupational field (24%) or because it was required or expected by their employer (14%). Relative to those who were employed or not in the labor force, those who were unemployed more often reported that they engaged in work-related training to facilitate a change to a different occupational field. Not surprisingly, those who were not in the labor force more often reported that they engaged in this activity for leisure or personal interest. Women participated in work-related training at a higher rate than men: 61% compared with 55% of men (appendix table 3-7). This difference exists regardless of labor force status or highest degree level.

Table 3-15
Scientists and engineers participating in work-related training, by employment status and occupation: 2008

Employment status and occupation	Number	Percent
All scientists and engineers	23,232,000	57.8
Employed	19,244,000	66.5
S&E occupations	4,874,000	58.1
Computer and mathematical scientists	1,970,000	54.1
Biological, agricultural, other life scientists	498,000	56.2
Physical scientists	322,000	53.1
Social scientists	502,000	62.9
Engineers	1,582,000	63.1
S&E-related occupations	5,542,000	78.5
Non-S&E occupations	8,828,000	63.6
Unemployed	604,000	31.8
S&E occupations	140,000	25.9
Computer and mathematical scientists	61,000	28.8
Biological, agricultural, other life scientists	12,000	24.7
Physical and related scientists	10,000	22.5
Social and related scientists	11,000	36.8
Engineers	45,000	20.2
S&E-related occupations	106,000	44.0
Non-S&E occupations	359,000	30.5
Not in labor force	3,383,000	13.1

NOTES: Scientists and engineers include those with one or more S&E or S&E-related degrees at bachelor's level or higher, or who have non-S&E degree at bachelor's level or higher and employed in S&E or S&E-related occupation in 2006. Unemployed individuals are those not working but who looked for job in preceding 4 weeks. For unemployed, the last job held was used for classification. Total excludes scientists and engineers who never worked. Detail may not add to total because of rounding.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2008), http://sestat.nsf.gov.

Science and Engineering Indicators 2012

S&E Labor Market Conditions

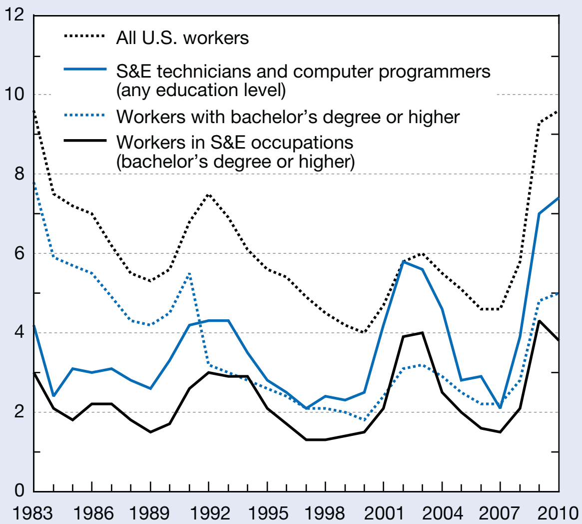
Labor market conditions for scientists and engineers affect the attractiveness of S&E fields to both students and those already in the labor force. Assessing the state of the labor market generally includes examining a variety of indicators that can include employment and unemployment conditions and earnings, and the interplay of these indicators with other economic measures. The most recent recession officially began in December 2007 and ended in June 2009.[11] These two endpoints represent the peak of a business cycle through the trough. Although there are no fixed definitions that identify peaks and troughs of business activity, factors such as the gross domestic product, aggregate employment, and national income are considered relevant. As various measures are presented in this section, it is important to note that many of these measures are lagging indicators. That is, they are economic factors that sometimes do not change until the economy has already begun to follow a particular trend. For example, unemployment rates can continue to rise or can remain the same although a recession has ended. Unemployment rates, involuntarily out-of-field rates, and earnings should all be considered in this context. This section looks at both long-term and recent trends in these indicators using NSF, Census Bureau, and BLS data ranging from before and continuing after the recession.

Unemployment in the S&E Labor Force

In general, those who hold S&E degrees or those working in S&E occupations have had lower rates of unemployment than other college graduates and much lower rates than those without a college education. However, this does not exempt them from unemployment due to overall business cycles or specific events affecting individuals with training in their fields.

Unemployment rates in S&E occupations are also generally less volatile than unemployment rates for these other groups (figure 3-19). The Bureau of Labor Statistics' Current Population Survey data for 1983–2010 indicate that the unemployment rate for all individuals in S&E occupations ranged from 1.3% to 4.3%, which contrasted favorably with rates for all U.S. workers (from 4.0% to 9.6%) and all workers with a bachelor's degree or higher (from 1.8% to 7.8%). The rate for S&E technicians and computer programmers ranged from 2.1% to 7.4%. During most of the period, computer

Figure 3-19
Unemployment rate, by occupation: 1983–2010



SOURCES: National Bureau of Economic Research, Merged Outgoing Rotation Group files (various years); Bureau of Labor Statistics, Current Population Survey (various years).

Science and Engineering Indicators 2012

programmers had an unemployment rate similar to that of workers in S&E occupations, but with greater volatility (from 1.2% to 6.7%). By 2010 unemployment rates for all U.S. workers were still increasing, while the unemployment rate for workers in S&E occupations had begun to go down.

The recent economic downturn that began in late 2007 generally follows the historic pattern. In 2008, workers in S&E occupations or S&E technician and computer programmer occupations had lower unemployment rates (2.1% or 3.9%, respectively) than all workers (5.8%). By 2009, when unemployment had reached much higher levels, workers in S&E occupations and S&E technicians and technologists still had lower rates (4.3% and 7.0%, respectively) than all workers in general (9.3%); a similar pattern existed for 2010.

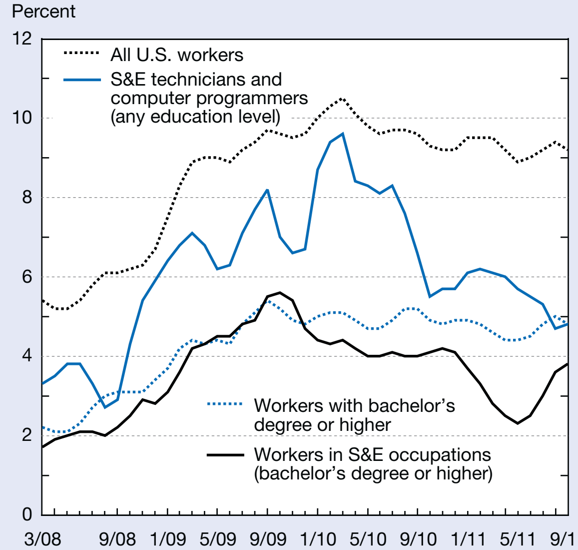
Three-month unemployment rates tell a somewhat more nuanced story. College-educated S&E workers generally have lower unemployment rates than all college graduates; this pattern was still valid in the period from 2007 to 2010. However, in the 3-month period ending in September 2009, the unemployment rate of college educated S&E workers rose to 5.5%, approximately the same rate as for all college graduates (5.4%). S&E technicians and computer programmers continued to experience a considerably lower unemployment rate (8.2%) than that of the general labor force (9.7%) (figure 3-20). These rates immediately followed the end of the official recession (June 2009). Moving forward to the 3-month period ending in September 2011, the more classic pattern emerges of college-educated S&E workers having a significantly lower unemployment rate (3.8%) than all college graduates (4.8%). It should be noted, however, that unemployment rates for college graduates have remained relatively stable since approximately April 2011, while they have risen for college-educated S&E workers.

Broader Measures of Labor Underutilization

The most commonly cited unemployment measure is the percentage of people who are not working but who have looked for work in the preceding 4 weeks. This is the standard (U3) unemployment rate. In addition to U3, the Bureau of Labor Statistics reports five other rates of labor underutilization (U1, U2, U4, U5, and U6; see table 3-16). These provide additional detail about differences in employment patterns between the S&E labor force and the general U.S. labor force (appendix table 3-8).

Trends in indicators of labor underutilization during the economic downturn that began at the end of 2007 consistently indicate that workers whose most recent job was in an S&E occupation experienced lower underutilization rates than the general labor force. Moreover, the advantages for workers in S&E occupations increased over the course of the economic downturn. Figure 3-21 shows the growing gap between these workers and the general labor force in both standard (U3) and long-term (U1) unemployment rates. The difference between their monthly standard rates ranged between 3.2 and 4.1 percentage points in 2008, between 4.0 and 4.9 percentage points in 2009, and between 5.0 and 6.1

Figure 3-20
Estimated unemployment rates over previous 3 months for workers in S&E occupations and selected other categories: March 2008–September 2011



NOTES: Estimates not seasonally adjusted. Estimates from pooled microrecords of Current Population Survey and, although similar, are not same as 3-month moving average.

SOURCE: Bureau of Labor Statistics, Current Population Survey, Public-Use Microdata Sample (PUMS), March 2008–September 2011.

Science and Engineering Indicators 2012

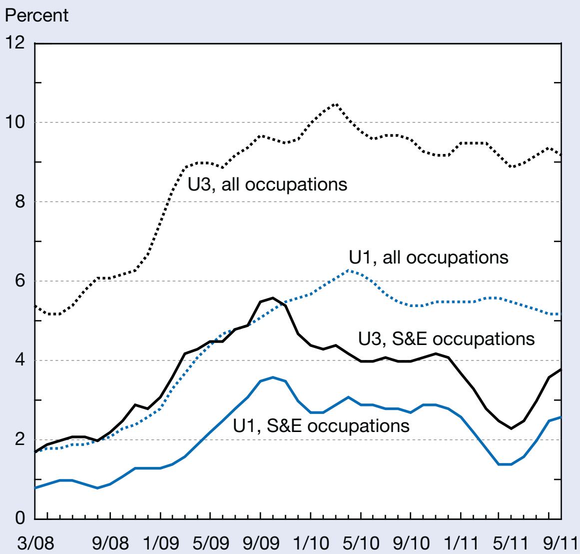
Table 3-16
Alternative measures of labor underutilization

Measure	Definition
U1	Percentage of the labor force unemployed for 15 weeks or longer
U2	Percentage of the labor force who lost jobs or completed temporary work
U3	Official unemployment rate: percentage of the labor force without jobs who have actively looked for work within the past four weeks
U4	U3 + percentage of the labor force who are discouraged workers (those who have stopped looking for work)
U5	U4 + percentage of the labor force who are marginally attached workers (those who would like to work but have not looked for work recently)
U6	U5 + percentage of the labor force who are part-time workers but want to work full time

SOURCE: Bureau of Labor Statistics, http://www.bls.gov/lau/stalt.htm.

Science and Engineering Indicators 2012

Figure 3-21
Measures of labor underutilization for S&E occupations and all occupations: March 2008–September 2011



U1 = % of labor force unemployed for 15 weeks or more; U3 = % of labor force without jobs who have looked for work in past 4 weeks (official unemployment rate)

NOTES: Estimates not seasonally adjusted. Estimates made from pooled microrecords of Current Population Survey and, although similar, are not same as 3-month moving average.

SOURCE: Bureau of Labor Statistics, Current Population Survey, Public-Use Microdata Sample (PUMS), March 2008–September 2011.

Science and Engineering Indicators 2012

percentage points in 2010. It remained near 6 percentage points for most of 2011. Whereas general unemployment peaked at 10.5% (March 2010), S&E unemployment rose only as high as 5.6% in October 2009.

Similarly, the difference in long-term unemployment, defined as more than 15 weeks, grew as the downturn went on. It rose from about 1 to 1.3 percentage points in 2008 to between 1.5 and 2.6 percentage points in 2009, and over 3 percentage points in the first half of 2010 before dropping later in the year. Beginning near the end of 2009, the rate of long-term unemployment in the general labor force exceeded the rate of standard unemployment for those in S&E occupations.

The most comprehensive labor underutilization indicator (U6) includes various kinds of workers who are not employed full time but would like to be. More than the U3 unemployment rate, this indicator captures the difference between workers' labor market aspirations and outcomes. During the downturn, the gap between this measure and the standard unemployment rate among workers in S&E occupations was substantially smaller than the comparable gap in the general labor force (appendix table 3-8). Thus, the proportion of underutilized workers who were unemployed in the standard sense of the term was consistently higher among S&E workers than it was in the general labor force.

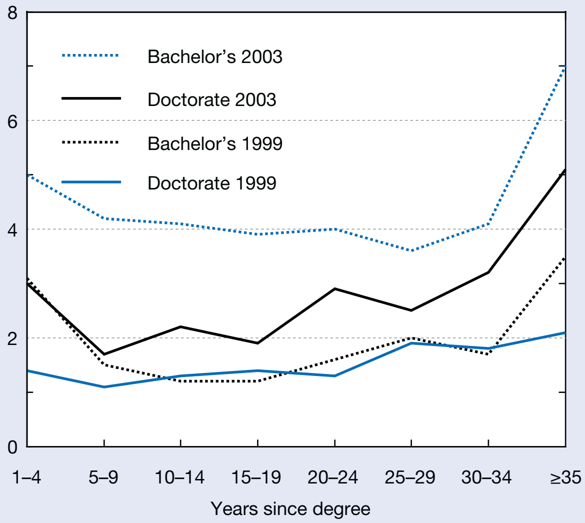
Unemployment Rates by Degree and Field

In most economic downturns, workers with advanced S&E degrees have been less vulnerable to changes in economic conditions than individuals who hold only S&E bachelor's degrees. Figure 3-22 compares unemployment rates over career cycles for persons with S&E bachelor's degrees and doctorates, regardless of their occupation, for 1999 and 2003—periods of relatively good and relatively difficult labor market conditions, respectively. The relatively difficult 2003 labor market had a greater effect on bachelor's degree holders: for individuals at various points in their careers, the unemployment rate increased by between 1.6 and 3.5 percentage points between 1999 and 2003. Labor market conditions had a smaller effect on doctorate holders, but some increases in unemployment rates affected individuals in most years-since-degree cohorts.

Similarly, among those who said they were working involuntarily outside the field of their highest degree, labor market conditions from 1999 to 2003 had a greater effect on the proportion of bachelor's degree holders than on doctorate holders (figure 3-23). These rates ranged from 7% to 12% for bachelor's degree holders in 2003 versus 2% to 5% for those with doctorates. Rates of working involuntarily out-of-field (IOF) for doctorate holders changed little between 1999 and 2003.

Although S&E qualifications may help workers weather recessions, they do not make them immune to the adverse labor market conditions that recessions bring. The estimated 4.3% unemployment rate for S&E occupations in April 2009, although low relative to other occupations, was the highest in 25 years.

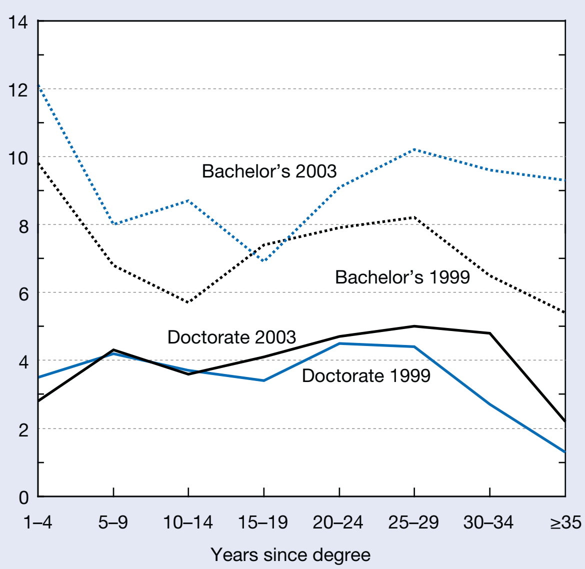
Figure 3-22
Unemployment rates for individuals with S&E as highest degree, by degree level and years since degree: 1999 and 2003



SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (1999 and 2003), http://sestat.nsf.gov.

Science and Engineering Indicators 2012

Figure 3-23
Individuals with highest degree in S&E who are involuntarily working out of field, by degree level and years since highest degree: 1999 and 2003



NOTE: Individuals involuntarily employed out of their field include those in jobs not related to field of highest degree because job in that field not available, and those employed part time because full-time work not available.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (1999 and 2003), http://sestat.nsf.gov.

Science and Engineering Indicators 2012

Earnings

The estimated annual wages of individuals in S&E occupations, based on the OES survey, are considerably higher than the average of the total workforce. Median annual wages in 2010 (regardless of education level or field) in S&E occupations were $75,820, more than double the median ($33,840) for all U.S. workers (table 3-17). The spread in average (mean) wage was less dramatic but still quite wide, with individuals in S&E occupations again earning considerably more on average ($80,170) than workers in all occupations ($44,410). Mean S&E wages ranged from $71,860 for social science occupations to $87,980 for engineering occupations.

The 2007–10 annual growth in mean and median wages for both the S&E and STEM occupation groups were similar to those for employed U.S. workers in the OES data.

Workers with S&E degrees also have higher earnings than those with degrees in other fields. Figure 3-24 shows estimates of median salary at different points in life for individuals with a bachelor's degree as their highest degree in a variety of fields. Except in the first 4 years after earning their degrees, holders of S&E bachelor's degrees earn more than those with non-S&E degrees at every year since degree. Median salaries for S&E bachelor's degree holders in 2003 peaked at $65,000 at 15–19 years after receiving their degree, compared with $49,000 for those with non-S&E bachelor's degrees. Median salaries of individuals with bachelor's degrees in S&E-related fields (such as technology, architecture, or health) peaked at $52,000 at 25–29 years after degree, but were higher than those for non-S&E bachelor's degree holders regardless of years of experience.

Earnings at Different Degree Levels

Data on educational histories of all college graduates have been periodically collected by the National Survey of College Graduates, allowing for detailed comparisons of S&E and other college degree holders. Figure 3-25 illustrates the distribution of median salaries earned by individuals with S&E degrees at various levels. (Because the distributions are heavily skewed, the median is the preferred summary statistic.) Not surprisingly, salaries are higher for those with more advanced degrees. In 2003 (the most recent data available), 11% of S&E bachelor's degree holders had salaries higher than $100,000, compared with 28% of doctorate holders. Similarly, 22% of bachelor's degree holders earned less than $30,000, compared with 8% of doctorate holders.[12]

Figure 3-26 shows a cross-sectional profile of median 2003 salaries for S&E degree holders over the course of their career. Median earnings generally increase with time since degree, as workers add on-the-job knowledge to their formal training. For holders of bachelor's and master's degrees in S&E, average earnings adjusted for inflation begin to decline in mid to late career, a common pattern that is often attributed to "skill depreciation." In contrast, earnings for S&E doctorate holders continue to rise even late in their

Table 3-17
Annual earnings and earnings growth in science and technology and related occupations: May 2007–May 2010

Occupation	Mean: 2007 annual earnings ($)	Mean: 2010 annual earnings ($)	Mean: Annual growth rate since 2007 (%)	Median: 2007 annual earnings ($)	Median: 2010 annual earnings ($)	Median: Annual growth rate since 2007 (%)
All U.S. employment	40,690	44,410	2.2	31,410	33,840	1.9
STEM occupations	72,000	79,000	2.3	66,950	73,290	2.3
S&E occupations	74,070	80,170	2.0	70,600	75,820	1.8
Computer/mathematical scientists	71,940	77,320	1.8	68,910	73,790	1.7
Life scientists	71,700	77,850	2.1	63,170	68,740	2.1
Physical scientists	73,720	80,490	2.2	67,190	72,850	2.0
Social scientists	66,370	71,860	2.0	60,380	65,540	2.1
Engineers	81,050	87,980	2.1	77,750	83,610	1.8
Technology occupations	67,870	74,510	2.4	NA	62,180	NA
S&E managers	114,470	NA	NA	NA	NA	NA
S&E technicians/computer programmers	53,165	NA	NA	NA	NA	NA
S&E-related occupations (not included above)	66,150	72,580	2.3	50,540	71,320	9.0
Health-related occupations	66,000	72,480	2.4	55,310	59,350	1.8
Other S&E-related occupations	73,110	78,350	1.7	50,250	71,320	9.1

NA = not available

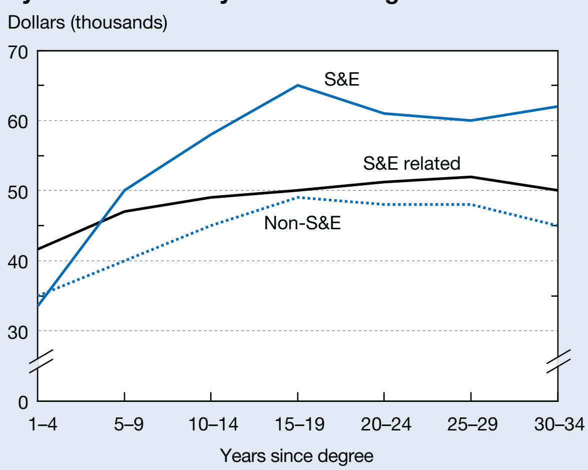
STEM = science, technology, engineering, and mathematics

NOTE: Occupational Employment Statistics (OES) employment data do not cover employment in agriculture, private household, or among self-employed and therefore do not represent total U.S. employment.

SOURCE: Bureau of Labor Statistics, OES Survey (May 2007 and May 2010).

Science and Engineering Indicators 2012

Figure 3-24
Median salaries for bachelor's degree holders, by broad field and years since degree: 2003



NOTE: See table 3-2 for definitions of S&E, S&E-related, and non-S&E degrees.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, National Survey of College Graduates (2003).

Science and Engineering Indicators 2012

careers. Median salaries in 2003 peaked at $65,000 for bachelor's degree holders, $73,000 for master's degree holders, and $96,000 for doctorate holders.

Recent S&E Graduates

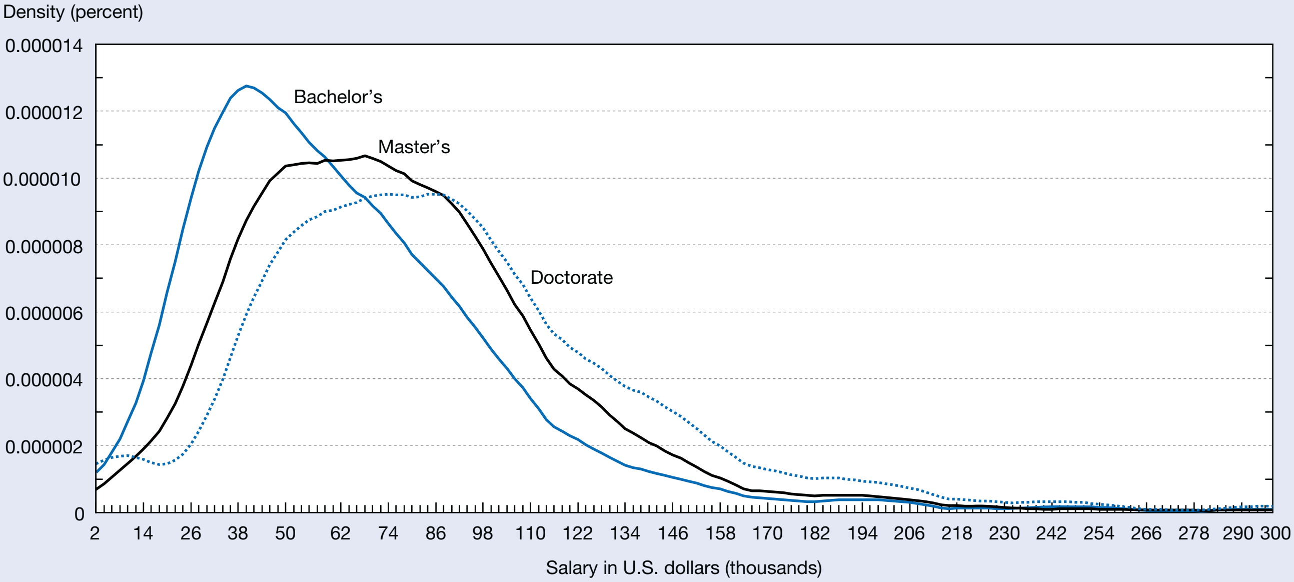
Compared with experienced S&E workers, recent S&E graduates more often bring newly acquired skills to the labor market and have relatively few work or family commitments that limit their job mobility. As a result, measures of the success of recent graduates in securing good jobs can be sensitive indicators of changes in the S&E labor market.

This section looks at a number of standard labor market indicators for recent S&E degree recipients at all degree levels and examines a number of other indicators that may apply only to recent S&E doctorate recipients.

General Labor Market Indicators for Recent Graduates

Table 3-18 summarizes some basic labor market statistics in 2008 for recent recipients of S&E degrees, with *recent* meaning up to 5 years from receiving the degree. Across all fields of S&E degrees, there was a 5.3% unemployment rate for bachelor's degree holders who received their degrees in

Figure 3-25
Salary distribution of S&E degree holders employed full time, by degree level: 2003

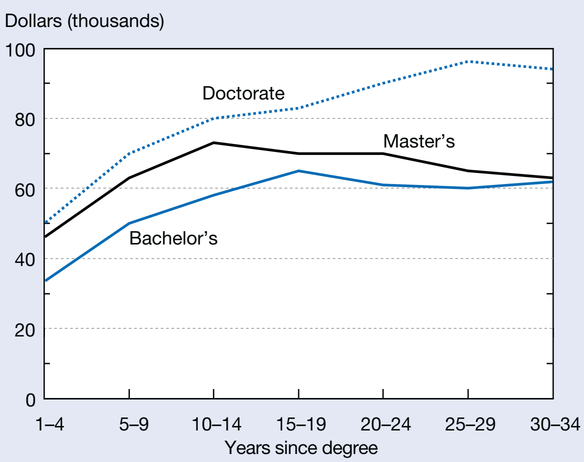


NOTE: Salary distribution smoothed using kernel density techniques.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2003), http://sestat.nsf.gov.

Science and Engineering Indicators 2012

Figure 3-26
Median salaries of individuals with highest degree in S&E, by degree level and years since degree: 2003



SOURCE: National Science Foundation, Division of Science Resources Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2003), http://sestat.nsf.gov.

Science and Engineering Indicators 2012

the previous 5 years. This ranged from 2.1% for those with engineering degrees to 6.7% for social science degree recipients. Early in their careers, individuals tend to change jobs more often and have a higher incidence of unemployment. However, with the exception of those who earned a bachelor's degree in the social sciences, the unemployment rate for those with recent S&E degrees was less than the unemployment rate of 6.5% for the full U.S. labor force in October 2008.

A useful but more subjective indicator of labor market conditions for recent graduates is the proportion reporting that a job in their degree field was not available. This involuntarily out-of-field (IOF) rate is a measure unique to NSF's labor force surveys. At the bachelor's degree level, across all S&E fields, the IOF rate in 2008 was 7.9%, but it ranged from 2.4% for recent engineering graduates to 12.0% for recent graduates in the social sciences. In all fields of degrees, the IOF rate decreases as the level of education increases, reaching a low of 1.5% for recent doctorate recipients.

The median salary for recent S&E bachelor's degree recipients in 2008 was $39,800, ranging from $30,000 in the life sciences to $59,000 in engineering. Recent master's degree recipients had average salaries of $57,000, with recent doctorate recipients earning $65,000.

Recent Doctorate Recipients

The career rewards of highly skilled individuals in general, and doctorate holders in particular, often extend beyond salary and employment to the more personal rewards of doing the kind of work for which they have trained. No single standard measure satisfactorily reflects the state of the doctoral S&E labor market; a range of relevant labor market indicators are discussed below, including unemployment rates, IOF employment, employment in academia versus other sectors, employment in postdoc positions, and salaries. Although a doctorate opens both career and salary

Table 3-18
Labor market indicators for recent S&E degree recipients up to 5 years after receiving degree, by field: 2008

		Highest degree field				
Indicator and degree	All S&E fields	Computer/ mathematical sciences	Biological/ agricultural/ environmental life sciences	Physical sciences	Social sciences	Engineering
Unemployment rate (%)						
All degree levels	4.6	3.2	5.1	3.4	6.1	2.0
Bachelor's	5.3	3.2	6.0	3.9	6.7	2.1
Master's	2.9	3.5	2.4	2.5	3.5	2.0
Doctorate	1.5	0.3	2.1	2.5	1.2	1.0
Involuntarily out-of-field rate (%)						
All degree levels	7.9	4.0	7.6	5.6	12.0	2.4
Bachelor's	9.7	5.4	9.1	7.6	13.6	2.5
Master's	3.5	0.7	4.1	1.8	6.1	2.6
Doctorate	1.5	0.9	1.2	3.1	1.9	0.8
Median annual salary ($)						
All degree levels	42,000	55,000	34,000	40,000	36,000	63,000
Bachelor's	39,800	51,000	30,000	32,000	34,000	59,000
Master's	57,000	72,000	44,000	47,000	43,000	70,000
Doctorate	65,000	80,000	50,000	67,000	60,000	86,000

NOTES: Median annual salaries are rounded to nearest $1,000. All degree levels includes professional degrees not broken out separately. Includes degrees earned from October 2003 to October 2008. Involuntarily out-of-field rate is proportion of individuals employed in job not related to field of highest degree because job in that field was not available.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2008), http://sestat.nsf.gov.

Science and Engineering Indicators 2012

opportunities, these opportunities come at the price of many years of lost labor market earnings. For some doctorate holders, a postdoc position further extends this period of low earnings. In addition, some doctorate holders do not obtain the jobs they desire after they complete their education.

Although the official recession began in the United States in December 2007 and overall unemployment rose precipitously after April 2008, as of October 2008, the labor market indicators for individuals who recently earned an SEH doctoral degree in the United States remained relatively positive. Their unemployment rate was only modestly higher than in April 2006; the rate of working involuntarily outside of one's field was slightly lower than in 2006; the decline in the proportion of recent doctorate holders who had secured either tenure or tenure-track faculty appointments was modest; and inflation-adjusted salaries rose considerably between 2006 and 2008.

Unemployment

As of October 2008, the 1.5% unemployment rate for SEH doctorate recipients up to 3 years after receiving their doctorates was considerably lower than the unemployment rate of the civilian labor force in general (6.5%) and the unemployment rate for recent recipients of S&E bachelor's degrees (5.3%). Among recent SEH doctoral degree recipients, the unemployment rate in each of the broad SEH degree areas was lower in 2008 than it was in 2003 with the exception of the physical sciences (table 3-19). With a 3% unemployment rate, the physical sciences had considerably higher unemployment among recent doctoral degree recipients than other SEH areas. Indeed, in all other broad SEH fields except the social sciences the unemployment rate among recent SEH doctoral degree recipients was below 2% in 2008.

Working Involuntarily Outside the Field

In addition to the 1.5% who were unemployed in 2008, another 1.3% of recent SEH doctorate recipients in the labor force reported that they took a job that was not related to the field of their doctorate because a job in their field was not available. The share of recent SEH doctoral degree recipients who have reported involuntarily working outside of their field has declined steadily from 2001, when the IOF rate was 2.8% (table 3-19).

The highest IOF rates were found for recent doctorate recipients in the physical sciences and the social sciences. However, within the physical sciences the IOF rate declined from 5.4% to 2.3% between 2001 and 2008.

Tenure-Track Positions

Many SEH doctorate recipients may aspire to tenure-track academic appointments, but most will end up working in other positions and sectors. In 2008, 16% of all those who had earned their SEH doctoral degree within the previous 3 years had a tenure or tenure-track faculty appointment, a share that has held

Table 3-19
Employment characteristics of recent SEH doctorate recipients up to 3 years after receiving doctorate, by field: 2001–08
(Number and percent)

	Recent doctorates (*n*)				Unemployment rate (%)				Involuntarily out-of-field rate (%)			
Field	2001	2003	2006	2008	2001	2003	2006	2008	2001	2003	2006	2008
All recent SEH doctorates	48,700	43,700	49,500	52,600	1.3	2.5	1.2	1.5	2.8	2.1	1.4	1.3
Biological, agricultural, and environmental life sciences	12,300	11,200	12,600	13,400	1.4	2.4	0.9	1.7	2.6	1.0	0.3	1.0
Computer/information sciences	1,600	1,400	1,500	2,400	0.3	4.1	1.9	S	S	S	2.6	1.4
Mathematics and statistics	2,200	1,600	2,000	2,400	0.2	3.4	S	S	1.4	3.4	2.2	1.1
Physical sciences	7,700	6,500	7,400	7,500	1.5	1.3	1.1	3.0	5.4	4.2	2.6	2.3
Psychology	7,200	6,300	7,000	5,800	1.5	2.7	1.2	0.8	3.0	1.5	1.4	0.8
Social sciences	5,800	6,000	6,200	5,900	1.6	3.1	1.4	2.1	3.3	3.0	2.3	3.4
Engineering	9,400	8,000	9,500	12,000	1.5	3.0	1.8	1.2	2.0	3.0	1.6	0.7
Health	2,400	2,700	3,200	3,300	0.4	0.7	0.9	1.2	S	1.1	S	S

S = suppressed for reasons of confidentiality and/or reliability

SEH = science, engineering, and health

NOTES: Involuntarily out-of-field rate is proportion of individuals employed in job not related to field of doctorate because job in that field was not available. 2001 and 2006 data include graduates from 12 to 36 months prior to survey reference date; 2003 and 2008 data include graduates from 15 to 36 months prior to survey reference date.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Doctorate Recipients (SDR), (2001–08), http://sestat.nsf.gov.

Science and Engineering Indicators 2012

broadly steady since 1993, with a 2003 peak approaching 19% and subsequent modest declines (table 3-20).

The share of SEH degree recipients who hold a tenure or tenure-track faculty appointment increases with increasing time since earning the doctorate. In 2008, the proportion of SEH doctorates with tenure or tenure-track appointments who were less than 3 years from completing their doctorate was 16.2%; for those who had been in the labor market for 3 to 5 years, the comparable rate was 22.9%. In computer and information sciences, 22.0% of individuals who had less than 3 years in the labor force since earning their doctoral degree had a tenure or tenure-track faculty appointment; the proportion increases by 15.8 percentage points to 37.8% for those 3 to 5 years from the doctoral degree. Psychology and the social sciences are the only areas that do not show a dramatic rise in the share of the labor force with a tenure or tenure-track appointment among those with 3 to 5 years of labor market exposure compared to those with less than 3 years of labor market exposure. (See chapter 5 for a discussion of trends in tenure-track positions as a proportion of all academic positions.)

The availability of tenure-track positions may be counterbalanced by the availability of desirable nonacademic employment opportunities. One of the quickest declines among recent doctoral degree recipients in tenure-track employment occurred in computer sciences, from 31.5% in 1993 to 18.2% in 1999 despite the high demand for computer sciences faculty (table 3-20).

Salaries for Recent SEH Doctorate Recipients

For all SEH degree fields in 2008, the median annual salary for recent doctorate recipients up to 5 years after they received their degrees was $67,000. Across various SEH fields of degree, median annual salaries ranged from a low of $50,000 in the biological sciences to a high of $88,000 in computer and information sciences (table 3-21). From 2006 to 2008, salaries for recent recipients of doctoral degrees rose considerably. After adjusting for inflation, the median salary for recent doctoral degree recipients rose by 17%.

By type of employment, salaries for recent doctorate recipients ranged from $42,000 for postdoc positions to $85,000 for those employed by private for-profit businesses (table 3-22).

Postdoc Positions

The growing number of recent doctorate recipients in postdoctoral appointments, generally known as *postdocs*,[13] has become a major concern in science policy. Neither the reasons for this growth nor its effect on the health of science are well understood. Increases in competition for tenure-track academic research jobs, collaborative research in large teams, and needs for specialized training are possible factors explaining this growth. Although individuals in postdoc positions often perform cutting-edge research, there is concern that time spent in a postdoc position is time added onto the already long time spent earning a doctorate, thereby delaying the start and advancement of independent careers. Because postdoc positions usually offer low pay, forgone earnings add significantly to the costs of a doctoral education and may discourage doctoral-level careers in S&E.

How Many Postdocs Are There?

In 2010, *Science and Engineering Indicators* (NSB 2010) included an analysis of a one-time postdoc module from the 2006 Survey of Doctorate Recipients (SDR), and compared it

Table 3-20
Employed SEH doctorate recipients holding tenure and tenure-track appointments at academic institutions, by years since degree and field: 1993–2008
(Percent)

Years since doctorate and field	1993	1995	1997	1999	2001	2003	2006	2008
<3 years								
All SEH fields	18.1	16.3	15.8	13.5	16.5	18.6	17.7	16.2
Biological, agricultural, and environmental life sciences	9.0	8.5	9.3	7.7	8.6	7.8	7.2	6.5
Computer/information sciences	31.5	36.5	23.4	18.2	20.7	32.5	31.2	22.0
Mathematics and statistics	40.9	39.8	26.9	18.9	25.2	38.4	31.6	31.3
Physical sciences	8.8	6.9	8.5	7.8	10.0	13.3	9.8	8.8
Psychology	12.8	13.6	14.7	16.0	15.6	14.6	17.0	18.1
Social sciences	43.5	35.9	37.4	35.4	38.5	44.8	39.3	45.4
Engineering	15.0	11.5	9.4	6.4	11.3	10.8	12.4	9.3
Health	33.9	34.2	30.1	28.1	32.1	30.3	36.2	27.7
3–5 years								
All SEH fields	27.0	24.6	24.2	21.0	18.5	23.8	25.9	22.9
Biological, agricultural, and environmental life sciences	17.3	17.0	18.1	16.4	14.3	15.5	13.7	14.3
Computer/information sciences	55.7	37.4	40.7	25.9	17.3	32.2	45.7	37.8
Mathematics and statistics	54.9	45.5	48.1	41.0	28.9	45.5	50.6	40.7
Physical sciences	18.8	15.5	14.5	11.9	15.8	18.3	19.7	16.5
Psychology	17.0	20.7	16.8	17.6	17.5	19.9	23.8	18.3
Social sciences	54.3	52.4	50.4	46.5	38.8	46.0	50.4	48.9
Engineering	22.7	19.3	19.4	12.6	10.8	15.9	16.3	15.5
Health	47.4	40.2	41.1	39.5	25.1	40.8	43.1	34.4

SEH = science, engineering, and health

NOTES: Proportions calculated on basis of all doctorates working in all sectors of economy. Data for 1993–1999, 2001, and 2006 includes graduates from 12 to 60 months prior to survey reference date; 2003 and 2008 data include graduates from 15 to 60 months prior to survey reference date.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Doctorate Recipients (1993–2008), http://sestat.nsf.gov.

Science and Engineering Indicators 2012

Table 3-21
Salary of recent SEH doctorate recipients up to 5 years after receiving degree, by field and percentile: 2008
(Dollars)

Field of doctorate	25th percentile	50th percentile	75th percentile
All SEH fields	48,000	67,000	88,000
Biological, agricultural, and environmental life sciences	41,000	50,000	68,000
Computer and information sciences	72,000	88,000	107,000
Mathematics and statistics	52,000	65,000	90,000
Physical sciences	50,000	68,000	85,000
Psychology	48,000	58,000	75,000
Social sciences	50,000	62,000	82,000
Engineering	70,000	86,000	100,000
Health	60,000	76,000	95,000

SEH = science, engineering, and health

NOTES: Salaries are rounded to nearest $1,000. Includes graduates from 15 to 60 months prior to survey reference date.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Doctorate Recipients (2008), http://sestat.nsf.gov.

Science and Engineering Indicators 2012

to data collected on NSF's Survey of Graduate Students and Postdocs in Science and Engineering, in order to estimate the total number of postdocs in the United States. Similar more recent data from the SDR are not available. However, there are several point estimates from more recent years.

In October 2008, the SDR measured 27,100 individuals with SEH doctorates who were employed in postdoc positions. The SDR covers U.S. residents with research doctorates in SEH fields from U.S. universities, but not those with non-U.S. doctorates. The NSF Graduate Student Survey (GSS) gathers information on postdocs from U.S. academic graduate departments, regardless of where these individuals earned their doctorates. It does not cover people in nonacademic employment, at some university research centers, or at academic departments that lack graduate programs. The fall 2008 estimate from the GSS was 54,100 postdocs. The SDR and GSS estimates overlap in some populations (U.S.-trained doctorates and those working in academia), but differ in others (GSS covers foreign-trained doctorates, but not those in the industry or government sectors).

Postdocs by Academic Discipline

More than half of all U.S.-educated SEH doctorates in postdoctoral positions in 2008 (57%) had doctorates in biological or health sciences (figure 3-27). In these fields,

Table 3-22
Median annual salary of recent SEH doctorate recipients up to 5 years after receiving degree, by field and employment sector: 2008
(Dollars)

Field of doctorate	All sectors	Education: 4-year institution: Tenured or tenure-track position	Education: 4-year institution: Postdoc	Education: 4-year institution: Other academic positions	Education: 2-year or precollege institution	Govern-ment	Business/ industry
All SEH fields	67,000	65,000	42,000	55,000	60,000	71,000	85,000
Biological, agricultural, and environmental life sciences	50,000	62,000	41,000	50,000	55,000	60,000	65,000
Computer and information sciences	88,000	80,000	46,000	80,000	80,000	90,000	100,000
Mathematics and statistics	65,000	59,000	52,000	50,000	60,000	86,000	97,000
Physical sciences	68,000	60,000	43,000	53,000	52,000	69,000	85,000
Psychology	58,000	57,000	42,000	55,000	62,000	75,000	65,000
Social sciences	62,000	60,000	50,000	52,000	56,000	87,000	85,000
Engineering	86,000	80,000	43,000	68,000	45,000	78,000	95,000
Health	76,000	75,000	43,000	68,000	69,000	82,000	85,000

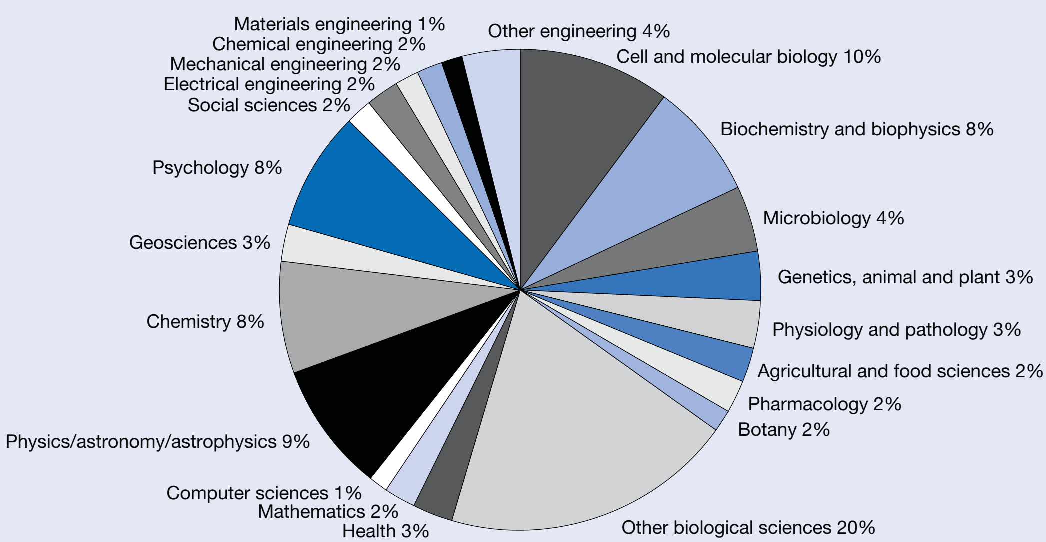
SEH = science, engineering, and health

NOTES: Salaries are rounded to nearest $1,000. Includes graduates from 15 to 60 months prior to survey reference date.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Doctorate Recipients (2008), http://sestat.nsf.gov.

Science and Engineering Indicators 2012

Figure 3-27
U.S.-educated SEH doctorate holders in postdoctorate positions, by doctorate field: 2008



SEH = science, engineering, and health

NOTE: Percentages do not add to 100% because of rounding.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Doctorate Recipients (2008), http://sestat.nsf.gov.

Science and Engineering Indicators 2012

postdoc training has been common for a long time and individuals remain in postdoc positions longer than in other fields. Psychology, chemistry, and physics also have high rates of graduates entering postdoc positions and together make up another one-quarter of postdoc positions. The remaining quarter come from all other SEH fields, most of which do not have a strong postdoc tradition as part of their career paths.

Increase in the Likelihood and Length of Postdoc Positions

Among holders of U.S. SEH doctorates received before 1972, 31% reported having had a postdoc position earlier in their careers (NSB 2010). This proportion has risen over time to 46% among 2002–05 graduates and has increasingly involved fields in which, formerly, only a small number of doctorate recipients went on to postdoc positions. In traditionally high-postdoc fields such as the life sciences (from 46% to 60%) and the physical sciences (from 41% to 61%), most doctorate recipients now have a postdoc position as part of their career path. Similar increases were found in mathematical and computer sciences (19% to 31%), social sciences (18% to 30%), and engineering (14% to 38%). Recent engineering doctorate recipients are now almost as likely to take a postdoc position as physical sciences doctorate holders were 35 years ago.

Postdoc Pay and Benefits

Low pay and fewer benefits for postdocs are frequently raised as concerns by those worried about the effect of the increasing number of postdoc positions on the attractiveness of science careers. The median academic postdoc salary is 44% less than the median salary for nonpostdocs up to 5 years after receiving their doctorates (table 3-23). Among engineering doctorates, academic postdocs are paid half the salary of those who are not in postdoc positions up to 5 years after receiving their doctorate. Among social sciences doctorates, this gap is closer to one-quarter (24%). Nonacademic postdocs are better paid than academic postdocs, but their median salary is still 33% less than that of those who are not in postdoc positions.

The 2006 Survey of Earned Doctorates asked about employment benefits among postdocs. Across all S&E fields, 90% of postdocs reported having medical benefits and 49% reported having retirement benefits. It is not possible to know from the survey how extensive medical benefits may be or how transferable retirement benefits are. In the social sciences, medical benefits are less available, with only 75% of postdocs reporting that they had medical benefits.

Postdoc Positions as a Sign of Labor Market Distress

In 2006, former postdoc position holders reported reasons for accepting their appointment that are consistent with the traditional intent of a postdoc position as a type of apprenticeship, such as seeking “additional training in doctorate field” or “training in an area outside of doctorate field.” However, 10% of SDR respondents in a postdoc position in October 2008 reported that they took their current postdoc position because “other employment not available.” This reason was given by 9% of postdocs in the biological and agricultural sciences, 5% in the health sciences, 12% in computer sciences and mathematics, 12% in the physical sciences, 6% in the social sciences, and 16% in engineering.

Postdoc Outcomes

In 2006, most former postdocs reported that their most recent postdoc appointment had enhanced their career opportunities, and the proportions who said this were similar for different cohorts (NSB 2010). Across all S&E fields and cohorts, 53%–56% of former postdocs said that their postdoc appointment enhanced their career opportunities to a “great

Table 3-23
Median salary of U.S. SEH doctorate holders in postdoc positions: 2008

Field of doctorate	Median salary ($) Academic postdocs	Nonacademic postdocs	Nonpostdocs
All SEH	42,000	50,000	75,000
Biological/agricultural/environmental life sciences	41,000	47,000	65,000
Computer/information sciences	46,000	S	90,000
Mathematical sciences	52,000	S	71,000
Physical sciences	43,000	57,000	75,000
Psychology	42,000	48,000	60,000
Social sciences	47,000	S	62,000
Engineering	43,000	57,000	90,000
Health	43,000	63,000	80,000

S = suppressed for reasons of confidentiality and/or reliability

SEH = science, engineering, and health

NOTE: Salaries are rounded to nearest $1,000.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Doctorate Recipients (2008), http://sestat.nsf.gov.

Science and Engineering Indicators 2012

extent”; an additional 33%–38% said that their postdoc appointment “somewhat” enhanced their career opportunities. The proportion of those completing postdoc positions who said that it was no help to their career opportunities ranged from only 8% for the 2002–05 graduation cohort to 12% for the 1987–91 cohort. For a more detailed look at perceived and actual outcomes from a postdoc experience, see chapter 3 in the 2008 edition of *Science and Engineering* (NSB 2008) and NSF/SRS (2008b).

Demographics of the S&E Workforce

This section describes the demographic composition of the U.S. S&E workforce by sex, race/ethnicity, foreign origin, and age. It also addresses the relationship between workforce demographics and selected indicators of labor force rewards and participation.

The section begins with a focus on differences by sex among workers in S&E occupations and among S&E degree holders. Similar comparisons will be made across race/ethnicity categories. Historically, in the United States, very high proportions of workers in S&E occupations have been male and white (non-Hispanic). Engineering and physical science occupations have had particularly low concentrations of women and of members of most underrepresented minority groups (i.e., blacks, Hispanics, American Indians, and Alaska Natives), both relative to the concentrations of these groups in other occupational areas and relative to their representation in the population in general. However, both women and minorities increasingly have been entering a wide range of S&E occupations. Asians have also been increasing their participation in S&E occupations, although with concentrations in areas different from women and underrepresented minorities. This section documents, across S&E occupations, the extent to which the numbers and the share of workers who are women, underrepresented minorities, and Asians have risen, and provides indicators of their contemporary levels of participation.

The presentation of indicators of levels of participation will be followed by an analysis of the relationship between wage differences and demographic factors. Historically, women and minorities in S&E occupations have received lower salaries than white men. This section will provide data on contemporary salary differences as well as findings regarding how various factors contribute to these differences.

This discussion of wage differences will be followed by a presentation of indicators pertaining to S&E immigration trends. Increasing global competition for S&E workers and changes in economic conditions influence levels of immigration. This section describes recent trends in immigration of S&E workers that can be compared with other factors (like economic growth). Indicators are collected from population data from the U.S. Census Bureau and visa data from the U.S. Citizenship and Immigration Service, as well as S&E workforce data from the NSF SESTAT data system. Data from the Survey of Earned Doctorates will be presented to capture stay rates: rates at which noncitizen recipients of U.S. S&E doctoral degrees remain in the United States.

The demographics section ends with a presentation of indicators of the aging of the S&E workforce as the baby-boom generation moves toward retirement age. The high concentration of workers over age 50 suggests that the S&E workforce will soon experience high levels of turnover. Thus, indicators will also be presented pertaining to levels of workforce participation and engagement of individuals at the ages near the end of their career cycle.

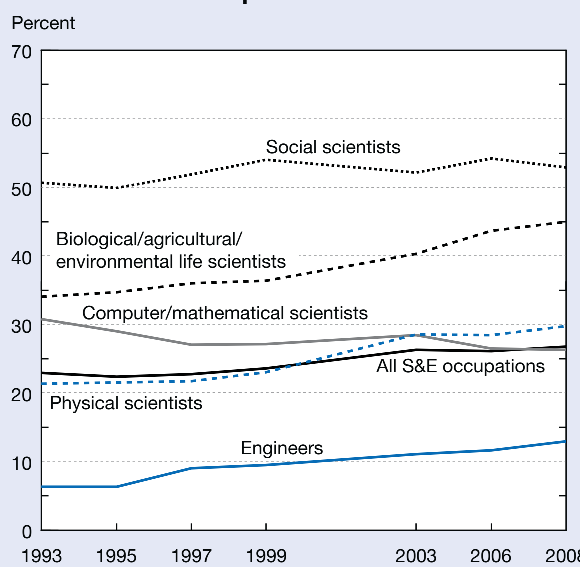
Sex Differences in the S&E Workforce

Sex Differences in S&E Occupations

Historically, men in S&E occupations have outnumbered women by wide margins. Yet the number of women in these occupations has been on the rise, increasing over the past two decades by more than half-a-million workers. These recent increases in the number of women have narrowed overall disparities by sex, but only modestly. In 2008, overall disparities remained pronounced, with women constituting 27% of workers, only a slightly higher share than in the previous decade when women made up 23% of workers (figure 3-28).

Sex disparities vary across occupations (appendix table 3-9). The most extreme disparities are within engineering, where women constituted 13% of the workforce in 2008. Among large engineering occupations, the disparity between men and women is greatest among mechanical engineers, with men outnumbering women by more than 12

Figure 3-28
Women in S&E occupations: 1993–2008



NOTE: National estimates not available from Scientists and Engineers Statistical Data System (SESTAT) in 2001.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, SESTAT (1993–2008), http://sestat.nsf.gov.

Science and Engineering Indicators 2012

to 1. Other large engineering occupations in which women account for as few as 9% of workers include electrical and electronics engineers and aerospace, aeronautical, and astronautical engineers.

Both computer and mathematical scientists (26% women) and physical scientists (30% women) are disproportionately male. Within physical science occupations, physicists have the largest imbalance by sex. Within computer and mathematical scientist occupations, the largest component, computer and information scientists (25% women), is the most imbalanced. Mathematical scientists (45% women) are much closer to parity.

Sex parity in participation was nearly achieved by 2008 among biological and medical scientists (51% women). With 53% of women in the field in 2008, parity in the social sciences has been long established. Occupations within social sciences, however, vary with respect to the proportion of female workers. For example, women account for slightly less than one-third of economists, but more than two-thirds of psychologists. Psychology, with about 185,000 total workers, is the only large S&E occupation with substantially more women than men.

The number of women working in each occupational area has risen since the early 1990s. Growth has been strongest in the biological and related sciences, where the number of female workers doubled between 1993 and 2008. This rate of growth has far outstripped that of men in these occupations, thus women's share of workers has also increased (from 34% in 1993 to 45% in 2008, see figure 3-28). During the same period, women have also increased their share among workers in engineering (from 9% to 13%) and in the physical sciences (from 21% to 30%). In these two occupational areas, women's increased share emerged as women's numbers in the workforce expanded (roughly by 60%) but men's numbers did not, remaining roughly similar between 1993 and 2008.

In social science occupations, the growth in women's participation has occurred at levels similar to those in engineering and the physical sciences. However, men's participation in these occupations has grown at similar levels and, therefore, the balance between men and women has changed little.

With 230,000 more female computer and mathematical scientists in 2008 than in 1993, women have added more workers in this area than in any of the other S&E occupations. The rate of growth of women in this area is also higher than in any other area, except for life scientists. However, unlike in the other four areas, men's rate of growth in this occupational area is higher than women's. Thus, women's share of this occupation has been declining. From 1993 to 2008 women's share of computer and mathematical scientists dropped from 31% to 26%, making the sex disparity here even greater than in physical science occupations. The declining share of women in the computer and mathematical science occupations reflects increasing disparities in participation among those whose highest degree is at the bachelor's degree level. Among those with a doctoral degree, women's share of workers in computer science occupations increased from 13% to 18% over this period.

Sex Differences in Age and Racial/Ethnic Groups

With the recent, greater growth among women than among men in S&E occupations, women in the field tend to be somewhat younger than the men (table 3-24). Age disparities are greatest among life scientists, physical scientists, and engineers, where women's participation levels have been increasing relative to men's. Age disparities are small among computer and mathematical scientists, where women have lost ground relative to men in levels of participation. Overall, in 2008 28% of men working in S&E occupations were over age 50 compared with 22% of women. Only 13% of men were younger than 30, but 17% of women were. The median age of women in S&E occupations was 41 years compared with 43 years among men.

Women in S&E occupations were more likely than men to be classified as an American Indian/Alaska Native, black, Hispanic, Native Hawaiian/Pacific Islander or of two or more races. In 2008, 14% of women in S&E occupations identified themselves within one of these groups compared with 10% of men (appendix table 3-10). Neither occupational area nor age explains the increased likelihood for women to be from a minority group, and less likely to be white. Women are more likely to be minorities within all five broad occupational areas whether or not age is controlled.

Sex Differences Among S&E Degree Holders

Sex disparities among the general U.S. workforce with S&E degrees are somewhat smaller than disparities within S&E occupations. In 2008, among individuals with their highest degree in an S&E field, women constituted 38% of those who were employed, up from 31% in 1993. Over the

Table 3-24
Age distribution of workers in S&E occupations, by sex and race/ethnicity: 2008
(Percent)

	Age (years)		
Sex and race/ethnicity	<30	30–50	>50
All S&E occupations	14.1	59.3	26.7
Sex			
Male	12.9	58.6	28.4
Female	17.2	61.0	21.9
Race/ethnicity			
Asian	17.8	67.7	14.5
American Indian/Alaska Native	8.7	70.5	20.8
Black	12.5	65.8	21.8
Hispanic	18.2	65.1	16.7
White	12.6	56.6	30.8
Native Hawaiian/Other Pacific Islander	24.8	65.3	9.9
Two or more races	29.8	53.6	16.6

NOTE: All single-race categories include non-Hispanics only.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2008), http://sestat.nsf.gov.

Science and Engineering Indicators 2012

same period, the share of women among unemployed workers with an S&E degree rose more dramatically, from 34% to 45%. Among those out of the labor market, the share of women rose from 46% to 50%.

At every age, women with their highest degree in an S&E field are more likely than men to be out of the labor market (figure 3-29). However, at typical ages for career entry and exit (before age 30 and after age 60) these differences are modest. The sex disparity in the likelihood of being out of the labor market is particularly pronounced in the middle years of the career cycle. Between ages 30 and 55, 16.1% of women were out of the labor market compared with 2.2% of men.

Many women between ages 30 and 55 with S&E degrees who were not in the labor market identified family reasons as an important factor: 69% of women reported that family was a factor compared with 25% of men. Within this age range, women were also much more likely than men to report that they did not need to work or did not want to work (46% of women and 26% of men).

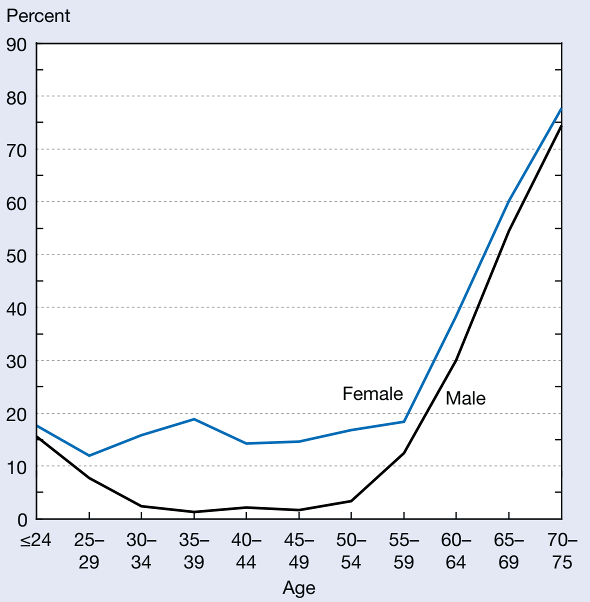
Sex Differences in Degree Fields and Degree Levels

With respect to the proportion of men and women among S&E highest degree holders, the pattern of variation among degree fields echoes the pattern of variation among occupations associated with those fields (see appendix table 3-11). In 2008, more than half (54%) of degree holders in the social science fields were women, as were nearly half (46%) of those with a degree in the biological and related sciences. Men outnumbered women among computer sciences and mathematics degree holders (31% women) and among physical science degree holders (28% women). Disparities, however, were greatest among those with a degree in engineering, where only 13% of degree holders were women. In all fields except computer and mathematical sciences, the share of women with degrees in the workforce has been increasing over the past two decades. In computer science and mathematics this share has remained flat.

Sex differences are not limited to the field of degree, but also to the level of the S&E degree. Men in the workforce are more likely to have a more advanced S&E degree. For example, women accounted for 38% of those whose highest degree in S&E is at the bachelor's level but 29% of workers whose highest degree in S&E is at the doctoral level (figure 3-30). At the doctoral degree level, however, women's share has been steadily increasing. Women's share of S&E bachelor's degree holders in the workforce has also been rising since the early 1990s, but in 2008 this share was not larger than it had been in 2006.

Working men and women with S&E degrees also differ in the extent to which they are employed in the same field as their S&E degree. However, this disparity is largely the result of women having a high concentration in the two degree areas—social sciences and life sciences—where degree holders most often work outside of S&E occupations.

Figure 3-29
Highest degree holders in S&E not in the labor force, by sex and age: 2008

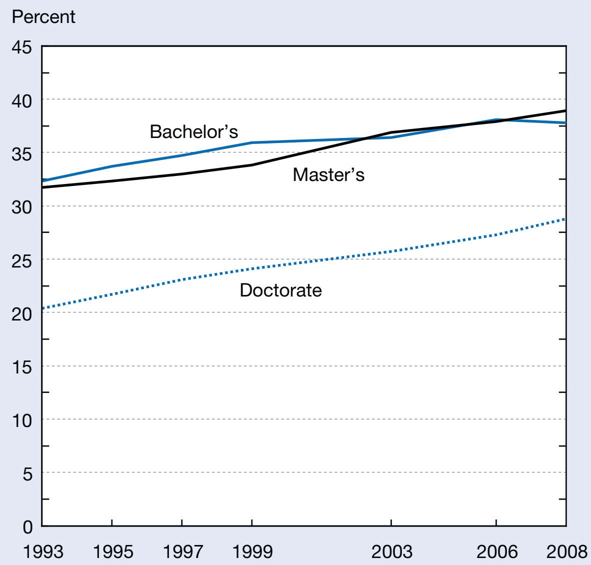


NOTE: Not in labor force includes those not working nor looking for work in the 4 weeks prior to October 2008.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System, SESTAT (2008), http://sestat.nsf.gov.

Science and Engineering Indicators 2012

Figure 3-30
Employed women with highest degree in S&E, by degree level: 1993–2008



NOTE: National estimates not available from Scientists and Engineers Statistical Data System (SESTAT) in 2001.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, SESTAT (1993–2008), http://sestat.nsf.gov.

Science and Engineering Indicators 2012

In 2008, across all degree areas, 21% of women with a highest degree in S&E compared with 35% of men were employed in the field in which they earned their degree (appendix table 3-12). About 26% of women were working in an S&E occupation compared with 45% of men. However, within most degree areas, a similar proportion of men and women work in an occupation that matches their degree field, and similar proportions work in non-S&E jobs. Computer and mathematical science fields are exceptions, where men are more likely to work in an occupation that matches their degree field.

Racial/Ethnic Differences in the S&E Workforce

This section addresses the level of diversity in science and engineering by describing the cross-cutting social categories of race and Hispanic status. Like the preceding section, this section draws on data from the NSF science and engineering labor force surveys to report on levels of participation in science and engineering: first, across occupations, and next, across the overall workforce with science and engineering degrees.

Whether defined by occupation, S&E degree, or the combined criteria used in SESTAT, the majority of scientists and engineers in the United States are non-Hispanic white. The next largest group of scientists and engineers are Asians, who have been increasing their share in the S&E field since the early 1980s. On the other hand, several minority groups, including blacks, Hispanics, and Native Americans, have low levels of participation in science and engineering occupations both compared with other groups and compared with their proportion of the general working-age population (table 3-25). Both blacks and Hispanics also have low levels of participation in S&E relative to their proportion in the general population with a college degree. The composition of the S&E workforce across these groups has been a concern of policymakers who are interested in the development and utilization of human capital to maintain the United States' global competitiveness in science and engineering.

In 2008, with 3.5 million workers in S&E occupations, whites made up over 70% of the country's scientists and engineers. Whites accounted for more than 50% of workers within each of the S&E occupations (see appendix table 3-13). Whites are particularly highly concentrated in areas that focus on macrophysical systems. For example, whites were a strong majority of forestry and conservation scientists (91%); earth, atmospheric, and ocean scientists (86%); and agricultural and food scientists (82%).

Asians, with 824,000 workers in S&E occupations, accounted for 17% of scientists and engineers. They are strongly concentrated in computer engineering fields, constituting 40% of computer hardware engineers, 30% of computer software engineers, and 23% of the related occupations of electrical and electronics engineering. On the other hand, Asians participate in social science occupations at much lower rates than whites. For example, Asians account for 4% of psychologists and just 3% of sociologists and anthropologists.

The social sciences are the one occupation within S&E in which the underrepresented minorities (American Indian/Alaska Natives, blacks, Hispanics, and Native Hawaiians/Pacific Islanders) outnumber Asians. Collectively, these groups account for 17% of sociologists and anthropologists, and 12% of psychologists. These minorities also account for a comparatively high share of computer support specialists (16%) and statisticians (14%). On the other hand, underrepresented minorities account for relatively few physicists and astronomers (6%). Moreover, among these minority physicists and astronomers, only one-third were born in the United States compared with the more than two-thirds of underrepresented minorities who are in other S&E occupations and were born in the United States. U.S.-born underrepresented minorities accounted for less than 2% of physicists and astronomers.

Table 3-25
Racial/ethnic distribution of individuals in S&E occupations, S&E degree holders, college graduates, and U.S. residents: 2008
(Percent)

Race/ethnicity	S&E occupations	S&E degree holders	College degree holders	Total U.S. residential population
S&E occupations				
Asian	16.9	11.2	8.5	4.7
American Indian/Alaska Native	0.3	0.4	0.3	0.7
Black	3.9	5.5	7.2	11.7
Hispanic	4.9	5.6	6.2	13.9
White	71.8	75.2	76.5	67.6
Native Hawaiian/Other Pacific Islander	0.4	0.4	0.1	0.1
Two or more races	1.7	1.7	1.1	1.2

SOURCES: Census Bureau, American Community Survey (2008); National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2008), http://sestat.nsf.gov.

Science and Engineering Indicators 2012

Race/Ethnicity Trends in S&E Occupations

Over the past two decades, the U.S. workforce in S&E occupations has been becoming more diverse with increasing numbers of minorities and Asians and a decreasing share of whites. In 1993, 84% of workers in S&E occupations reported their race as white. By 2008, this proportion declined to 72%. Some of this decline reflects changes to the NCSES workforce surveys that collect information on race in the S&E workforce. After 2000, respondents were able to report two or more races rather than just one. Some of those who self-reported as white in the 1990s may have instead reported a multiracial identity after 2000 if they had the option, which would have decreased the estimated numbers of whites. However, because less than 2% of S&E workers self-reported two or more races in years when the option was available, it is unlikely that this change contributed to much of the decline in the share of whites between 1993 and 2008. Most of the decline in whites was offset by growth among Asians during this period and some by growth in other groups, particularly Hispanics (table 3-26).

Age Differences Among Racial/Ethnic Groups

The age structure of different demographic groups (see table 3-24) reflects the fact that members of the different groups entered the S&E workforce in different numbers at different times. The largest demographic group, whites, is also the oldest, with a median age of 44. Almost one-third of whites were older than 50 and only 13% were age 30 or younger. Blacks (median age of 42) and Hispanics (median age of 39) are somewhat younger. Asians are even younger, with a median age of 38. The comparative youthfulness of Asians reflects the age distribution of Asians working in S&E who were born in the United States. Native-born Asians were dramatically younger than other demographic groups, including foreign-born Asians. The median age among U.S. native-born Asians working in S&E occupations was 30, and only 9% were older than 50.

Racial/Ethnic Differences Among S&E Degree Holders

Most patterns across demographic groups among workers in S&E occupations also hold for members of the workforce with a highest degree in an S&E field. Additionally, outcomes that vary by race among S&E degree holders deal with unemployment rates and level of degree attainment.

In 2008, among those whose highest degree was in an S&E field, Hispanics and blacks had the highest unemployment rate (5.2% and 5.1%, respectively), which was roughly two percentage points higher than the unemployment rate for whites (3.2%). Although whites had the lowest unemployment rate, they also had the highest labor force nonparticipation rate (17%). Because of the large numbers of whites who are out of the labor force, whites have the lowest rates of employment among S&E highest degree holders.

Among those who are employed and whose highest degree is in an S&E field, race/ethnicity groups have concentrations in different degree fields. Differences in degree fields resemble those among S&E occupations. Both blacks and Hispanics are more concentrated in the social sciences, and Asians are more concentrated in engineering and in computer and mathematical sciences. In 2008, among blacks, more than half had their highest S&E degree in the social sciences, while 46% of Hispanics did (table 3-27). For both of these groups, close to one-third had their highest S&E degrees in engineering or in the computer and mathematical sciences. Asians, on the other hand, are heavily concentrated in the computer and mathematical sciences and in engineering, with 59% having their highest degree in one of these two fields and 20% having their highest degree in the social sciences. The distribution of degree fields for whites more closely resembles that for non-Asian groups. (See appendix table 3-14 for more detailed data on S&E degrees by race and Hispanic status.) On the whole, the field differences among S&E degree holders are more pronounced than are the corresponding differences among workers in S&E occupations.

Table 3-26
Distribution of workers in S&E occupations, by race/ethnicity and year: 1993–2008
(Percent)

Race/ethnicity	1993	1995	1997	1999	2003	2006	2008
Asian	9.1	9.6	10.4	11.0	14.2	16.1	16.9
American Indian/Alaska Native	0.2	0.3	0.3	0.3	0.3	0.4	0.3
Black	3.6	3.4	3.4	3.4	4.3	3.9	3.9
Hispanic	2.9	2.8	3.1	3.4	4.4	4.6	4.9
White	84.1	83.9	82.9	81.8	75.2	73.2	71.8
Native Hawaiian/Other Pacific Islander	NA	NA	NA	NA	0.3	0.5	0.4
Two or more races	NA	NA	NA	NA	1.4	1.4	1.7

NA = not available

NOTES: Before 2003, respondents could not classify themselves in more than one racial/ethnic category. Before 2003, Asian included Native Hawaiians and other Pacific Islanders.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (1993–2008), http://sestat.nsf.gov.

Science and Engineering Indicators 2012

Table 3-27
Field of highest degree among workers with highest degree in S&E, by race/ethnicity: 2008
(Percent)

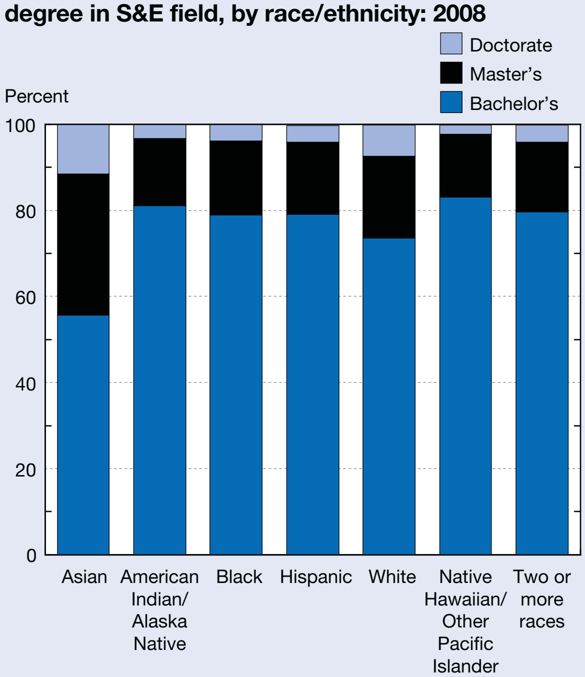
Race/ethnicity	All S&E fields	Computer/ mathematical sciences	Biological/ agricultural/ environmental life sciences	Physical sciences	Social sciences	Engineering
Employed with highest degree in S&E	12,588,000	15.3	15.6	6.7	39.3	23.2
Asian	1,545,000	24.7	13.8	7.4	20.2	33.9
American Indian/Alaska Native	46,000	19.9	17.3	6.3	41.3	15.1
Black	638,000	17.0	12.3	3.5	54.0	13.1
Hispanic	722,000	11.7	14.7	5.1	45.8	22.7
White	9,348,000	14.0	16.1	7.0	40.6	22.3
Native Hawaiian/Other Pacific Islander	53,000	14.1	14.9	3.6	40.2	27.2
Two or more races	236,000	11.1	14.7	5.5	50.3	18.5

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2008), http://sestat.nsf.gov.

Science and Engineering Indicators 2012

In addition to having concentrations in different fields, the demographic groups differ in the level of their highest degree. For example, among Asians with a highest degree in an S&E field, 56% have their highest degree at the bachelor's level and 12% have a doctoral degree (figure 3-31). In comparison, among both blacks and Hispanics 79% have their highest degree at the bachelor's level and 4% have a doctoral degree.

Figure 3-31
Level of S&E degree among workers with highest degree in S&E field, by race/ethnicity: 2008



SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2008), http://sestat.nsf.gov.

Science and Engineering Indicators 2012

Asians whose highest degree is in an S&E field are more likely than are others to work in an S&E occupation and are more likely than are others to work in the area in which they earned their degree (see appendix table 3-12). Among blacks, only one-quarter work in an S&E occupation; among Hispanics and American Indians/Alaska Natives nearly one-third work in an S&E occupation. By comparison, more than half of Asians work in these occupations.

Race/ethnicity matters even for those with similar credentials. Some, but not all, of the high concentration of black S&E degree holders working outside of science and engineering, and the high concentration of Asian S&E degree holders working within S&E, can be explained by their different degree levels or fields. But Asians with an S&E degree have a higher propensity to work in S&E occupations than others even among individuals with similar degree levels and fields. Thus differences between Asians and blacks in the propensity among degree holders to work in S&E occupations remain even among those with the same degrees.

Salary Differentials for Women and Minorities

Women and minority groups generally receive less pay than their male and white counterparts. The median salary in 2008 among women with a highest degree in an S&E field and working full time was one-third lower than the median salary among similar men (appendix table 3-15). Salary differences between men and women are much greater among those who are not working in S&E occupations. Among those working full time in S&E occupations, women's salaries were 18% lower than men's.

Racial/ethnic salary differences were somewhat smaller than salary differences between men and women (appendix table 3-16). American Indians/Alaska Natives with a highest degree in an S&E field and working full time earned 19% less than whites; blacks earned 16% less than whites; and Hispanics earned 14% less than whites. These salary differences were generally more modest among those who worked in S&E occupations.

Overall, both salary differences between men and women and race/ethnicity salary differences remained largely unchanged in the 15-year period between 1993 and 2008.

Differences in average age, work experience, field of degree, sector of employment, and other characteristics can make direct comparison of salary and earnings statistics misleading. Statistical models can estimate the size of the wage difference between men and women, as well as the wage difference between minorities and whites when various salary-related factors are taken into account. Estimates of these differences vary somewhat depending on the assumptions that underlie the statistical model used. The remainder of this section presents estimates of the expected size of the wage difference between men and women among individuals who are similar in age, work experience, field of degree, and other relevant characteristics; data bearing on wage differences between non-Asian minorities and whites are also included. These estimates are substantively consistent with many of the other published analyses on these topics (see, for example, Xie and Shauman 2003). Without accounting for any factors except level of degree, women working full time whose highest degree is a bachelor's in an S&E field were paid salaries that were 38% lower than those of men (figure 3-32).[14] This salary difference is substantial, but it is smaller at both the master's level (28%) and at the doctoral level (24%). The salary differences for minorities relative to whites are narrower (figure 3-33). Minority salary levels are 10% lower than those of whites at the bachelor's level, 16% lower at the master's level, and 4% lower at the doctoral level. All estimated baseline differences are statistically significant.

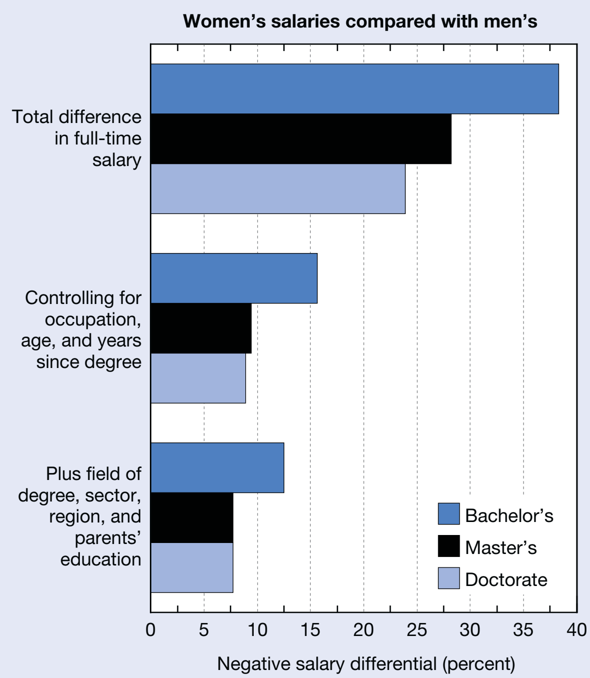
Effects of Occupation and Experience on Salary Differences

Salaries differ across occupations. For example, in the three S&E occupations with the lowest concentrations of women—aerospace, aeronautical, or astronautical engineers; mechanical engineers; and electrical and electronics engineers—the combined median salary among men is $90,000, and among women it is $81,000. These figures are substantially higher than the combined sex-specific median salary ($65,750 for men and $54,000 for women) in the three large S&E occupations with the highest concentrations of women—psychologists; medical scientists, except practitioners; and biological scientists (see appendix table 3-15). Salary also varies by indicators of experience, including both age and years since completing education. Estimates of salary differences are made by applying controls for occupation, age, and years since completing the highest degree.[15] After controlling for these factors, the estimated wage difference between men and women narrows. However, among men and women in similar jobs and with similar levels of experience, women are still paid 16% less than men (among individuals whose highest degree is at the bachelor's level) and 9% less than men (among individuals whose highest degree is at the master's and doctoral level). Minorities with their highest degree at the bachelor's level also earn somewhat less (6%) than whites, after controlling for occupation and experience. Among those with a doctoral degree, the wage difference between minorities and whites is mostly attenuated (3%) and at the master's degree level, the difference is fully attenuated after controlling for occupation and experience. This illustrates that at higher degree levels, minorities and white degree holders in similar S&E occupations and with similar experiences receive about the same salaries.

Effects of Other Factors: Sector, Field of Degree, and Region

Salaries vary by other work-related factors beyond occupation and experience. For example, salaries differ across sector. Academic and nonprofit employers typically pay less for the same skills than employers pay in the private sector, and government compensation falls somewhere between the two groups. These differences are salient for understanding salary variations by sex and race/ethnicity because whites and males are more highly concentrated in the

Figure 3-32
Estimated differences in full-time salary between women and men with highest degree in S&E, controlling for selected employment and other characteristics, by degree level: 2008

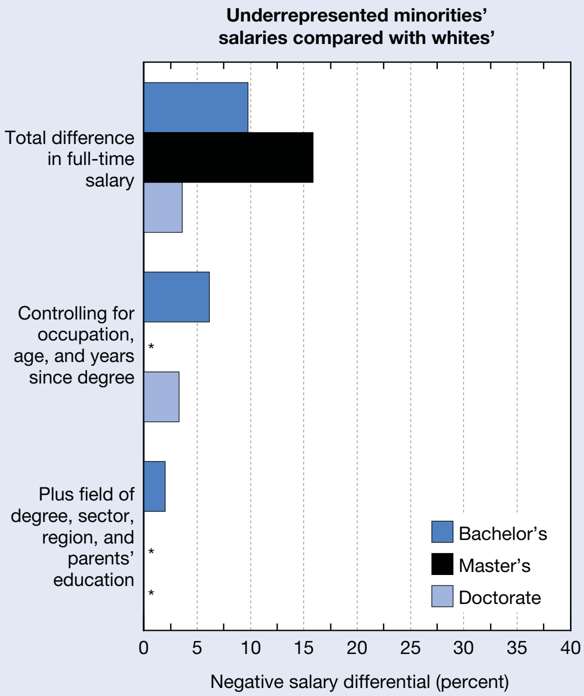


NOTES: Salary differentials represent estimated percentage differential of women's full-time salary relative to men's full-time salary. Coefficients are estimated in a mixed-effects regression model using natural log of full-time annual salary as dependent variable.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2008), http://sestat.nsf.gov.

Science and Engineering Indicators 2012

Figure 3-33
Estimated differences in full-time salary between underrepresented minorities and whites with highest degree in S&E, controlling for selected employment and other characteristics, by degree level: 2008



* Differences not significant at $p < .05$.

NOTES: Salary differentials represent estimated percentage differential of underrepresented minorities' full-time salary relative to whites' full-time salary. Coefficients estimated in a mixed-effects regression model using natural log of full-time annual salary as dependent variable. Asians and multiracial individuals, representing 15% of employed highest S&E degree holders, are not included in regression. Underrepresented minorities include American Indian/Alaska Natives, blacks, Hispanics, and Native Hawaiian/Other Pacific Islanders.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2008), http://sestat.nsf.gov.

Science and Engineering Indicators 2012

private for-profit sector. Salaries also differ across regions. For example, at $86,000, the Pacific census division had the highest median salaries for scientists and engineers among the nine U.S. census divisions and the west-north-central, at $75,000, had the lowest. Almost one-quarter (23%) of U.S.-born underrepresented minorities worked in the Pacific division compared with 15% of whites, whereas whites had a higher concentration in the west-north-central (9%) than underrepresented minorities (4%).

Salaries also vary by degree field. Salaries among those with degrees in engineering, the physical sciences, and in computer and mathematical sciences are higher than salaries among those with degrees in the environmental and life sciences, and among those with degrees in the social sciences. Degree areas with lower salaries also have higher concentrations of women and minorities.

However, taking these factors into account[16] in addition to occupation and experience results in only marginal changes in the estimated salary differences between men and women compared with estimates generated accounting for occupation and experience alone. Women who are similar to men along all seven of these factors receive salaries that are 13% (among bachelor's degree holders) to 8% (among master's degree and doctoral degree holders) lower than their male counterparts. The salary difference between minorities and whites fully attenuates when all seven factors are simultaneously controlled.

Effects of Family on Salary Differences

The family roles of wife and mother are associated with lower salaries for women. In contrast, the roles of husband and father are associated with higher salaries among men. To evaluate the effects of family status on wage differences between men and women, these differences are estimated separately for the set of workers in science and engineering occupations who are unmarried and without young children, who are married and without young children, and who are married and with young children. Each estimate is made accounting for occupation, age, time since degree, employment sector, field of degree, region, and parents' educational attainment, as described above. The analysis presented in figure 3-34 considers a household to include young children if a child age 12 or younger was present.[17]

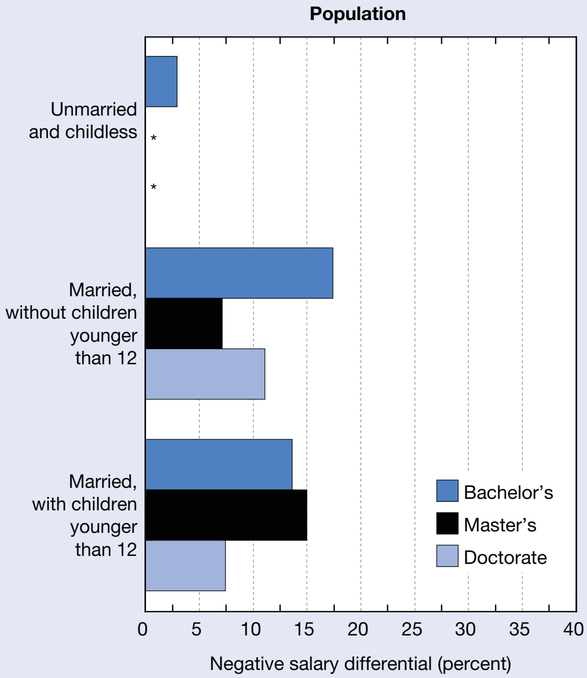
Among full-time workers with a highest degree in an S&E field who are both unmarried and childless, men and women tend to be paid similar salaries. At the bachelor's level, the estimated salary difference is 3% among men and women who are similar in occupation, age, experience, work sector, degree field, region, and parents' education (figure 3-34). At the master's and doctoral levels, estimated salary differences between men and women among the unmarried and childless are statistically insignificant. The presence or absence of children under age 12 does not consistently affect the size of salary differences between men and women beyond what would be expected considering other factors.[18]

S&E Immigrants

The foreign born constitute a considerable proportion of workers in science and engineering occupations, and both the number and share of foreign-born workers have been increasing. However, immigration of scientists and engineers to the United States has declined during the recent economic downturn. Most indicators presented in this section apply to all foreign born, despite the fact that *the foreign born* is a broad category comprising long-term U.S. residents with strong roots in the United States as well as recent immigrants who compete in global job markets or whose main social ties are in their countries of origin.

Several sources yield broadly consistent estimates of U.S. reliance on foreign-born scientists and engineers. Table 3-28

Figure 3-34
Estimated differences in full-time salary between men and women with highest degree in S&E, controlling for selected employment and other characteristics, by marital and parental status and degree level: 2008



* Not significantly different than zero at p = .05.

NOTES: Salary differentials represent estimated percentage differential of women's full-time salary relative to men's full-time salary when controlling for occupation, age, years of experience, field of degree, employment sector, region, and parents' education. Coefficients estimated in a mixed-effects regression model using natural log of full-time annual salary as dependent variable.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2008), http://sestat.nsf.gov.

Science and Engineering Indicators 2012

shows upward trends in the percentage of foreign-born individuals in U.S. S&E occupations over the first decade of the century. The share of nonacademic scientists and engineers who are foreign born rose from 22% in 2000 to 25% in 2009, although some evidence suggests that the rate of growth slowed in the last years of the decade.

The similarity in the estimates from SESTAT and the U.S. Census Bureau American Community Survey (ACS) is noteworthy because the two surveys differ methodologically. SESTAT surveys include only individuals who were counted in the most recent Decennial Censuses or who received a U.S. S&E degree, thereby excluding recently arrived foreign-born and foreign-educated scientists and engineers. The potential for an undercount of the foreign born is smallest in the earliest portion of the decade—the closer in time to the Decennial Census—and increases over the course of the decade.[19] The ACS, on the other hand, draws a new sample of the U.S. residential population every year. However, ACS occupation coding is less precise, and the ACS does not distinguish postsecondary teachers in science and engineering fields from other postsecondary teachers. The similarity in the estimates from these surveys, despite their contrasting limitations, suggests that the overall picture the surveys provide is broadly accurate.

Characteristics of the Foreign Born

The foreign born in S&E occupations tend to have higher levels of education than the U.S. native born. In most S&E occupations, the higher the degree level, the greater the proportion of the workforce who are foreign born (appendix table 3-17). This relationship is weakest among social scientists and strongest among computer and mathematical scientists and engineers. In 2003, at the bachelor's degree level, the proportion of foreign-born individuals within occupational areas ranged between 10% (social scientists) and 19% (computer and mathematical scientists). However, at the doctoral degree level, about half of the workers in computer and mathematical sciences and in engineering were foreign born.

In 2003, more than half (55%) of foreign born in the United States with a highest degree in an S&E field came from Asian countries. Just over one-fifth were born in Europe. North America (Canada), Central America, the Caribbean, South America, and Africa each supply roughly equal numbers (each accounting for from 4% to 5% of the foreign born). The leading country of origin among immigrant S&E workers in the United States is India, which accounted for 16% of the foreign born. China (with 11%) is the second leading country. Source countries for the 276,000 foreign-born holders of S&E doctorates are somewhat more concentrated, with China providing 22% and India 14% (figure 3-35 and appendix table 3-18).

Source of Education

The majority of foreign-born scientists and engineers in the United States came to the United States before completing their higher education, but a substantial number came to the United States after receiving their university training abroad. Although almost half of the foreign-born, university-educated individuals working in the United States have a degree from a foreign university, two-thirds earned their highest degree from a U.S. educational institution. Among the foreign born with a doctoral degree, just over two-thirds received this degree from a U.S. institution, although nearly 80% have at least one degree from a foreign institution.

New Foreign-Born Workers

The number and share of foreign-born S&E workers have been rising, but the volume of new foreign workers entering U.S. S&E occupations has shown signs of decline during the recent economic downturn. One indicator of new foreign-born S&E workers joining the U.S. workforce is the number of temporary work visas issued by the U.S. government in visa classes for high-skilled workers. A second indicator is

Table 3-28
Foreign-born workers in S&E occupations, by education level: Selected years, 2000–09
(Percent)

Education	2000 Decennial census	2003 SESTAT	2003 ACS	2006 SESTAT	2006 ACS	2008 SESTAT	2008 ACS	2009 ACS
All college educated[a]	22.4	22.6	24.2	24.0	25.3	24.8	24.9	25.2
Bachelor's	16.5	16.4	17.7	17.5	18.1	17.2	18.4	18.3
Master's	29.0	30.3	32.0	32.8	33.5	33.9	32.7	33.4
Doctorate	37.6	40.5	37.8	40.9	41.8	41.4	40.9	41.6

ACS = American Community Survey; SESTAT = Scientists and Engineers Statistical Data System

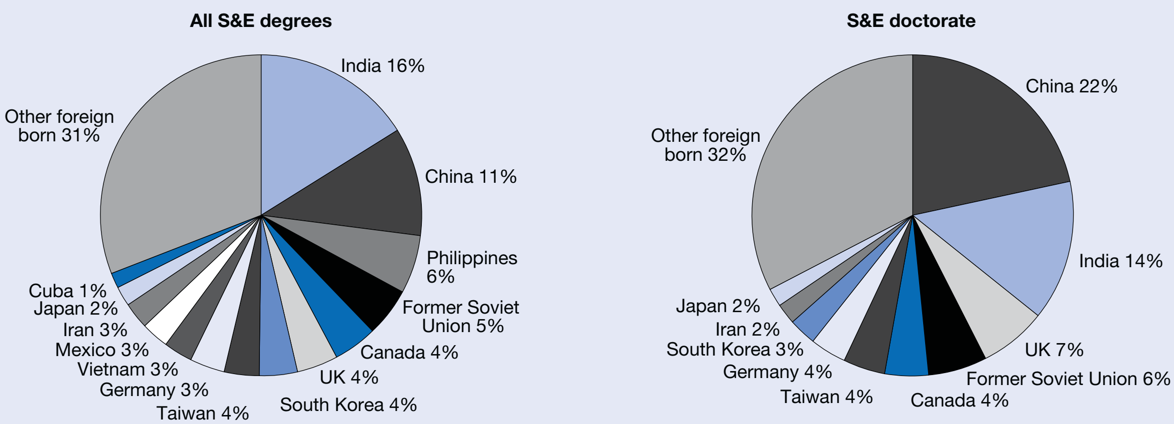
[a]Includes professional degrees not broken out separately.

NOTES: Includes all S&E occupations except postsecondary teachers because these occupations not separately reported in 2000 Census or ACS data files. SESTAT 2006 and 2008 data do not include foreign workers who arrived in the United States after 2000 Decennial Census and also did not earn S&E degree in United States.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, SESTAT (2003–08), http://sestat.nsf.gov; Census Bureau, 2000 Decennial Census Public Use Microdata Sample (PUMS) and ACS (2003, 2006, 2008, 2009).

Science and Engineering Indicators 2012

Figure 3-35
Foreign-born individuals with highest degree in S&E living in the United States, by place of birth: 2003



UK = United Kingdom

NOTE: Percents may not add to 100% because of rounding.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2003), http://sestat.nsf.gov. See appendix table 3-18.

Science and Engineering Indicators 2012

the rate at which foreign-born recipients of U.S. doctoral degrees remain in the United States after earning their degree ('stay-rates').

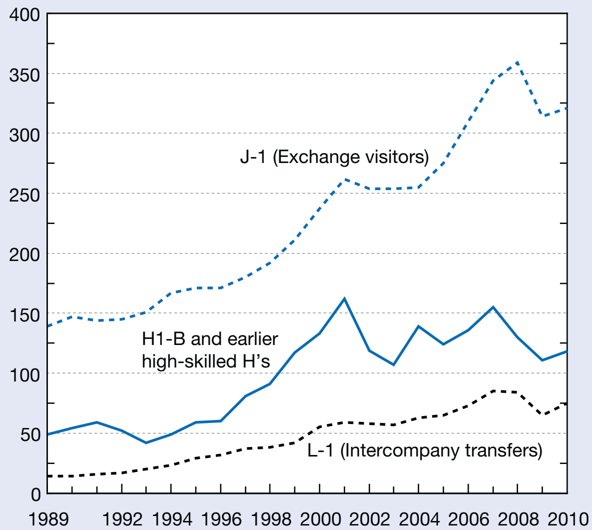
Temporary Visas

The number of temporary work visas issued for high-skill workers provides an indication of the volume of immigration of these workers. However, for all types of temporary work visas, the actual number of individuals using them is less than the number issued. For example, some individuals may have job offers from employers in more than one country and may choose not to foreclose any options until a visa is certain.

The largest classes of these temporary visas declined during the recent economic downturn, after several years of growth (figure 3-36). Data for 2010, however, suggest that this period of decline may be short-lived. The previous period of decline in the use of these visas occurred during the more mild recession in the earlier part of the decade, and these declines were unevenly experienced across visa categories.

H-1B temporary work visas account for a larger number of high-skill workers than other visa classes. This visa is issued to individuals who seek temporary entry into the United States in a specialty occupation that requires the skills of a professional. It is issued for up to 3 years with the possibility of an extension to 6 years. In 2010, the United States issued

Figure 3-36
Temporary work visas issued in categories with many high-skilled workers: FY 1989–2009



NOTE: J-1 exchange visitor visa used for many different skill levels.

SOURCE: U.S. Department of State, Nonimmigrant Visa Issuances by Visa Class and by Nationality, http://www.travel.state.gov/visa/statistics/nivstats/nivstats_4582.html (accessed May 4, 2011).

Science and Engineering Indicators 2012

more than 118,000 H-1B visas, down almost 25% from the nearly 155,000 issued in 2007.

Similarly, many fewer J-1 exchange visas—visas issued for limited periods of study, research, or teaching—were issued in 2010 than in 2007. For L-1 visas, which support intercompany transfers, the number was 12% lower in 2010 than in 2007. The smaller, more specialized visa programs for high-skilled workers also fell slightly in 2010. These visa classes include O-1 (a person of outstanding ability), O-2 (an assistant to an O-1, sometimes a postdoc), TN (college-degreed citizens of Canada and Mexico), and E-3 (college-degreed citizens of Australia).

Characteristics of H-1B Visa Recipients

The H-1B visa, which is the most common visa for new foreign entrants into the U.S. S&E workforce, is not issued exclusively for scientists and engineers. Other professional workers who use an H-1B visa include those in administrative occupations, legal occupations, and cultural occupations (such as artists and entertainers). However, because the U.S. Citizenship and Immigration Services do not classify occupations with the same taxonomy used by the National Science Foundation, precise counts of H-1B visas issued to scientists and engineers cannot be obtained. Nevertheless, it is safe to say that the bulk of H-1B visa recipients work in S&E or S&E-related occupations (appendix table 3-19). In 2009, workers in computer-related occupations were the most common recipients of H-1B visas, accounting for 35% of H-1B visas issued. The total number of newly initiated H-1B visas for workers in computer-related fields declined by nearly half from 2008 to 2009 while the share of total recipients who worked in these fields declined from 50% to 35%. Despite this drop, the proportion of H-1B recipients who worked in computer sciences was considerably higher than it was early in the decade. For example, in 2002, only 25% of these visa recipients worked in computer-related fields.

H-1B visa recipients tend to possess advanced degrees. In FY 2009, 58% of new H-1B visa recipients had an advanced degree, including 40% with master's degrees, 6% with professional degrees, and 13% with doctorates. This degree distribution differs by occupation, with 83% of mathematical and physical scientists holding advanced degrees (44% with doctorates). Among life scientists, 87% hold advanced degrees (61% with doctorates).

Almost half of recent H-1B visa recipients were from India (39%) or China (10%). Among doctorate holders, 29% were from China and another 16% from India (figure 3-37). Altogether, Asian citizens made up nearly two-thirds of all H-1B visa recipients with a doctoral degree.[20]

Table 3-29 shows salaries paid to new recipients of H-1B temporary work visas by occupation group and level of degree. These starting salaries, taken from final visa application forms sent to U.S. Citizenship and Immigration Services, are different from—and generally higher than—H-1B salaries that firms report on their applications to the Department of Labor, which are filed much earlier in the H-1B process. The relatively low average salaries for doctorate holders in the life sciences may reflect the common use of H-1B visas to hire individuals for relatively low-paying postdoc fellowships.

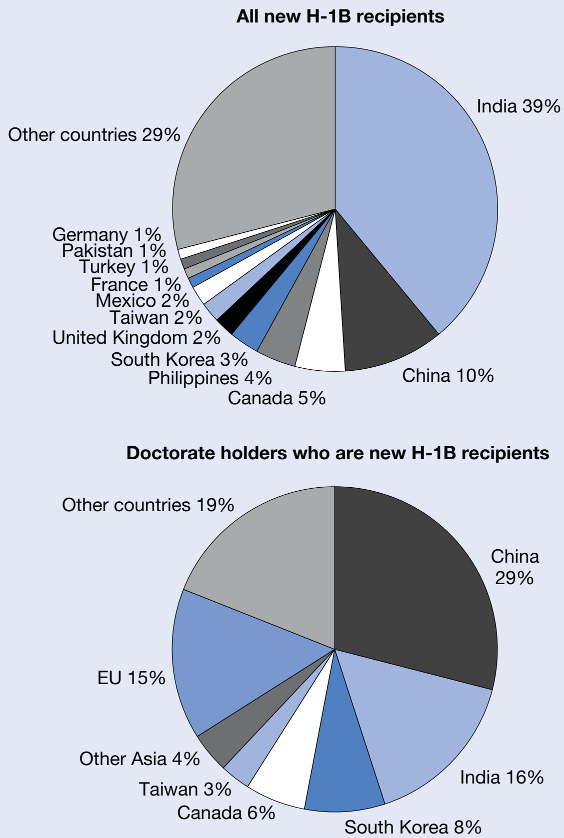
Short-Term Stay Rates for U.S. Doctorate Recipients

Among doctoral recipients, the period immediately after earning the doctoral degree is a pivotal point at which long-term career trajectories may be set. Foreign doctoral recipients who remain in the United States may set themselves on a pathway toward long-term residency.

At time of award, foreign students who receive doctoral degrees from U.S. universities report whether they intend to stay in the United States and whether they have a firm offer (either a postdoc or employment opportunity) to stay in the United States.[21] These responses provide estimates of short-term stay rates.

Most foreign U.S. doctorate recipients plan to stay in the United States after graduation. At the time of doctorate receipt, three-quarters of foreign recipients of U.S. S&E doctorates, including those on both temporary and permanent visas, plan to stay in the United States, and about half have either accepted an offer of postdoc study or employment or are continuing employment in the United States (figure 3-38).[22] Through the 1980s, about half of foreign students who earned S&E degrees at U.S. universities reported that they planned to stay in the United States after graduation, and about one-third said they had firm offers for postdoc study or employment (NSB 1998). In the 1990s, however, these percentages increased substantially. Thus, the proportion

Figure 3-37
Citizenship of new recipients of U.S. H-1B temporary work visas: FY 2009



EU = European Union

NOTE: Other Asia includes Hong Kong, Japan, Malaysia, Singapore, and Thailand.

SOURCE: Department of Homeland Security (DHS), U.S. Citizenship and Immigration Services; National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of DHS administrative records.

Science and Engineering Indicators 2012

of foreign S&E doctoral degree recipients reporting plans to stay in the United States rose to 72% in the 1998–2001 period and to 77% in the 2006–09 period (appendix table 3-20). In 2009, both the percentage who reported plans to stay in the United States and those with firm offers to stay declined modestly from 2008. The number of foreign doctoral degree recipients also declined in 2009, making the drop from 2008 to 2009 in numbers of foreign-born doctoral recipients with plans to stay in the United States somewhat more pronounced, with 6% fewer foreign-born doctoral recipients reporting plans to stay in the United States.

Overall S&E short-term stay rates reflect the high short-term stay rates in computer and mathematical sciences, the biological and related sciences, the physical sciences, and engineering. Between 2006 and 2009, the short-term stay rate in each of these four fields was about 80%, as measured by reports of intentions to stay in the United States. However, the short-term stay rate for foreign doctoral recipients in the social sciences and in health fields was considerably lower.

Stay rates vary by place of origin. In the period 2006–09, 89% of U.S. S&E doctoral recipients from China and from India reported plans to stay in the United States, and close to 60% reported accepting firm offers for employment or postdoc research in the United States. Doctorate recipients from Japan, South Korea, and Taiwan were less likely than those from China and India to stay in the United States (figure 3-39). Close to half of U.S. S&E doctoral degree recipients from Europe had firm plans to stay after graduation. In North America, the percentage of 2006–09 doctoral degree students who had definite plans to stay in the United States was higher for those from Canada than those from Mexico (see appendix table 3-20).

Between 2002–05 and 2006–09, the percentage of U.S. S&E doctoral degree recipients from the two top countries of origin (China and India) who were reporting definite plans to stay in the United States declined. Other countries, however, experienced sharp increases in short-term stay rates among S&E doctoral degree recipients in the United States, including Indonesia, New Zealand, Mexico, and Colombia.

Long-Term Stay Rates

The rate at which foreign recipients of U.S. doctoral degrees who stayed in the United States immediately after they received their degree continue to remain in the United States over longer durations can also be observed.[23] Recent trends in long-term stay rates show that within cohorts, long-term stay rates are similar to short-term rates. This similarity is particularly evident for the cohort of foreign S&E doctoral recipients who earned their degrees in 1993 (figure 3-40). Two years after receiving the doctoral degree, 53% of these foreign doctorates who were temporary residents when they earned their degree remained in the United States. By 2009, 52% remained, with little variation along the way. More recent cohorts have had higher short-term stay rates, but these stay rates have declined over time. The cohort of degree recipients who earned their doctorates in 1999 had a stay rate after 2 years of 68%. After 10 years, this rate declined by 7 percentage points, but the rate of decline gradually attenuated. The cohort of foreign S&E doctoral degree recipients of 2004 had a 2-year stay rate of 66%, which declined to 62% by 2009 (figure 3-40; Finn 2012, forthcoming).

The stability of stay rates over time applies whether or not these rates are calculated for foreign doctoral recipients from U.S. institutions who received their doctoral degree while on a temporary visa status or for those who held either a temporary or permanent visa. Temporary visa holders make up the largest share of foreign S&E doctoral degree recipients. They also have lower stay rates than do permanent residents. For example, among foreign S&E doctoral degree recipients from the 1993 cohort, those who were permanent residents at the time they earned their degree had stay rates that were 24 percentage points higher than those with temporary visas. This difference persisted through 2009. Among more recent cohorts, the difference in stay rates between permanent and

Table 3-29
Average annual salary of new H-1B visa recipients, by occupation and education level: FY 2009
(Dollars)

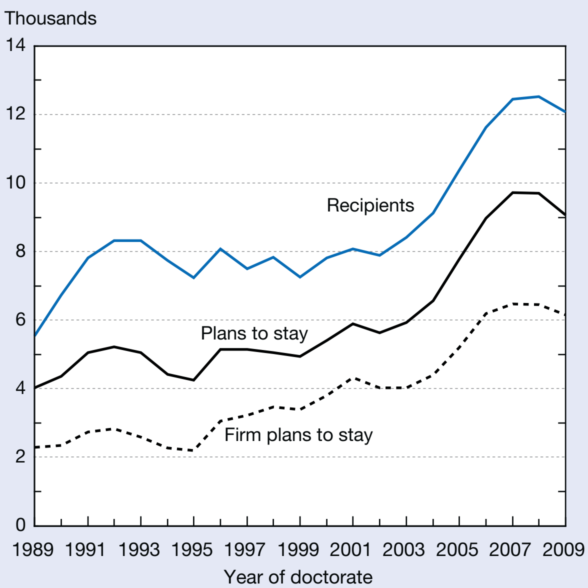
Occupation	All degree levels	Bachelor's	Master's	Professional	Doctorate
Administrative specializations	57,700	56,000	59,000	77,000	89,000
Architecture/engineering/surveying	71,300	71,000	68,000	77,000	82,000
Art	47,800	47,000	50,000	na	na
Computer-related occupations	66,300	65,000	66,000	73,000	94,000
Education	53,200	40,000	48,000	78,000	57,000
Entertainment/recreation	36,600	37,000	36,000	na	na
Law/jurisprudence	108,200	83,000	74,000	137,000	na
Life sciences	53,300	47,000	52,000	54,000	55,000
Managers/officials nec	87,200	83,000	89,000	132,000	138,000
Mathematics/physical sciences	69,800	70,000	68,000	84,000	71,000
Medicine/health	76,500	55,000	58,000	100,000	64,000
Miscellaneous professional/technical/managerial	75,300	72,000	76,000	91,000	101,000
Museum/library/archival sciences	49,900	na	46,000	na	na
Religion/theology	37,800	41,000	36,000	na	na
Social sciences	67,400	60,000	70,000	na	95,000
Writing	44,600	44,000	43,000	na	na

na = not applicable; nec = not elsewhere classified

SOURCE: Department of Homeland Security (DHS), U.S. Citizenship and Immigration Services; National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of DHS administrative records.

Science and Engineering Indicators 2012

Figure 3-38
Plans of U.S. S&E doctorate recipients with temporary visas at graduation to stay in United States, by year of doctorate: 1989–2009



SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of Survey of Earned Doctorates.

Science and Engineering Indicators 2012

temporary residents was initially much smaller, but increased rapidly over the 5 years after receipt of the doctorate.

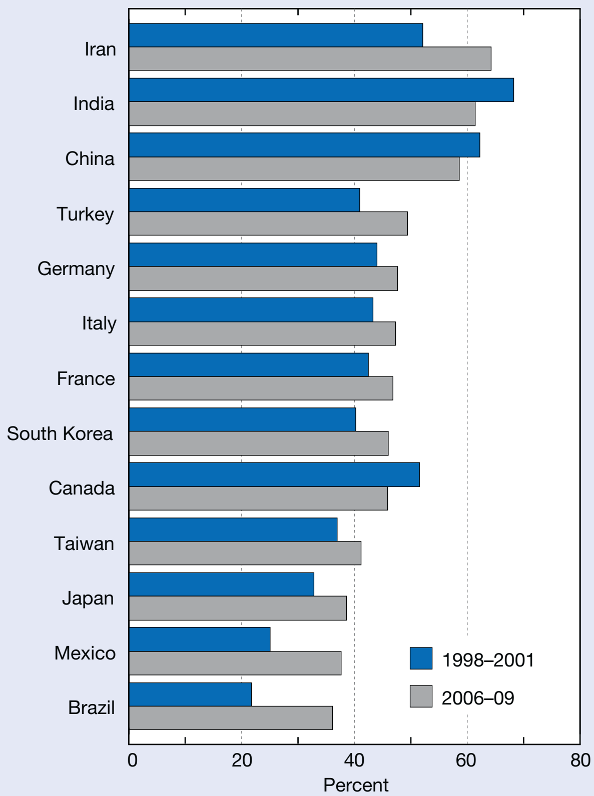
Because of the persistence of stay rates over time, factors that are associated with the level of short-term stay rates are similarly associated with the level of longer-term stay rates. For example, countries with the highest levels of short-term stay rates (e.g., China and India) are among the countries with the highest long-term stay rates. Similarly, academic fields that have the highest short-term stay rates (e.g., the physical sciences) also have the highest long-term stay rates, and the field with the lowest short-term stay rates, the social sciences, has the lowest long-term stay rates.

Some evidence suggests that stay rates may vary for doctorate recipients from graduate programs of different quality based on ratings of faculty by the publication *U.S. News and World Report* and on separate ratings by the National Research Council (Finn 2009). Doctorate recipients from the graduate programs designated among the top 25 were somewhat less likely to remain in the United States than were graduates of other programs (see table 3-30). The difference in 1-year stay rates was 2 percentage points: 69% of those from the top-rated programs and 71% of other doctorate recipients remained in the United States 1 year after receiving their degrees. By 5 years after receiving their degree, the two groups showed differences that rose to 5 percentage points, with stay rates of 59% and 64%, respectively.

Age and Retirement

The baby boom generation—the unusually large cohort born between 1946 and 1964 (with birth rates in the United States peaking in 1957)—affected the age structure of the S&E labor force in much the same way it affected the general labor force. Thus, in the early 1990s, this bulge produced a relatively large concentration of S&E workers in their late 20s to mid-40s contributing to a comparatively

Figure 3-39
Plans of U.S. S&E doctorate recipients with temporary visas at graduation to stay in the United States, by place of origin and year of doctorate: 1998–2001 and 2006–09

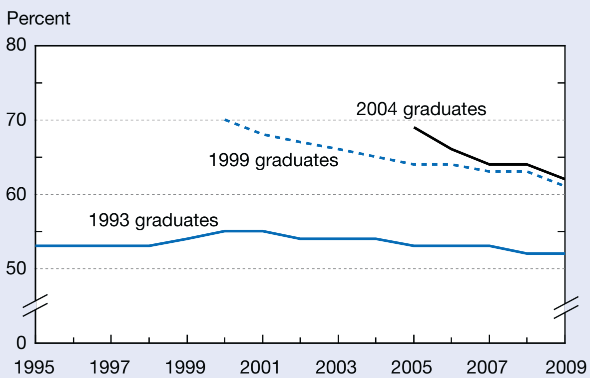


NOTE: Rates are proportions of each group reporting firm commitment to postgraduation employment in United States.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of Survey of Earned Doctorates.

Science and Engineering Indicators 2012

Figure 3-40
Stay rates for U.S. S&E doctorate recipients with temporary visas at graduation, by selected year of doctorate: 1995–2009



SOURCE: Finn M, Stay rates of foreign doctorate recipients from U.S. universities: 2012, Oak Ridge Institute for Science and Education (forthcoming).

Science and Engineering Indicators 2012

youthful S&E workforce. By 2008, these cohorts had aged into their early 40s to early 60s, with the oldest nearing traditional retirement ages. One indicator of the aging of the S&E workforce is the increasing percentage of individuals in this workforce above age 50 (as seen in figure 3-41). In 2008, 27% of individuals with S&E degrees and in S&E occupations were in that age group, whereas 15 years earlier just 18% were in that age group.

Another indication of the aging of the S&E labor force is the increase over time of the median age of individuals working in S&E occupations. From 1993 to 2008, the median age rose by 4 years, from 37 to 41 years of age. The median age of workers with a highest degree at the bachelor's level rose by 5 years (from 35 to 40), at the master's level by 3 years (from 39 to 42), and at the doctoral level by 3 years (from 44 to 47).

The increasing average age of S&E workers may mean increased experience and greater productivity among them. However, it could also reduce opportunities for younger researchers to make productive contributions by working independently. In many scientific fields, folklore and empirical evidence indicate that the most creative research comes from younger people (Stephan and Levin 1992).

Age Differences Among Occupations

Individuals with S&E degrees who work in S&E occupations are younger than individuals with S&E degrees who work in S&E-related occupations. They also are younger than those whose jobs are not in, nor related to, S&E. Figure 3-42 shows, for 2008, age distributions for S&E-degree holders by highest degree level and broad occupational area. Age differences across broad occupational areas are more pronounced at higher degree levels. Among those whose highest S&E degree is at the master's level, the median age of workers in S&E occupations was 42; for workers in S&E-related occupations it was 47; for workers in jobs not in nor related to S&E occupations it was 49. Among those whose highest S&E degree is at the doctoral level, the median age of workers in S&E occupations was 47 compared with 50 for workers in S&E-related occupations and 53 for workers in jobs not in nor related to S&E. The flow of workers out of S&E occupations into other occupations compared with the reverse flow from other occupations to S&E occupations contributes to much of the differences in age distributions across broad occupational areas. For example, among workers in S&E occupations who were observed in 2003, 16% were no longer in such occupations in 2006. On the other hand, only 5% of those workers in other occupations in 2003 were in S&E occupations in 2006. Among the S&E workers who moved into other occupations, one-third (approximately 200,000 workers) went into management positions, many of which involve supervising S&E workers.

Age Differences Among S&E Degree Fields

In 2008, the median age among those in the labor force with any degree in S&E was 43. Degree holders in different areas varied in their ages. Degree holders in the physical sciences were comparatively old with a median age of 47 and 38% of the field's workers over age 50 (figure 3-43). Degree holders in computer and mathematical sciences were relatively young, with a median age of 42 and only 22% over age 50. Within degree areas, specific fields differed considerably in the ages of their workers. For example, within engineering the youngest degree holders were in bioengineering and biomedical engineering, with a median age of 34 and with 39% younger than age 30 (see appendix table 3-21). On the other hand, more than 40% of the workers in metallurgical engineering and mining and mineral engineering were older than 50.

Leaving the Labor Force and Retirement

The increasing share of the S&E labor force over age 50 makes retirement patterns among S&E workers more important in terms of how they will affect the supply of these workers. Recent patterns of labor force exit and work reduction among the older members of the workforce suggest that by age 55 rates of participation in the S&E workforce begin to decline and are markedly reduced by the time workers reach

Table 3-30
Temporary U.S. residents who received S&E doctorates in 2002, by program rating and year: 2003–07
(Percent)

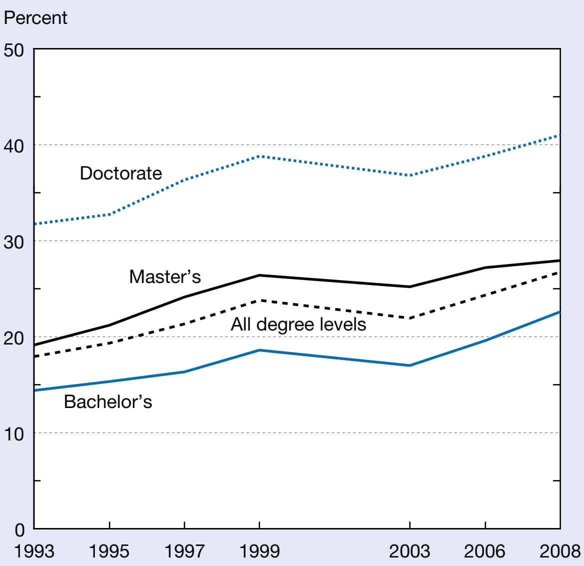
Program rating	Foreign doctorate recipients (*n*)	2003	2004	2005	2006	2007
All programs	7,850	70	67	65	63	63
Top-rated programs	2,611	69	65	62	60	59
All other programs	5,239	71	69	67	65	64

NOTE: Characterization of programs as "top-rated" by Finn, using ratings of faculty reputation in research from *U.S. News and World Report* and National Research Council.

SOURCE: Finn M, Stay rates of foreign doctorate recipients from U.S. universities: 2012, Oak Ridge Institute for Science and Education (forthcoming).

Science and Engineering Indicators 2012

Figure 3-41
Workers older than age 50 in S&E occupations, by highest degree level and year: 1993–2008

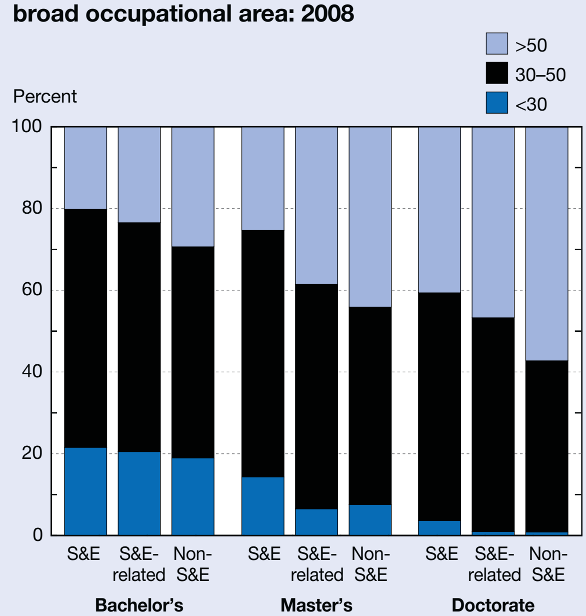


NOTES: Total includes professional degrees not broken out separately. National estimates not available from Scientists and Engineers Statistical Data System (SESTAT) in 2001.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, SESTAT (1993–2008), http://sestat.nsf.gov.

Science and Engineering Indicators 2012

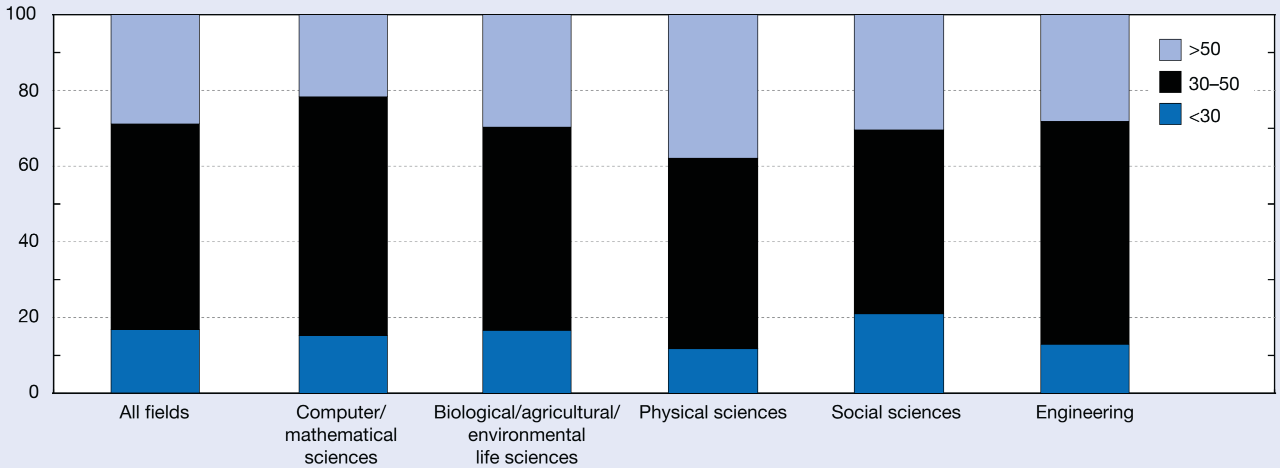
Figure 3-42
Age distribution of employed individuals with highest degree in S&E, by degree level and broad occupational area: 2008



SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2008), http://sestat.nsf.gov.

Science and Engineering Indicators 2012

Figure 3-43
Age distribution among employed individuals with highest degree in S&E, by degree field: 2008



SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2008), http://sestat.nsf.gov.

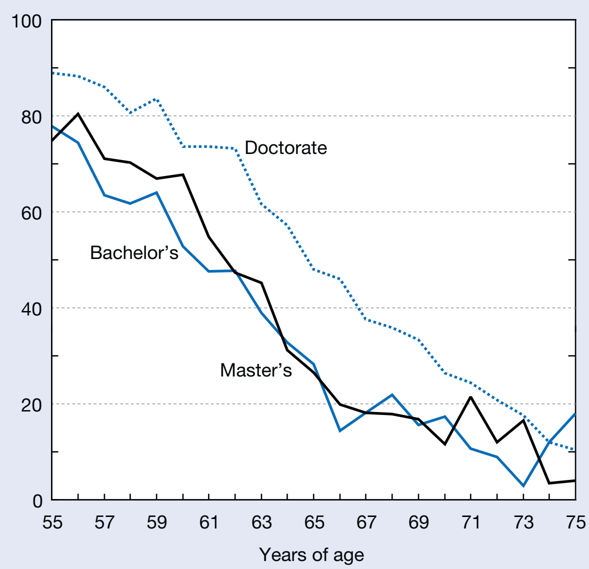
Science and Engineering Indicators 2012

their mid-60s. One indication of the relationship between age and the level of labor force participation is illustrated by figure 3-44, which shows full-time work rates among older S&E degree holders by highest level of education. In 2008, at age 55, 78% of those whose highest degree was at the bachelor's level, 75% of those whose highest degree was at the master's level, and 89% of those whose highest degree was at the doctoral level worked full time. However, at all degree levels, full-time labor force participation rates decline quickly as S&E workers age into their late 50s. By age 61, more than half of S&E bachelor's degree holders are not working full time. Among those whose highest degree is at the master's level, this milestone is reached at age 62. For S&E doctoral degree holders, half are not working full time by age 64. After age 65, no more than one-quarter of the workforce with a highest degree at the master's or bachelor's level worked full time. Among those with a doctoral degree, this proportion is reached at age 71.

Another indicator of the relationship between age and labor force participation is the proportion of S&E degree holders who reported that they were out of the labor market. In 2008, at age 55, 12% of those whose highest degree is at the bachelor's level, 7% of those whose highest degree is at the master's level, and 5% of those whose highest degree was at the doctoral level were out of the labor force. By the early 60s, the proportion of people who are out of the labor force takes a sharp turn upwards, and by age 65 about half of those whose highest degree is at the master's level and half of those whose highest degree is at the bachelor's level report that they are neither working nor looking for work. Among those with a doctoral degree, more than half report neither working nor looking for work at age 68.

Table 3-31 shows the rates at which holders of U.S. S&E doctorates left full-time employment, by sector of employment, between April 2006 and October 2008. Rates of leaving full-time employment for S&E doctorate holders were higher for those working in the private sector than those

Figure 3-44
Older individuals with highest degree in S&E who work full time, by age and degree level: 2008



SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2008), http://sestat.nsf.gov.

Science and Engineering Indicators 2012

Table 3-31
Employed S&E doctorate holders who left full-time employment after April 2006, by employment sector and age: October 2008
(Percent)

	April 2006 employment sector			
Age (years)	All sectors	Education	Government	Business/ industry
50–55......	4.7	3.3	2.5	6.9
56–62......	9.7	7.9	10.2	11.7
63–70......	27.6	26.3	28.0	29.3

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2006, 2008), http://sestat.nsf.gov.

Science and Engineering Indicators 2012

employed in education or government, although in the oldest group this sector difference largely disappears.

Between 1993 and 2008, increasing percentages of SESTAT respondents in their 60s reported that they were still in the labor force. Whereas 59% of S&E degree holders between the ages of 60 and 64 were employed in 1993, the comparable percentage rose to 66% in 2006. For S&E degree holders between ages 65 and 69, the increase was larger, rising from 32% in 1993 to 44% in 2006. After peaking in 2006, rates of employment among workers in their 60s declined slightly in 2008, but remained above rates prior to 2006. Other indicators, including full-time employment rates and retirement rates, show similar patterns, as do comparisons restricted to workers with similar highest degree levels and degrees in similar fields. In recent years, labor force participation has also risen slightly among S&E degree holders in their early 70s, but has not changed among those in their late 50s.

Global S&E Labor Force

Work that involves science and engineering occurs throughout the world. Such work is concentrated in developed nations, where most R&D also takes place. The availability of a suitable labor force is an important determinant of where businesses choose to locate S&E work (Davis and Hart 2010), and concentrations of existing S&E work, in turn, spawn new employment opportunities for workers with relevant S&E knowledge and skills. As a result, governments in many countries have made increased investments in S&E-related postsecondary education a high priority. At the same time, high-skill workers, such as those in S&E occupations, are increasingly mobile, and the number who leave their native countries to pursue education and career goals is growing. In recent years many nations, recognizing the value of high-skill workers for the economy as a whole, have changed their laws to make it easier for such workers to immigrate. These changes indicate an accelerating competition for globally mobile talent (Shachar 2006).

Ideally, data on the global S&E labor force would include statistics on its overall size and growth, enable detailed comparisons of S&E labor force characteristics in different countries, and track flows of S&E workers across national boundaries. Unfortunately, the internationally comparable data that exist are limited to establishment surveys that provide only basic information about workers in S&E occupations or with training in S&E disciplines. The U.S. SESTAT system, for example, includes far more data on members of the U.S. S&E labor force than is available in other national statistical systems. In addition, although surveys that collect workforce data are conducted in many member countries of the Organisation for Economic Co-operation and Development (OECD), they do not cover several countries—including Brazil, India, and Israel—that have been making concerted efforts to build knowledge economies in which S&E play a central role, and they do not provide fully comparable data for China.

This section begins with information about the size and growth of workforce segments whose jobs involve S&E in nations for which relevant data exist. It then reports limited data on high-skill migration trends. Data on the role of immigrants in the U.S. S&E labor force are reported earlier in this chapter (see "Demographics in the S&E Labor Force"). The section closes with data on international employment by U.S. multinational companies and international engagement by members of the U.S. S&E workforce.

Size and Growth of Global S&E Labor Force

Although comprehensive data on the worldwide S&E workforce do not exist, OECD data covering significant, internationally comparable segments of the S&E workforce provide strong evidence of widespread, though uneven, growth in the world's developed nations.

OECD countries, which include most of the world's highly developed nations, compile data on researchers from establishment surveys in member and selected non-member countries. These surveys mostly use a standardized occupational classification that defines researchers as "professionals engaged in the conception or creation of new knowledge, products, processes, methods and systems and also in the management of the projects concerned" (OECD 2002, p. 93). Because this definition can be applied differently when different nations conduct surveys, international comparisons should be made with caution. The OECD also reports data on personnel employed directly in R&D. These data include clerical and administrative staff employed in R&D organizations as well as professionals whose skills and career paths are more closely connected to R&D.

OECD reports an estimated increase in researchers in its member countries from 2.8 million in 1995 to 4.2 million in 2007. OECD also publishes estimates for eight non-member economies, including China and Russia; adding these to the OECD member total for 2007 yields a worldwide estimate of 6.3 million. Numerous uncertainties affect this estimate, however:

- Some non-member countries that engage in large and growing amounts of research (e.g., India, Brazil) are omitted entirely from these totals.
- China's data for 2009, collected in accordance with OECD definitions and standards, yield an estimate of about 440,000 fewer researchers than China's data for the preceding year.
- For some countries and regions, including the United States and the European Union, OECD estimates are derived from multiple national data sources and not from a uniform or standardized data collection procedure.

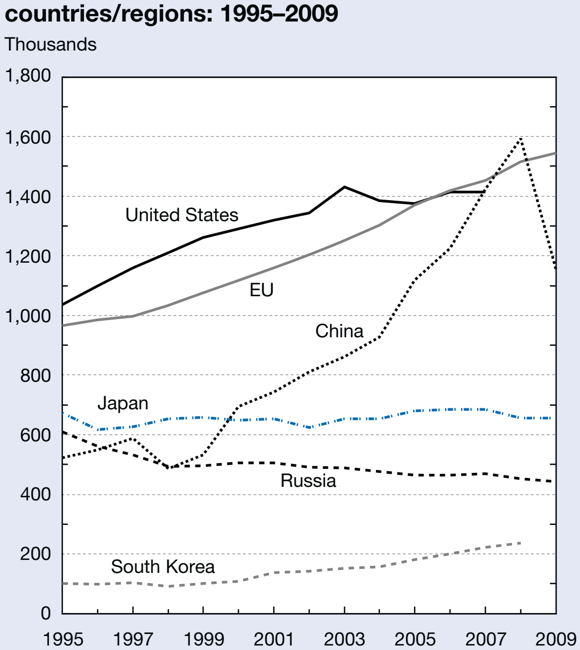
Despite these limitations for making worldwide estimates of the number of researchers, the OECD data are a reasonable starting point for estimating the rate of worldwide growth.

For most economies with large numbers of researchers, growth since the mid-1990s has been substantial (figure 3-45). China, whose pre-2009 data did not entirely correspond to the OECD definition, reported about triple the number of researchers in 2008 compared with 1995. South Korea doubled its number of researchers between 1995 and 2006 and continued to grow strongly between 2007 and 2008. The United States and the European Union experienced steady growth but at a lower rate between 1995 and 2007, both starting the period at about 1 million researchers and increasing to almost 1.5 million. Japan (little change) and Russia (decline, especially early in the period; see also Gokhberg and Nekipelova 2002) were exceptions to the overall worldwide trend. Trends in full-time equivalent R&D personnel were generally parallel to those for researchers in those cases for which both kinds of data are available (appendix table 3-22).

OECD also estimates the proportion of researchers in the workforce in different economies. In OECD's most recent estimates, small economies in Scandinavia (Denmark, Finland, Iceland, Norway, Sweden) and East Asia (Singapore, Taiwan) report that at least 1% of their workforce are researchers (appendix table 3-23).[24] Among economies with more than 200,000 researchers, OECD's latest estimates are that researchers make up the highest proportions of the workforce in Japan (1.04%), South Korea (1.00%), and the United States (0.95%). Although China reports a large number of researchers, they are a much smaller percentage of its workforce (0.15%) than in OECD member countries.

Several Asian economies have shown marked and continuous increases since 1995 in the percentage of their workforce employed as researchers. These include China, South Korea, Singapore, and Taiwan. In the United States and Japan, where growth occurred at all, it took place mostly between 1995 and 2003 (figure 3-46). Patterns and trends in the proportion of the workforce classified as R&D personnel are generally similar to those for researchers.

Figure 3-45
Estimated number of researchers in selected countries/regions: 1995–2009



EU = European Union

NOTES: Researchers are full-time equivalents. Before 2009, counts for China were not consistent with Organisation for Economic Co-operation and Development (OECD) standards.

SOURCE: OECD, Main Science and Technology Indicators (2010/1 and earlier years).

Science and Engineering Indicators 2012

High-Skill Migration

Worldwide or internationally comparable data on migration of workers in S&E occupations or with college-level S&E degrees do not exist. Docquier, Lowell, and Marfouk (2009; see also Docquier and Marfouk 2006) compiled and analyzed data on migrants to OECD countries in 1990 and 2000. Their data come from almost 200 source locations, all but a handful of them independent nations. They report several characteristic patterns in high-skill migrations, defined as emigration of people with some postsecondary education from the country of their birth:

- Between 1990 and 2000, the overall number of immigrants to OECD countries increased from about 42 million to about 58 million.
- Rates of legal emigration were much greater among high-skill persons than among persons with less education.
- In countries the World Bank classifies as low income, the gap in emigration rates between high- and low-skill groups (6.1% compared with a total emigration rate of 0.5%) was especially large.
- The proportion of women among high-skill migrants rose, partly but not entirely because of the worldwide increase in the proportion of people with some postsecondary education who are women.
- Countries estimated to have the largest number of high-skill emigrants living in OECD countries in 2000 were the United Kingdom (1.5 million), the Philippines (1.1

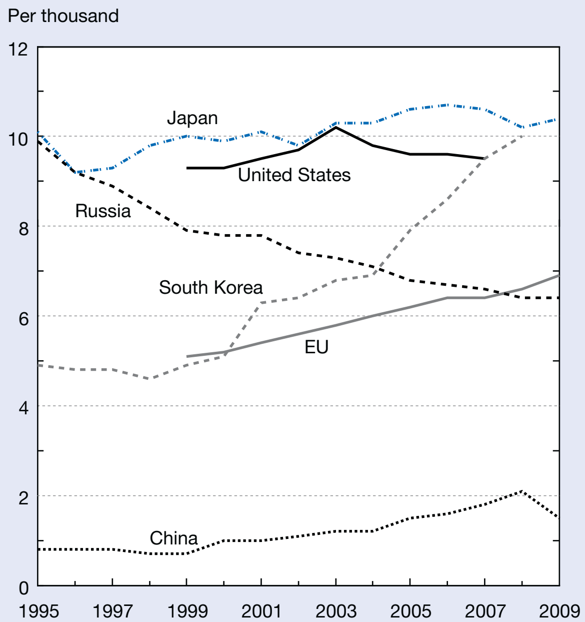
million), India (1.0 million), Mexico (0.9 million), and Germany (0.9 million) (figure 3-47).

- In both 1990 and 2000, about half of the immigrants with tertiary education living in OECD countries were in the United States.

In a more limited study covering six major destination countries, Defoort (2008) concluded that worldwide emigration rates for high-skill persons were stable between 1975 and 2000; Docquier and Marfouk (2006) calculate an increase in the migration rate for these persons from 5.0% to 5.4% between 1990 and 2000. Nonetheless, because worldwide education levels are rising, the proportion of high-skill persons among those who immigrated to OECD countries rose between 1990 and 2000 (Docquier and Marfouk 2006).

Insofar as S&E workers, especially those in natural science and engineering fields, are less dependent on language- and culture-specific skills than highly educated workers trained in other fields, they may be more internationally mobile than other high-skill workers. Thus, in the United States high-skill immigrants are disproportionately found in S&E occupations and disproportionately have degrees in the natural sciences and engineering. However, current international data do not enable researchers to assess whether and how migration rates vary among different categories of high-skill workers.

Figure 3-46
Researchers as a share of total employment in selected countries/regions: 1995–2009



EU = European Union

NOTES: Researchers are full-time equivalents per thousand total employment. Before 2009, counts for China were not consistent with Organisation for Economic Co-operation and Development (OECD) standards.

SOURCE: OECD, Main Science and Technology Indicators (2010/1 and earlier years).

Science and Engineering Indicators 2012

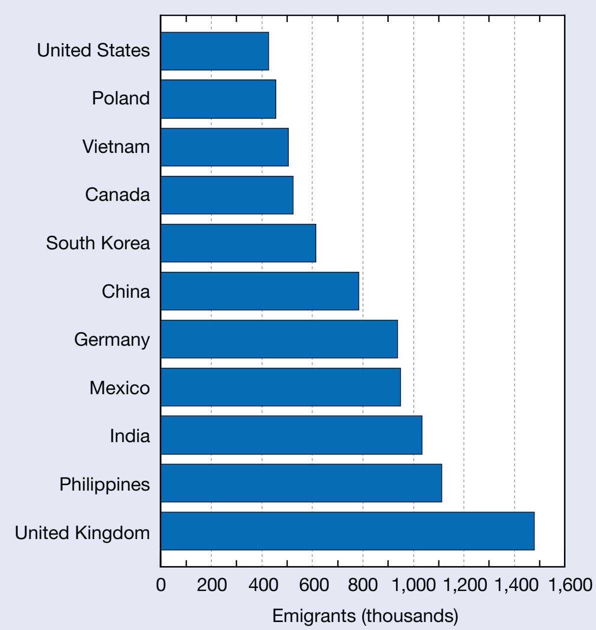
R&D Employment Abroad by U.S. Companies

R&D jobs located abroad in U.S.-owned companies are an indicator of global engagement in the world's S&E workforce. Data from the 2009 Business R&D and Innovation Survey provide an overview of R&D employment in the business sector and enable comparisons between domestic and foreign R&D employment in companies located in the United States (both U.S.- and foreign-owned) that have R&D activity (table 3-32). These data identify employment as either domestic or foreign on the basis of the job's location and not on the basis of the company's ownership, the employee's citizenship, or the employee's place of birth.

Among firms with five or more employees, R&D employment is disproportionately domestic. About one-third of all employees are located abroad, compared with about one-quarter of R&D employees. There is a large disparity between the overall proportion of manufacturing employment that is foreign (41%) and the proportion of manufacturing R&D employment that is foreign (25%). In contrast, the proportions in nonmanufacturing industries are similar: 24% for overall employment and 23% for R&D employment.

Larger companies locate more of their R&D employment outside the country than small ones. In firms with 1,000 or more employees, 30% of R&D employment is foreign-based, whereas only 11% is foreign-based in firms with

Figure 3-47
Top countries of origin of foreign-born persons having at least a tertiary education and residing in an OECD country: 2000



OECD = Organisation for Economic Co-operation and Development

SOURCE: Docquier F, Lowell BL, Marfouk A. A Gendered Assessment of Highly Skilled Emigration (2009), http://perso.uclouvain.be/frederic.docquier/filePDF/DLM_PDR09.pdf.

Science and Engineering Indicators 2012

Table 3-32
Domestic and foreign business-sector employment, by company characteristics: 2009

	Company size				Industry type			
	5–999		≥1,000		Manufacturing		Nonmanufacturing	
Education	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Total employment								
Worldwide	4,915	100	22,177	100	16,679	100	10,415	100
Domestic	3,840	78	13,947	63	9,882	59	7,906	76
Foreign	1,075	22	8,321	37	6,798	41	2,509	24
R&D employment								
Worldwide	587	100	1,290	100	1,137	100	742	100
Domestic	523	89	902	70	850	75	574	77
Foreign	65	11	391	30	287	25	167	23

NOTES: Data are representative of companies where worldwide R&D expense plus worldwide R&D costs funded by others are greater than zero. Includes 2002 North American Industry Classification System (NAICS) codes 21–23, 31–33, and 42–81. Detail may not add to total because of rounding. Industry classification based on dominant business code for domestic R&D performance, where available. For companies not reporting business codes, classification used for sampling was assigned.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Business R&D and Innovation Survey (2009 preliminary).

Science and Engineering Indicators 2012

fewer than 1,000 employees. In both cases, comparable percentages are higher for overall employment (37% and 22%, respectively).

The domestic and foreign R&D workforces of U.S.-located businesses have similar occupational and demographic profiles. Data on broad occupational categories, levels of educational attainment, and sex distributions for businesses in different sectors and of different sizes are in appendix table 3-24.

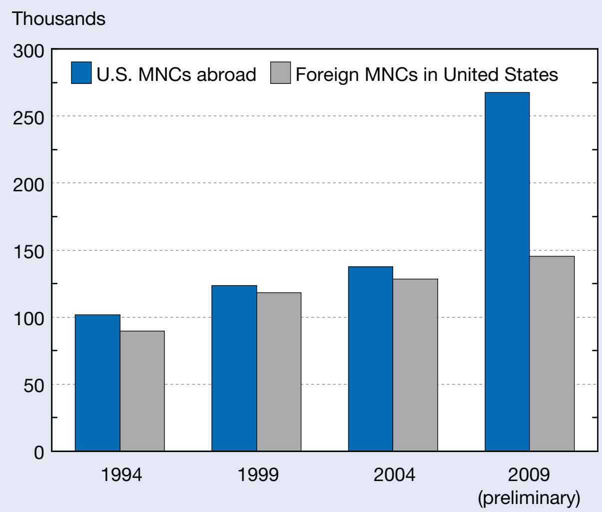
Multinational companies (MNCs) perform a substantial proportion of R&D through foreign direct investment (FDI) (see chapter 4). Data on MNC R&D employment count managers, scientists, engineers, and other professional and technical employees engaged in R&D. The Survey of U.S. Direct Investment Abroad, conducted by the Bureau of Economic Analysis (BEA), provides data on R&D employment of parent companies of U.S. MNCs and their overseas affiliates every 5 years. Preliminary data for this indicator are available for 2009. Separately, BEA's Survey of Foreign Direct Investment in the United States includes data on U.S. R&D employment by foreign-based MNCs.[25]

Between 1994 and 2004, R&D employment in the United States by foreign firms grew slightly faster than R&D employment abroad by U.S. firms. During this period, R&D employment in the United States by majority-owned affiliates[26] of foreign firms rose from 89,800 to 128,500, a 43% increase (figure 3-48). Over the same 10 years, R&D employment by U.S. firms at their majority-owned foreign affiliates grew 35%, from 102,000 in 1994 to 137,800 in 2004. Adding U.S. parent company R&D employment of 716,400 workers, U.S. MNCs employed 854,200 R&D workers globally (figure 3-49) in 2004.

The average annual growth in R&D employment abroad by U.S. firms from 1994 to 2004 was 3%. This shifted their proportion of overseas employment slightly, increasing it from 14% to 16% of total employment.

The 2009 data on MNC R&D employment abroad show a markedly different trend after 2004 from the trend in the preceding decade. About 85% of MNC R&D employment growth occurred abroad. Whereas employment abroad nearly doubled, domestic employment during the same period

Figure 3-48
R&D employment of U.S. multinational corporations at their foreign affiliates, and foreign MNCs at their U.S. affiliates: 1994, 1999, 2004, and 2009



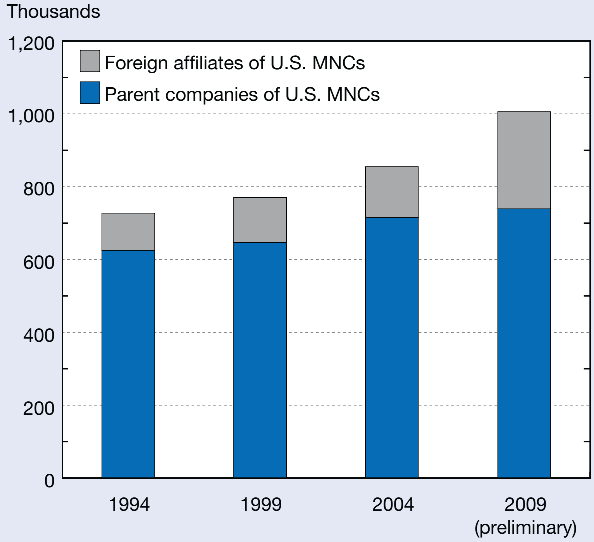
MNC = multinational corporation

NOTE: Includes only employment at majority-owned affiliates.

SOURCE: Bureau of Economic Analysis, Survey of Foreign Direct Investment in the United States and Survey of U.S. Direct Investment Abroad (various years).

Science and Engineering Indicators 2012

Figure 3-49
R&D employment of U.S. multinational corporations' parent companies in the United States and their foreign affiliates: 1994, 1999, 2004, and 2009



MNC = multinational corporation

NOTE: Includes only employment at majority-owned affiliates.

SOURCE: Bureau of Economic Analysis, Survey of U.S. Direct Investment Abroad (various years).

Science and Engineering Indicators 2012

grew by less than 5%. As a result, the proportion of MNC R&D employment located outside the United States went from 16% to 27%.

The unprecedented increase in U.S. MNC R&D employment abroad contrasts with the continuation of modest growth in R&D employment by foreign firms in the United States. Because of this, unlike in 2004 and prior years, the amount of R&D employment attributed to U.S. MNCs abroad is much larger than the comparable figure for foreign firms in the United States (figure 3-48).

The data in figures 3-48 and 3-49 are consistent with two trends discussed in this chapter: growth in S&T employment in the United States coinciding with a general expansion throughout the world of the capacity to do S&T work.

International Engagement by the Domestic S&E Workforce

Working with people in foreign countries is an indicator of how globally engaged the S&E workforce is. In 2006, SESTAT asked survey respondents whether they had worked "with individuals located in other countries" during a particular week. Seventeen percent of respondents reported that they had.

The proportion of the workforce that reported this kind of international engagement varied depending on differences in their work roles and demographic characteristics (table 3-33; appendix table 3-25) (NSF/NCSES 2012c, forthcoming). The following patterns were found among SESTAT respondents:

- Workers in for-profit organizations (24%) had the highest rates of international work, more often reporting such work than those in government, education, self-employment, or nonprofit organizations. Federal government workers had higher rates than state or local employees, and those in 4-year higher educational institutions had higher rates than persons teaching at institutions serving less advanced students.
- Workers in S&E occupations had much higher rates of international engagement (28%) than those in non-S&E (16%) or S&E-related (8%) occupations.
- Among those in S&E occupations, computer and mathematical scientists and engineers had the highest rates of international engagement and social scientists had the lowest rates. However, within employment sectors field differences did not consistently follow this pattern.
- Doctorate holders had substantially higher rates of international engagement than individuals whose highest degrees were at the master's or bachelor's level. Professional degree holders had the lowest rates of all.
- Men (21%) reported international engagement more often than women (11%).
- Foreign-born survey respondents (24%) reported international engagement more often than U.S.-born individuals (15%).
- SESTAT respondents who earned degrees both in the United States and abroad had the highest rates of international engagement (31%). The comparable figure for those who earned their degrees abroad was 23%, and for those with only U.S. degrees it was 16%.

SESTAT respondents showed substantial variation in international engagement depending on their work activities. For persons reporting either computer applications, programming, and systems or R&D as a primary or secondary work activity, the rate of international engagement was high—about one-quarter reported an international interaction. Rates for teaching (6%) and for professional services (7%) were substantially lower than for other activities.

Data on another indicator of international engagement, international coauthorship of S&E journal articles, are reported in chapter 5.

Table 3-33
Scientists and engineers reporting international engagement, by demographic characteristics, education, employment sector, occupation, and salary: 2006

Characteristic	Total employment	Reporting international engagement: Number	Reporting international engagement: Percent
All employed scientists and engineers	18,927,000	3,157,000	16.7
Sex			
Male	10,683,000	2,293,000	21.5
Female	8,244,000	865,000	10.5
Place of birth			
U.S. born	15,714,000	2,397,000	15.3
Not U.S. born	3,213,000	761,000	23.7
Age group (years)			
≤24	619,000	86,000	13.9
25–34	3,951,000	679,000	17.2
35–44	5,169,000	1,006,000	19.5
45–54	5,381,000	886,000	16.5
55–64	3,165,000	425,000	13.4
≥65	641,000	75,000	11.8
Place of postsecondary education			
All degrees earned in United States	17,031,000	2,675,000	15.7
Degrees earned abroad and in United States	730,000	229,000	31.4
All degrees earned abroad	114,000	254,000	22.8
Highest degree			
Bachelor's	10,886,000	1,761,000	16.2
Master's	5,384,000	970,000	18.0
Professional	1,774,000	171,000	9.7
Doctorate	883,000	254,000	28.8
Employment sector			
Business/industry	13,137,000	2,653,000	20.2
For-profit	7,682,000	2,048,000	26.7
Self-employed[a]	3,624,000	478,000	13.2
Non-profit	1,830,000	127,000	6.9
Government	2,228,000	216,000	9.7
Federal	824,000	146,000	17.8
State/local	1,405,000	69,000	4.9
Education	3,562,000	289,000	8.1
4-year educational institutions[b]	1,549,000	229,000	14.8
Other educational institutions[c]	2,014,000	60,000	3.0
Occupation			
S&E occupations	5,024,000	1,416,000	28.2
Computer/mathematical scientists	2,112,000	667,000	31.6
Biological/agricultural/other life scientists	487,000	116,000	23.9
Physical scientists	334,000	80,000	23.9
Social scientists	47,000	70,000	14.8
Engineers	1,621,000	483,000	29.8
S&E-related occupations	5,246,000	394,000	7.5
Non-S&E occupations	8,657,000	1,348,000	15.6
Salary			
<$30,000	2,923,000	190,000	6.5
$30,000–49,999	4,127,000	362,000	8.8
$50,000–69,999	3,872,000	522,000	13.5
$70,000–89,999	2,986,000	636,000	21.3
$90,000–109,999	2,068,000	551,000	26.6
≥$110,000	2,950,000	897,000	30.4

[a]Includes self-employed or business owners in incorporated or unincorporated businesses, professional practices, or farms.
[b]4-year educational institutions include 4-year colleges or universities, medical schools (including university-affiliated hospitals or medical centers), and university-affiliated research institutions.
[c]Other educational institutions include 2-year colleges, community colleges, or technical institutes and other precollege institutions.

NOTES: International engagement defined as working with individuals located in other countries during survey reference week. *Scientists and engineers* refers to all persons who have received a bachelor's degree or higher in an S&E or S&E-related field, plus persons holding a non-S&E bachelor's or higher degree who were employed in an S&E or S&E-related occupation in 2003. Numbers rounded to nearest 1,000. Detail may not add to total because of rounding.

SOURCE: National Science Foundation, National Center for Science and Engineering, Scientists and Engineers Statistical Data System (SESTAT) (2006), http://sestat.nsf.gov.

Science and Engineering Indicators 2012

Conclusion

The S&E labor force may be defined in a variety of ways. At its core are individuals in S&E occupations, with S&E degrees, using knowledge and skills closely related to their S&E training, and working in jobs that make use of this expertise. But in a modern knowledge-based economy many workers have one or two of these attributes rather than all of them. Nonetheless, by any plausible definition, the S&E labor force experienced strong growth in the United States and the world throughout the second half of the twentieth century.

Policymakers with otherwise divergent perspectives agree that jobs involving S&E are good for workers and good for the economy as a whole. These jobs pay more, even when compared to jobs requiring similar amounts of education and experience. Workers with S&E training or in S&E occupations are less likely to be unemployed. Industries with higher proportions of workers in S&E occupations tend to offer higher pay even to their employees who are in other lines of work.

Worldwide, growing numbers of workers are engaged in research. Growth has been especially marked in rapidly developing economies, such as South Korea and China, that have either recently joined the ranks of the world's developed economies or are poised to do so. Mature developed economies in North America and Europe have maintained slower growth, while the number of researchers in the struggling Japanese economy has been stagnant.

The United States has shown some recent signs of slower growth: little change in the number of trained workers in S&E occupations, an aging S&E workforce that is drawing nearer to retirement (though showing signs of delaying retirement to somewhat later ages), and a modest drop during the most recent recession in the proportion of foreign recipients of U.S. advanced S&E degrees who join the U.S. labor force. At the same time, members of historically underrepresented groups (e.g., women, blacks) have played an increasing role in the U.S. S&E labor force, although more so in some fields (e.g., biological and social sciences) than in others (e.g., mathematical and physical sciences and engineering). In addition, the United States has remained an attractive destination for foreign workers with advanced S&E training.

Numerous factors beyond the availability of workers equipped to use S&E knowledge and skills on the job will affect the kinds of jobs that the U.S. economy generates in the future. As a result, data on current labor force trends do not necessarily portend future patterns that will emerge in a dynamic world economy recovering from the shocks produced by a prolonged economic downturn.

Notes

1. The standard definition of the term *labor force* includes the population that is employed or not working but seeking work (unemployed); other individuals are not considered in the labor force. When data refer only to employed persons, the term *workforce* is used. For data on unemployment rates by occupation, calculations assume that unemployed individuals are seeking further employment in their most recent occupation.

2. Despite the limitations of this subjective measure, variations among occupations in the proportions of workers who say they need this level of S&E technical expertise accord with common sense. For example, among doctoral level postsecondary teachers of physics, 99.7% said they needed at least a bachelor's degree level of knowledge in engineering, computer sciences, mathematics, or the natural sciences, compared with 5% among doctoral level postsecondary teachers of English. Likewise, among the small numbers of S&E bachelor's degree holders whose occupation is *secretary/receptionist/typist,* fewer than one in six reported that their job needed bachelor's level S&E expertise of any kind.

3. Estimates of the size of the S&E workforce vary across the example surveys because of differences in the scope of the data collection (SESTAT surveys collect data from individuals with bachelor's degrees and above only); because of the survey respondent (SESTAT surveys collect data from individuals, OES collects data from establishments, and ACS collects data from households); or because of the level of detail collected on an occupation, which aids in coding. All of these differences can affect the estimates.

4. Many comparisons using Census Bureau data on occupations are limited to looking at all S&E occupations except postsecondary teachers because the Census Bureau aggregates all postsecondary teachers into one occupation code. Only NSF surveys of scientists and engineers and some BLS surveys collect data on postsecondary teachers by field.

5. SESTAT/National Survey of College Graduates (NSCG) 2003 and 2008 estimates for the data displayed in figure 3-11 are not comparable. The 2003 estimates include a full complement of respondents to the 2003 NSCG, many of whom report that their jobs require S&E expertise, even though they lack degrees in S&E fields. SESTAT 2008 continues to gather data from S&E degree holders identified in the NSCG, but does not include individuals who are not either in S&E occupations or holders of S&E degrees. Thus, SESTAT 2003 data, although less current, are in some ways better suited for analyzing the relationships among occupations, degrees, and subjective assessments of job requirements. Relevant 2003 data were reported in *Science and Engineering Indicators 2010*. Because of the limitations of the 2008 SESTAT data, table 3-3 uses 2003 estimates.

6. Only U.S. citizens and nationals may be appointed in the competitive civil service; however, federal agencies may employ certain noncitizens who meet specific employability requirements in the excepted service or the Senior Executive Service.

7. This list does not include the National Institutes of Health, which is a part of the Department of Health and Human Services (DHHS). The proportion of all federal scientists and engineers working at DHHS is 5%.

8. SES includes occupations of senior managerial, supervisory, and policy positions in the executive branch of the federal government who generally serve as the link between political appointees and the rest of the federal workforce.

9. The commercialization success rate is the ratio of patents commercialized to patents granted.

10. The patent activity rate is the proportion who report having been named as an inventor on a patent application in the previous 5 years.

11. The Business Cycle Dating Committee of the National Bureau of Economic Research is generally the source for determining the beginning and end of recessions or expansions in the U.S. economy. See http://www.nber.org/cycles/recessions.html for additional information.

12. Many doctorate holders with salaries at this level are postdocs in temporary training positions.

13. Although the formal job title is often postdoc fellowship or research associate, titles vary among organizations. This chapter generally uses the shorter, more commonly used, and best understood name, *postdoc*. A postdoc is traditionally defined as a temporary position that individuals take primarily for additional training—a period of advanced professional apprenticeship—after completion of a doctorate.

14. This estimate differs slightly from the observed median difference in salary by sex because the former addresses mean differences and the latter addresses median differences. The former is influenced by extreme cases and outliers, and the latter is not.

15. Occupation, age, and years since completion of education are each controlled for as a random effect. SESTAT respondents working in science and engineering have been classified into 62 distinct occupations. Age is observed in one of eleven 5-year brackets. Years of experience are observed in one of twelve 5-year brackets.

16. Occupational sector, region, field of degree, and parents' education are each controlled for as a random effect. *Employers* are classified into one of seven sectors: 4-year colleges and universities, 2-year colleges, for-profit private sector, nonprofit private sector, self-employment, federal government, and state and local government. *Regions* are classified into the nine U.S. census divisions. *Field of degree* is observed in 1 of 142 distinct degree fields among individuals whose highest degree is at the bachelor's level, and within 123 distinct degree fields among individuals whose highest degree is at the doctoral level. *Parents' education* measures the highest level of education completed by either parent and is observed in one of eight categories.

17. The analysis was repeated with different age cut-points defining young children. Results did not change substantially when this age limit was adjusted (from ages 0–18 to ages 0–6), indicating that the finding in the text is not substantively sensitive to where this cut-point is set.

18. Among married workers with children younger than age 12, the estimated salary differences between men and women are generally similar in magnitude to the estimates for all scientists and engineers. For example, among workers whose highest degree is a bachelor's in an S&E field, the estimated salary difference by sex is 13% among all workers and is also 13% among workers who are married and with children younger than age 12. At the doctoral level, the estimated 8% salary difference by sex applies to all workers and to workers who are married with children. Only at the master's degree level is the estimated salary difference between men and women among the married with children larger (at 15%) than the difference among all workers (7%).

19. In the future, however, the largest component of SESTAT, the National Survey of College Graduates, will be refreshed on a biennial basis using respondents from the ACS, and so the undercount of recent foreign arrivals will be minimized.

20. This includes East Asians, South Asians, and Southeast Asians, but excludes individuals from countries in the Middle East and from the former Soviet Republics.

21. This question is part of the Survey of Earned Doctorates, which is administered to all recipients of U.S. doctoral degrees.

22. The growth in the number of doctoral students from China accounts for much of the rapid increase in foreign recipients of doctoral degrees from the early 1980s through 1996. During this period, the annual count of Chinese recipients of doctoral degrees rose from fewer than 10 to more than 3,000 (from 0.1% to 27.4% of all foreign doctoral degree recipients). The decline in foreign doctoral degree awards following 1996 also is partially, but not fully, accounted for by changes in the numbers of Chinese doctoral degree recipients. One contributing factor to the decline in 1996 was the Chinese Student Protection Act of 1992.

23. Long-term stay rates are observed by annually calculating the ratio of the number of noncitizen Survey of Earned Doctorate respondents who made Social Security contributions to the number of noncitizen Survey of Earned Doctorate respondents.

24. OECD's 2009 estimates for Norway and Singapore exceeded 1%, although the 2008 estimates reported in appendix table 3-23 did not. Iceland, which is not included in appendix table 3-23, was also above 1% in both years. OECD's estimate for Japan reported in the text is also more recent than that in the appendix table.

25. Although R&D employment by subsidiaries is an important indicator of international R&D activity, it has a significant limitation in that it does not include various external arrangements for performing R&D, ranging from R&D contracting to consulting work and strategic collaborations.

26. An *affiliate* is a company or business enterprise located in one country but owned or controlled by a parent company in another country. Majority-owned affiliates are those in which the ownership stake of parent companies is more than 50%.

Glossary

Career path job: A job that helps graduates fulfill their future career plans.

European Union (EU): A union of 27 member states on the continent of Europe, including Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, and the United Kingdom.

Federally funded research and development center (FFRDC): An organization that performs research and development and is exclusively or substantially financed by the federal government either to meet a particular research and development objective or, in some instances, to provide major facilities at universities for research and associated training purposes.

Involuntarily out-of-field (IOF) employment: Employment in a job not related to the field of one's highest degree because a job in that field was not available.

Labor force: A subset of the population that includes both those who are employed and those who are not working but seeking work (unemployed); other individuals are not considered to be in the labor force.

Organisation for Economic Co-operation and Development (OECD): An international organization of 30 countries headquartered in Paris, France. The member countries are Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom, and United States. Among its many activities, the OECD compiles social, economic, and science and technology statistics for all member and selected non-member countries.

Postdoc: A temporary position awarded in academia, industry, government, or a nonprofit organization, primarily for gaining additional education and training in research after completion of a doctorate.

SESTAT: Scientists and Engineers Statistical Data System, a system of three surveys conducted by the National Science Foundation that measure the educational, occupational, and demographic characteristics of the science and engineering workforce. The three surveys are the National Survey of College Graduates (NSCG), the Survey of Doctorate Recipients (SDR), and the National Survey of Recent College Graduates (NSRCG).

Stay rate: The proportion of students on temporary visas who stay in the United States 1–10 years after receiving a doctorate.

Tertiary education: Roughly equivalent in U.S. terms to individuals who have earned at least technical school or associate's degrees and includes all degrees up to the doctorate.

Workforce: A subset of the labor force that includes only employed individuals.

References

Alpert A, Auyer J. 2003. Evaluating the BLS 1988–2000 employment projections. *Monthly Labor Review* (October):13–37.

Census Bureau. 2009. American Community Survey PUMS file, special tabulations. http://www.census.gov/acs.

Davis T, Hart DM. 2010. International cooperation to manage high-skill migration: The case of India-U.S. relations. *Review of Policy Research* 27(4):509–26.

Defoort C. 2008. Long-term trends in international migration: An analysis of the six main receiving countries. *Population-E* 63(2):285–318.

Docquier F, Lowell BF, Marfouk A. 2009. A gendered assessment of highly skilled emigration. *Population and Development Review* 35(2):297–321.

Docquier F, Marfouk A. 2006. International migration by educational attainment, 1990–2000. *In* Ozden C, Schiff M, editors, *International Migration, Remittances and Development.* New York: Palgrave Macmillan. p. 151–200.

Finn M. 2012 (forthcoming). Stay rates of foreign doctoral recipients from U.S. universities. Oak Ridge, TN: Oak Ridge Institute for Science and Education.

Gokhberg L, Nekipelova E. 2002. International migration of scientists and engineers in Russia. *In* OECD, *International Mobility of the Highly Skilled.* Paris: OECD. p. 177–188.

National Research Council (NRC). 2010. *Rising Above the Gathering Storm, Revisited: Rapidly Approaching Category 5.* Washington, DC: National Academies Press.

National Science Board (NSB). 1998. *Science and Engineering Indicators 1998.* Arlington, VA: National Science Foundation (NSB 98-1).

National Science Board (NSB). 2003. Report of the National Science Board Committee on Education and Human Resources Task Force on National Workforce Policies for Science and Engineering. Arlington, VA: National Science Foundation.

National Science Board (NSB). 2008. *Science and Engineering Indicators 2008*. Two volumes. Arlington, VA: National Science Foundation (volume 1, NSB 08-01; volume 2, NSB 08-01A).

National Science Board (NSB). 2010. *Science and Engineering Indicators 2010.* Arlington, VA: National Science Foundation (NSB 10-01).

National Science Foundation, National Center for Science and Engineering Statistics (NSF/NCSES). 2003. Scientists and Engineers Statistical Data System (SESTAT), special tabulations. http://sestat.nsf.gov.

National Science Foundation, National Center for Science and Engineering Statistics (NSF/NCSES). 2008. Scientists and Engineers Statistical Data System (SESTAT), special tabulations. http://sestat.nsf.gov.

National Science Foundation, Division of Science Resources Statistics (NSF/SRS). 2008b. Postdoc participation of science, engineering, and health doctorate recipients.

NSF 08-307, Hoffer T, Grigorian K, and Hedberg E. Arlington, VA: NSF/SRS.

National Science Foundation, National Center for Science and Engineering Statistics (NSF/NCSES). 2012a (forthcoming). BRDIS 2008-9 DST. Arlington, VA.

National Science Foundation, National Center for Science and Engineering Statistics (NSF/NCSES). 2012b (forthcoming). Federal S&E 2009 DST. Arlington, VA.

National Science Foundation, National Center for Science and Engineering Statistics (NSF/NCSES). 2012c (forthcoming). International collaboration of scientists and engineers.

Office of Management and Budget. 2009. *Update of Statistical Area Definitions and Guidance on Their Uses*. OMB Bulletin No. 10.02. http://www.whitehouse.gov/sites/default/files/omb/assets/bulletins/b10-02.pdf. Accessed 26 June 2011.

Organisation for Economic Co-operation and Development (OECD). 2002. *Frascati Manual*. Paris: OECD.

Shachar A. 2006. The race for talent: Highly skilled migrants and competitive immigration regimes. *New York University Law Review* 81(1):148–206.

Stephan P, Levin S. 1992. *Striking the Mother Lode in Science: The Importance of Age, Place, and Time*. New York: Oxford University Press.

Xie Y, Shauman K. 2003. *Women in Science: Career Processes and Outcomes.* Cambridge Massachusetts: Harvard University Press.

Chapter 4
Research and Development: National Trends and International Comparisons

List of Sidebars

List of Tables

List of Figures

Highlights

Trends in National R&D Performance

Growth in total U.S. R&D performance slowed noticeably in 2009, compared to the last several years, but the broader trend remains that R&D spending growth continues to significantly outpace growth of the U.S. economy as a whole.

- Overall R&D performed in the United States in 2009 totaled an estimated $400 billion (current dollars)—somewhat below the $403 billion level in 2008, but well above the $377 billion in 2007. Adjusted for inflation, the 2009 estimate represents a $6 billion or 1.7% decline from 2008.
- The 2009 slowdown primarily reflects a drop in business R&D in the face of the 2008–09 financial crisis and the economic recession. At the same time, R&D spending in other performing sectors continued to rise, notably for federal and academic R&D, in part because of the one-time federal R&D funding increase appropriated in the American Recovery and Reinvestment Act of 2009.
- U.S. R&D performance has increased largely uninterrupted since 1953. Over the last 5 years (2004–09), annual growth in U.S. R&D spending averaged 5.8%, compared to annual average growth of 3.3% for U.S. gross domestic product (GDP). Indeed, over the last several decades, average annual growth in R&D spending has substantially outpaced that of GDP.

The business sector continues to account for most of both U.S. R&D performance and R&D funding.

- The business sector performed an estimated $282 billion of R&D in 2009, or 71% of the U.S. total, drawing on business, federal sources, and other sources of R&D support. The business sector itself provided an estimated $247 billion of funding for R&D in 2009, or 62% of the U.S. total; almost all of which supported R&D performed by business.
- The levels of business R&D performance and funding were both higher in 2008 than in 2009 ($291 billion and $259 billion, respectively). Even with the decline in 2009, expanded business spending has accounted for most of the nation's R&D growth over the last 5 years.
- The academic sector is the second-largest performer of U.S. R&D, accounting for an estimated $54 billion in 2009, or about 14% of the national total.
- The federal government is the second-largest funder of U.S. R&D, providing an estimated $124 billion, or 31% of the U.S. total in 2009.

U.S. R&D is dominated by development activities, largely performed by the business sector. The business sector also performs the majority of applied research, but most basic research is conducted at universities and colleges and funded by the federal government.

- In 2009, basic research was about 19% ($76 billion) of total U.S. R&D performance, applied research was about 18% ($71 billion), and development was about 63% ($253 billion).
- Universities and colleges historically have been the main performers of U.S. basic research—and accounted for about 53% of all U.S. basic research in 2009. The federal government remains the primary source of basic research funding, accounting for about 53% of all such funding in 2009.
- The business sector is the predominant performer of applied research, accounting for 58% of all U.S. applied research in 2009. Business is also the largest source of funding for applied research, providing 48% in 2009.
- Development is by far the largest component of U.S. R&D. Funding for development comes primarily from the business sector, 78% in 2009; nearly all of the rest comes from the federal government.

R&D and GDP Growth

Treating R&D as an investment, rather than as an expense, affects estimates of GDP growth.

- When R&D is treated as an investment, estimates of average annual GDP growth between 1959 and 2007 are 0.07 points higher than when R&D is treated as an expense.
- The difference in estimated average annual growth is higher in recent periods: 0.17 percentage points for 1995 to 2001 and 0.12 percentage points from 2002 to 2007.

U.S. Business R&D

Domestic R&D performed by the business sector reached $291 billion in 2008.

- More than three-quarters of U.S. business R&D is performed in six industry groups—four in manufacturing (chemicals, computer and electronic products, aerospace and defense, and automotive) and two in services (software and computer-related products, and R&D services).

R&D by Multinational Companies

The majority of R&D by U.S. multinational companies (MNCs) continues to be performed in the United States. Outside the United States, R&D by U.S.-owned foreign affiliates is performed mostly in Western Europe, Canada, and Japan, followed more recently by other locations in the Asia-Pacific region.

- In 2008, U.S. MNC parent companies and their majority-owned foreign affiliates performed $236.1 billion in R&D worldwide, according to the Bureau of Economic Analysis. This included $199.1 billion performed by the parent companies in the United States and $37.0 billion by their majority-owned foreign affiliates.
- The share of R&D performed by Asia-located affiliates (other than in Japan) increased from 5.3% to 14.4% from 1997 to 2008. In particular, the share of U.S.-owned affiliates R&D performed in China, South Korea, Singapore, and India rose from a half percentage point or less in 1997 to 4% for China, just under 3% for South Korea, and just under 2% each for Singapore and India in 2008.
- Majority-owned affiliates of foreign MNCs located in the United States (U.S. affiliates) performed $40.5 billion of R&D in 2008 virtually unchanged from the $41.0 billion they performed in 2007. Since 1999, the share of these companies in total business R&D has fluctuated narrowly between 13% and 15%.

Exports and Imports of R&D-Related Services

Trends in cross-border transactions in research, development, and testing (RDT) services are another indicator of global linkages.

- In 2009, U.S. RDT exports and imports stood at $18.2 billion and $15.8 billion, respectively, for a balance of $2.5 billion.
- In 2008, the proportion of RDT exports ($17.4 billion) to domestic U.S. business R&D performance ($290.7 billion) was 5.6%. This proportion was about 3.8% in 2001.
- Most transactions in RDT services—around 85% of total annual RDT exports—occur within multinational companies.

Federal R&D

Federal spending on R&D has continued to grow, although at a slower pace, when adjusted for inflation, in the last several years. Defense continues to account for more than half of annual federal R&D spending. Health-related R&D accounts for the majority of federal nondefense R&D.

- Eight federal agencies accounted for 97% of federal R&D spending in FY 2009: the departments of Commerce, Defense, Energy, Health and Human Services, and Homeland Security, and the National Science Foundation and National Air and Space Administration. Federal obligations for R&D have increased annually since the late 1990s. When adjusted for inflation, growth has been flatter after FY 2005.
- In FY 2009, federal obligations for R&D reached $133.3 billion and an additional $3.6 billion for R&D plant. The American Recovery and Reinvestment Act of 2009 obligated an additional $8.7 billion for R&D and $1.4 billion for R&D plant for the same fiscal year.
- In the last 10 years, federal funding for basic and applied research has grown faster in the life sciences, mathematics/computer sciences, and psychology than in other fields. In the environmental sciences, growth has not kept pace with inflation.
- Over the last two decades, the greatest change in federal R&D priorities has been the rise in health-related R&D, which currently accounts for just over half of nondefense R&D spending.

Federal R&E Tax Credit

To counteract potential business underinvestment in R&D, the federal government makes available tax credits for companies that expand their R&D activities.

- Business research and experimentation (R&E) tax credit claims were about $8.3 billion both in 2007 and in 2008.
- Five industries accounted for 75% of R&E credit claims in 2008: computer and electronic products; chemicals, including pharmaceuticals and medicines; transportation equipment, including motor vehicles and aerospace; information, including software; and professional, scientific, and technical services, including computer and R&D services.

International R&D Comparisons

The top three R&D-performing countries: United States, China—now the second largest R&D performer—and Japan represented just over half of the estimated $1.28 trillion in global R&D in 2009.

- The United States, the largest single R&D-performing country, accounted for about 31% of the 2009 global total, down from 38% in 1999.
- Asian countries—including China, India, Japan, Malaysia, Singapore, South Korea, Taiwan, and Thailand—represented 24% of the global R&D total in 1999 but accounted for 32% in 2009, including China (12%) and Japan (11%).

- The pace of real growth over the past 10 years in China's overall R&D remains exceptionally high at about 20% annually.
- The European Union accounted for 23% total global R&D in 2009, down from 27% in 1999.

Wealthy economies generally devote larger shares of their GDP to R&D than do less developed economies.

- The U.S. R&D/GDP ratio (or R&D intensity) was about 2.9% in 2009 and has fluctuated between 2.6% and 2.8% during the past 10 years, largely reflecting changes in business R&D spending.
- In 2009, the United States ranked eighth in R&D intensity—surpassed by Israel, Sweden, Finland, Japan, South Korea, Switzerland, and Taiwan—all of which perform far less R&D annually than the United States.
- Among the top European R&D-performing countries, Germany reported a 2.8% R&D/GDP ratio in 2008; France, 2.2%; and the United Kingdom, 1.9%.
- The Japanese and South Korean R&D/GDP ratios were among the highest in the world in 2008, each at about 3.3%. China's ratio remains relatively low, at 1.7%, but has more than doubled from 0.8% in 1999.

Introduction

Research and development activities are an important input to commercial innovation and the objectives of government agencies. R&D is part of a class of intangible inputs that also include software, higher education, and worker training. Intangibles are at least as important sources of long-term economic growth as are physical investments in machinery, equipment, and other infrastructure (Corrado et al. 2006; Jorgenson 2007; Van Ark and Hulten 2007). Indeed, the America COMPETES Act[1] specifically recognizes the role of innovation, STEM education, entrepreneurship, and technology transfer based on federally performed or funded R&D in strengthening U.S. competitiveness.

This chapter focuses on R&D, presenting data on public and private funding and performance in the United States. It also examines related international investments or transactions involving R&D financing or performance.

Chapter Organization

This chapter is organized into eight main sections. A section on trends in national R&D performance is followed by four sections on the business sector. Business R&D, the second section, covers domestic R&D in detail. The third section covers foreign operations of U.S.-owned companies. The fourth section examines R&D by U.S. multinational companies (MNCs) and foreign-owned MNCs with U.S. activities, and the fifth describes international transactions in R&D services.

The sixth section presents patterns of federal government R&D, including mission areas such as defense, energy, and health, and concludes with federal tax incentives for business R&D. This is followed by a section on selected federal programs to aid small businesses and activities in technology transfer and commercialization.

The eighth and last section discusses international comparisons of R&D, including national R&D expenditures by performer and source (including universities), national R&D intensities, and government R&D priorities across member countries of the Organisation for Economic Cooperation and Development (OECD). The chapter also includes two appendix tables (appendix tables 4-1 and 4-2) that contain information on how R&D comparisons across time and among different countries can be made.

Trends in National R&D Performance

The U.S. R&D system consists of a variety of performers and sources of funding, including businesses, the federal government, universities and colleges, other (nonfederal) government, and nonprofit organizations. Organizations that perform R&D often receive significant levels of outside funding; those that fund R&D may also be significant performers. (See sidebar, "Measured and Unmeasured R&D.") The discussion throughout this section examines current levels and key trends in U.S. R&D performance and funding (see Glossary for definitions).[2] Supporting this section is a series of appendix tables (appendix tables 4-3 through 4-10) that report core data on U.S. national patterns of R&D funding and performance.

Trends in U.S. R&D Performance and R&D Intensity

Overall spending on R&D conducted in the United States in calendar year 2009 is estimated to have totaled $400.5 billion, somewhat below the 2008 level of $403.0 billion, but well above the $377.0 billion in 2007 (current dollars) (table 4-1). Adjusted for inflation, the 2009 level is a $6 billion or 1.7% decline from 2008.[3]

The 2009 spending slowdown primarily reflects a drop in business R&D in both current and constant dollars in the face of the 2008–09 financial crisis and economic recession. However, R&D spending in other sectors continued to rise, in both current and constant dollar terms. Some of this was the effect—notably for federal and academic R&D and R&D infrastructure—of the one-time $18.3 billion funding increase appropriated in the American Recovery and Reinvestment Act of 2009 (ARRA, Public Law 111-5, enacted in February 2009).

The 2009 slowdown in spending growth notwithstanding, increases in national R&D spending have occurred largely uninterrupted since 1953 in both current and real dollars (figure 4-1). U.S. R&D spending crossed the $100 billion (current dollars) threshold in 1984, passed $200 billion in 1997, exceeded $300 billion in 2004, and was at or above $400 billion in both 2008 and 2009.

The year-over-year rate of R&D funding growth outpaced that of gross domestic product in each of the last 3 years—even during the economic downturn (table 4-2). Over the last 5 years (2004–09), annual growth in the total of R&D spending averaged 5.8%, compared to GDP at 3.3%. And, similarly, growth in total R&D spending outpaces that of GDP when the averaging period is either 10 or 20 years. The same relative findings prevail when the dollars are adjusted for inflation (table 4-2).

R&D intensity—a country's national R&D expenditures expressed as a percentage of its GDP—provides another gauge of overall national R&D performance and is a widely used target-setting tool internationally.

In 2009, the U.S. R&D/GDP ratio was nearly 2.9%, rising from around 2.8% in 2008 and 2.7% in 2007 (figure 4-2). The ratio has ranged from 1.4% in 1953 to a high of nearly 2.9% in 1964 and has fluctuated in the range of 2.1% to 2.8% in the subsequent years.

Most of this continuity in the U.S. R&D/GDP ratio reflects the growth in nonfederal R&D spending, which rose from about 0.6% of GDP in 1953 to just below 2.0% in the last several years. The increase reflects the growing role of business R&D in the national R&D system and, more broadly, the growing prominence of R&D-derived goods and services in the national and global economies.

The peaks and valleys in the U.S. R&D/GDP ratio also reflect changing federal R&D priorities. The ratio's drop from its peak in 1964 resulted largely from federal cutbacks in defense and space R&D programs. From 1975 to 1979, gains in energy R&D activities worked to keep the ratio stable. Beginning in the late 1980s, cuts in defense-related R&D lowered the federal R&D/GDP ratio, which was counterbalanced by a steady or rising nonfederal ratio. Since 2000, increased federal spending for, notably, defense and biomedical research have helped to push upward the federal ratio.

Performers of R&D

The National Science Foundation (NSF) tracks the R&D spending patterns of all the major performers in the overall U.S. R&D system: businesses, intramural R&D activities of federal agencies, federally funded R&D centers (FFRDCs), universities and colleges, and other nonprofit organizations. For state-level detail see sidebar, “Location of R&D Performance by State” and chapter 8.

Measured and Unmeasured R&D

The statistics on U.S. R&D discussed in this section reflect the National Science Foundation’s periodic National Patterns of R&D Resources reports and data series with a comprehensive account of total U.S. R&D performance. The National Patterns data, in turn, derive from five major NSF surveys of organizations that perform the bulk of U.S. R&D. These are:

- ♦ Survey of Federal Funds for R&D
- ♦ Survey of R&D Expenditures at Federally Funded R&D Centers
- ♦ Business R&D and Innovation Survey
- ♦ Survey of R&D Expenditures at Universities and Colleges
- ♦ Survey of R&D Funding and Performance by Nonprofit Organizations

National Patterns integrates the R&D spending and funding data from these separate surveys into U.S. R&D totals, which are calculated on a calendar-year basis, disaggregated for the main performing sectors and funding sources. Due to practical constraints, some elements of R&D performance are omitted from the U.S. totals. In evaluating R&D performance trends over time and in international comparisons, it is important to be aware of these omissions.

To reduce cost and respondent burden, the U.S. business R&D estimates are derived from a survey of R&D-performing companies with five or more employees. Accordingly, no estimates of R&D performance currently are available for companies with fewer than five employees. (NSF is currently working on the design and implementation of a Microbusiness Innovation and Science and Technology (MIST) Survey, which will collect data from companies with fewer than five employees.)

Social science R&D had, until 2008, been excluded from the U.S. business R&D statistics. R&D in the humanities and other non-S&E fields (such as law) has been excluded from the U.S. academic R&D statistics. (Other countries include both in their national statistics, making their national R&D expenditures relatively larger when compared with those of the United States.) Changes are now underway in both these respects in the U.S. surveys. NSF’s new U.S. Business R&D and Innovation Survey (see BRDIS sidebar later in this chapter), fielded for the first time in 2009 (to collect 2008 data), now includes social science R&D ($1.2 billion in 2008) and will also better capture the full range of business R&D funded by others. NSF is also now fielding a redesigned Higher Education R&D Survey (starting with the 2010 academic fiscal year), which will include non-S&E R&D expenditures in the reported totals.

The statistics for academic R&D track research expenditures that are separately budgeted and accounted (notably, sponsored research). But U.S. universities generally do not maintain records for the “departmental research” performed by faculty, which then cannot be included in the academic R&D totals. This can be a significant limitation in international R&D comparisons, as department research estimates are often included in the national statistics of other countries. (For a further discussion, see sidebar “Government Funding Mechanisms for Academic Research” later in this chapter.)

Likewise, the activity of individuals performing R&D on their own time and not under the auspices of a corporation, university, or other organization is omitted from official U.S. R&D statistics.

Statistics on R&D performance by state governments had only been sporadically collected until 2006 and 2007, when NSF and the U.S. Census Bureau first fielded a survey on this topic (now being conducted every 2 years; state government R&D performance totals only several hundred million dollars annually). Finally, NSF has not fielded a full survey on R&D performance by nonprofit organizations since 1998—the National Patterns performance figures for this sector in the national R&D totals are estimated.

The National Center for Science and Engineering Statistics has commissioned the National Research Council’s Committee on National Statistics (CNSTAT) to form a panel to review the methodologies used in developing the National Patterns dataset. The panel began work in mid-2011.

Business Sector

The business sector is by far the largest performer of U.S. R&D. R&D performed by businesses in the United States totaled an estimated $282.4 billion in 2009 (table 4-1), about 71% of total U.S. R&D (figure 4-3). This predominance of the business sector has long been the case (figure 4-4), with shares of national R&D performance ranging from 69% to 75% over the course of the last 20 years. The business sector is also the nation's largest R&D funder, accounting for about 62% of the U.S. total.

Table 4-1
U.S. R&D expenditures, by performing sector and source of funding: 2004–09

Sector	2004	2005	2006	2007	2008	2009
	Current $millions					
All performing sectors	302,503	324,993	350,162	376,960	403,040	400,458
Business	208,301	226,159	247,669	269,267	290,681	282,393
Federal government	37,685	39,568	41,611	43,906	44,674	46,151
Federal intramural[a]	24,898	26,322	28,240	29,859	29,839	30,901
FFRDCs	12,788	13,246	13,371	14,047	14,835	15,250
Industry administered[b]	2,485	2,601	3,122	5,165	6,346	6,446
U&C administered[b]	7,659	7,817	7,306	5,567	4,766	4,968
Nonprofit administered	2,644	2,828	2,943	3,316	3,724	3,835
Universities and colleges	43,122	45,190	46,955	49,010	51,650	54,382
Other nonprofit organizations	13,394	14,077	13,928	14,777	16,035	17,531
All funding sectors	302,503	324,993	350,162	376,960	403,040	400,458
Business	191,266	207,680	227,057	246,679	258,626	247,357
Federal government	91,656	96,276	100,768	105,822	117,611	124,432
Universities and colleges	7,936	8,578	9,285	9,959	10,707	11,436
Nonfederal government	2,883	2,922	3,021	3,265	3,518	3,675
Other nonprofit organizations	8,761	9,538	10,031	11,235	12,578	13,559
	Constant 2005 $millions					
All performing sectors	312,548	324,993	339,202	354,864	371,184	364,951
Business	215,218	226,159	239,917	253,484	267,706	257,355
Federal government	38,937	39,568	40,308	41,332	41,143	42,059
Federal intramural[a]	25,724	26,322	27,356	28,109	27,480	28,161
FFRDCs	13,212	13,246	12,953	13,224	13,663	13,897
Industry administered[b]	2,568	2,601	3,024	4,862	5,844	5,875
U&C administered[b]	7,913	7,817	7,078	5,241	4,389	4,528
Nonprofit administered	2,732	2,828	2,851	3,121	3,429	3,495
Universities and colleges	44,554	45,190	45,485	46,137	47,568	49,561
Other nonprofit organizations	13,839	14,077	13,492	13,911	14,767	15,977
All funding sectors	312,548	324,993	339,202	354,864	371,184	364,951
Business	197,617	207,680	219,950	232,220	238,184	225,425
Federal government	94,700	96,276	97,614	99,619	108,315	113,399
Universities and colleges	8,200	8,578	8,995	9,375	9,861	10,422
Nonfederal government	2,979	2,922	2,926	3,074	3,240	3,349
Other nonprofit organizations	9,052	9,538	9,717	10,576	11,584	12,356

FFRDC = federally funded research and development center; U&C = universities and colleges

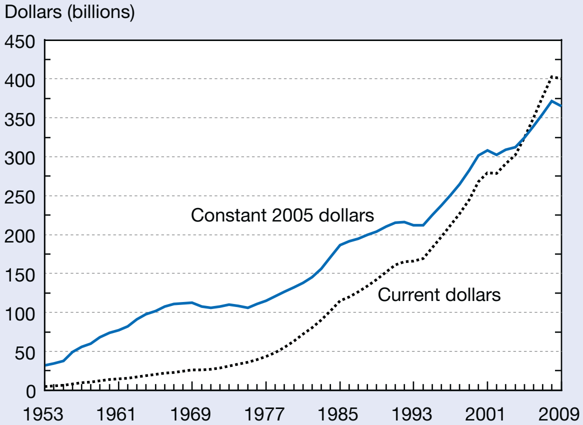
[a] Includes expenditures of federal intramural R&D and costs associated with administering extramural R&D.
[b] Los Alamos National Laboratory (approximately $2 billion in annual R&D expenditures in recent years) became industry administered in June 2006; previously, it was U&C administered. Lawrence Livermore National Laboratory (more than $1 billion in annual R&D expenditures in recent years) became industry administered in October 2007; previously, it was U&C administered. These shifts in administration category are a main reason for the changes apparent in the R&D performer figures across 2006, 2007, and 2008.

NOTES: Data are based on annual reports by performers except for the nonprofit sector. Expenditure levels for academic and federal government performers are calendar-year approximations based on fiscal year data. For federal government expenditures, the approximation is equal to 75% of the amount reported in the same fiscal year plus 25% of the amount reported in the subsequent fiscal year. For academic expenditures, the respective percentages are 50 and 50, because those fiscal years generally begin on July 1 instead of October 1. Some of the figures for other nonprofit organizations are estimated and may later be revised.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources (annual series). See appendix tables 4-3 and 4-7.

Science and Engineering Indicators 2012

Figure 4-1
U.S. total R&D expenditures: 1953–2009

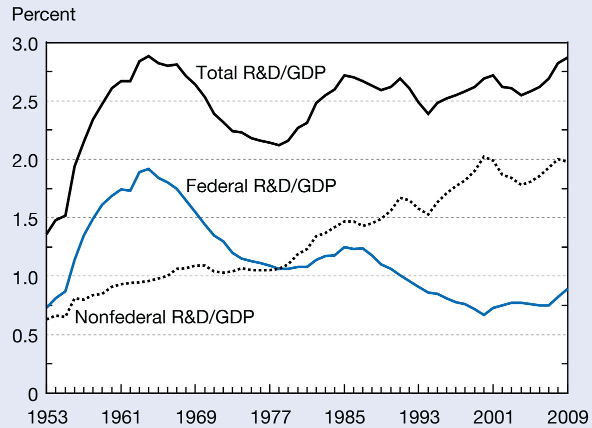


NOTE: Some figures involve estimates and may later be revised.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources (annual series). See appendix table 4-3.

Science and Engineering Indicators 2012

Figure 4-2
Ratio of U.S. R&D to gross domestic product, roles of federal and nonfederal funding for R&D: 1953–2009



GDP = gross domestic product

NOTES: Some figures involve estimates and may later be revised. Federal R&D/GDP ratios represent the federal government as a funder of R&D by all performers; the nonfederal ratios reflect all other sources of R&D funding.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources (annual series).

Science and Engineering Indicators 2012

Table 4-2
Annual rates of growth in U.S. R&D expenditures, total and by performing sectors: 1989–2009
(Percent)

	Longer term trend			Most recent years		
Expenditures and gross domestic product	1989–2009	1999–2009	2004–09	2006–07	2007–08	2008–09
	Current dollars					
Total R&D, all performers	5.3	5.0	5.8	7.7	6.9	-0.6
Business	5.3	4.5	6.3	8.7	8.0	-2.9
Federal government	3.6	5.7	4.1	5.5	1.8	3.3
Federal intramural[a]	3.6	5.6	4.4	5.7	-0.1	3.6
FFRDCs	3.6	5.8	3.6	5.1	5.6	2.8
Universities and colleges	6.4	6.8	4.7	4.4	5.4	5.3
Other nonprofit organizations	8.1	7.9	5.5	6.1	8.5	9.3
Gross domestic product	4.8	4.1	3.3	4.9	1.9	-2.5
	Constant 2005 dollars					
Total R&D, all performers	2.9	2.6	3.1	4.6	4.6	–1.7
Business	3.0	2.1	3.6	5.7	5.6	–3.9
Federal government	1.3	3.2	1.6	2.5	–0.5	2.2
Federal intramural[a]	1.3	3.2	1.8	2.8	–2.2	2.5
FFRDCs	1.3	3.3	1.0	2.1	3.3	1.7
Universities and colleges	4.0	4.3	2.2	1.4	3.1	4.2
Other nonprofit organizations	5.7	5.4	2.9	3.1	6.2	8.2
Gross domestic product	2.4	1.7	0.7	1.9	–0.3	–3.5

[a]Includes expenditures of federal intramural R&D as well as costs associated with administering extramural R&D.

NOTE: Longer term trend rates are calculated as compound annual growth rates.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources (annual series).

Science and Engineering Indicators 2012

A decline of business R&D performance from $290.7 billion in 2008 to $282.4 billion in 2009 was the first such year-to-year decline since 2002. Nevertheless, business R&D performance rose on average (table 4-2) at 6.3% annually from 2004 to 2009, outpacing the growth rates of both total U.S. R&D (5.8%) and gross domestic product (3.3%). After adjusting for inflation, business R&D grew at a 3.6% annual rate, total R&D at 3.1%, and U.S. GDP at 0.7%).

Universities and Colleges

Universities and colleges performed $54.4 billion of R&D in 2009 (table 4-1). This was almost 14% of total U.S. R&D spending that year, making academia the second-largest performer of U.S. R&D (figure 4-3).

Academic R&D spending increased in each of the last 5 years (in both current dollars and constant dollars). The academic share in total U.S. R&D has ranged between 11% and 14% over the past 20 years.

Universities and colleges have a special niche in the nation's R&D system: they performed more than half (53%) of the nation's basic research in 2009. Academic institutions also rely much more extensively than the business sector on external sources of funding, particularly the federal government, at about 60%, to support the R&D they perform. (See chapter 5 for an extensive analysis of academic R&D.)

Location of R&D Performance by State

Distribution of R&D expenditures among the U.S. states

In 2008, the 10 states with the largest R&D expenditure levels accounted for about 62% of U.S. R&D expenditures that can be allocated to the states: California, New Jersey, Texas, Massachusetts, Washington, New York, Maryland, Michigan, Pennsylvania, and Illinois (table 4-A).* California alone accounted for 22% of the U.S. total, exceeding the next-highest state, Massachusetts, by almost 4 times. The top 20 states accounted for 84% of the R&D total; the 20 lowest-ranking states, around 5% (see appendix tables 4-11 and 4-12).

The states with the biggest R&D expenditures are not necessarily those with the greatest relative concentration of R&D. Among those with the highest R&D/GDP ratios in 2008 were New Mexico, the District of Columbia, Maryland, and Massachusetts (table 4-A). New Mexico is the location of a number of major government research facilities. The District of Columbia is home to major federal science and technology agencies with intramural research labs and R&D management activities. Maryland is also the site of many government research facilities and growing research universities. Massachusetts benefits from both leading research universities and thriving high-technology industries. California has relatively high R&D intensity, but nonetheless is ninth from the top. (Chapter 8 provides additional information on R&D related activities in the states.)

U.S. R&D performance by sector and state

The proportion of R&D performed by each of the main R&D-performing sectors (business, universities and colleges, federal intramural and FFRDCs) varies across the states, but the states that lead in total R&D also tend to be well represented in each of these sectors (table 4-A).

In 2008, R&D performed by the business sector accounted for about 73% of the U.S. R&D total that could be allocated to specific states. Of the top 10 states in total R&D performance, 9 are also in the top 10 in industry R&D. Connecticut, 8th in business-sector R&D and home to substantial pharmaceutical R&D activity, surpasses Maryland in the business R&D ranking.

University-performed R&D accounts for 14% of the allocable U.S. total and mirrors the distribution of overall R&D performance. Only New Jersey and Washington fall out of the top 10 total R&D states, replaced by North Carolina and Ohio.

Federal R&D performance (including both intramural and FFRDCs)—about 12% of the U.S. total—is more concentrated geographically than that in other sectors. Only 5 states—Maryland, California, New Mexico, the District of Columbia, and Virginia—account for 65% of all federal R&D performance.** This figure rises to 80% when the other 5 of the top 10 states—Massachusetts, Tennessee, Washington, Illinois, and Alabama—are included.

Federal R&D accounts for the bulk of total R&D in several states, including New Mexico, which is home to the nation's two largest FFRDCs (Los Alamos and Sandia National Laboratories) and Tennessee (36%) home to Oak Ridge National Laboratory. The high figures for Maryland (55%), the District of Columbia (80%), and Virginia (37%) reflect the concentration of federal facilities and federal R&D administrative offices in the national capital area.

---

* The latest data available on the distribution of U.S. R&D performance by state are for 2008. Total U.S. R&D expenditures that year are estimated at $403.0 billion. Of this total, $372.7 billion could be attributed to one of the 50 states or the District of Columbia. This state-attributed total differs from the U.S. total for a number of reasons: some business R&D expenditures cannot be allocated to any of the 50 states or the District of Columbia because respondents did not answer the question related to location; nonfederal sources of nonprofit R&D expenditures (an estimated $8.4 billion in 2008) could not be allocated by state; state-level university R&D data have not been adjusted for double-counting of R&D passed from one academic institution to another; and state-level university and federal R&D performance data are not converted from fiscal to calendar years.

** Federal intramural R&D includes costs associated with the administration of intramural and extramural programs by federal personnel, as well as actual intramural R&D performance. This is a main reason for the large amount of federal intramural R&D in the District of Columbia.

Location of R&D Performance by State—continued

Table 4-A

Top 10 U.S. states in R&D performance, by sector and intensity: 2008

	All R&D[a]		Sector ranking			R&D intensity (R&D/GDP ratio)		
Rank	State	Amount (current $millions)	Business	U&C	Federal intramural and FFRDC[b]	State	R&D/GDP (%)	GDP (current $billions)
1	California	81,323	California	California	Maryland	New Mexico	7.58	78.0
2	New Jersey	20,713	New Jersey	New York	California	District of Columbia	6.15	96.8
3	Texas	20,316	Texas	Texas	New Mexico	Maryland	5.92	280.5
4	Massachusetts	20,090	Massachusetts	Maryland	District of Columbia	Massachusetts	5.53	363.1
5	Washington	16,696	Washington	Pennsylvania	Virginia	Connecticut	5.10	222.2
6	Maryland	16,605	Michigan	Massachusetts	Massachusetts	Washington	4.96	336.3
7	New York	16,486	New York	North Carolina	Tennessee	New Jersey	4.28	484.3
8	Michigan	15,507	Connecticut	Illinois	Washington	New Hampshire	4.24	58.8
9	Pennsylvania	13,068	Pennsylvania	Ohio	Illinois	California	4.22	1,925.5
10	Illinois	11,961	Illinois	Michigan	Alabama	Michigan	4.12	376.2

FFRDC = federally funded research and development center; GDP = gross domestic product; U&C = universities and colleges

[a]Includes in-state total R&D performance of business sector, universities and colleges, federal agencies, FFRDCs, and federally financed nonprofit R&D.
[b]Includes costs associated with administration of intramural and extramural programs by federal personnel and actual intramural R&D performance.

NOTES: Small differences in parameters for state rankings may not be significant. Rankings do not account for the margin of error of the estimates from sample surveys.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources (annual series). State GDP data are from the U.S. Bureau of Economic Analysis. See appendix tables 4-11 and 4-12.

Science and Engineering Indicators 2012

Federal Agencies and FFRDCs

R&D performed by the federal government includes the activities of agency intramural research laboratories and federally funded research and development centers (FFRDCs). The figures for intramural R&D also include expenditures for agency planning and administration of both intramural and extramural R&D projects. Federal agencies' intramural R&D performance is funded entirely by the federal government. FFRDCs are R&D-performing organizations that are exclusively or substantially financed by the federal government. An FFRDC is operated to provide R&D capability to serve agency mission objectives or, in some cases, to provide major facilities at universities for research and associated training purposes. Each FFRDC is administered by an industrial firm, a university, a nonprofit institution, or a consortium.

R&D spending by federal intramural labs and FFRDCs was $46.2 billion in 2009, about 12% of all U.S. R&D (table 4-1). Of this amount, $30.9 billion (8% of all U.S. R&D) was intramural and $15.3 billion (4%) was R&D by FFRDCs.

Spending on this federal R&D performance grew rapidly from 2001 to 2003, primarily reflecting increased defense spending following the terrorist attacks in the United States on September 11, 2001. A slower pace of growth has prevailed, however, since then.

The volume of the federal government's R&D performance is small compared with that of the U.S. business sector. Nonetheless, the $46.2 billion performance total in 2009 exceeds domestic R&D expenditures of every country except Japan, China, and Germany. And this figure does not include government investments in R&D infrastructure and equipment, which support the maintenance and operation of unique research facilities and the conduct of research activities that would be too costly or risky for a single company or university to undertake.

Other Nonprofit Organizations

R&D performed in the United States by nonprofit organizations other than universities and certain FFRDCs is estimated at $17.5 billion in 2009. This amount represents just over 4% of all U.S. R&D in that year, a share that has been fairly stable since 2000.

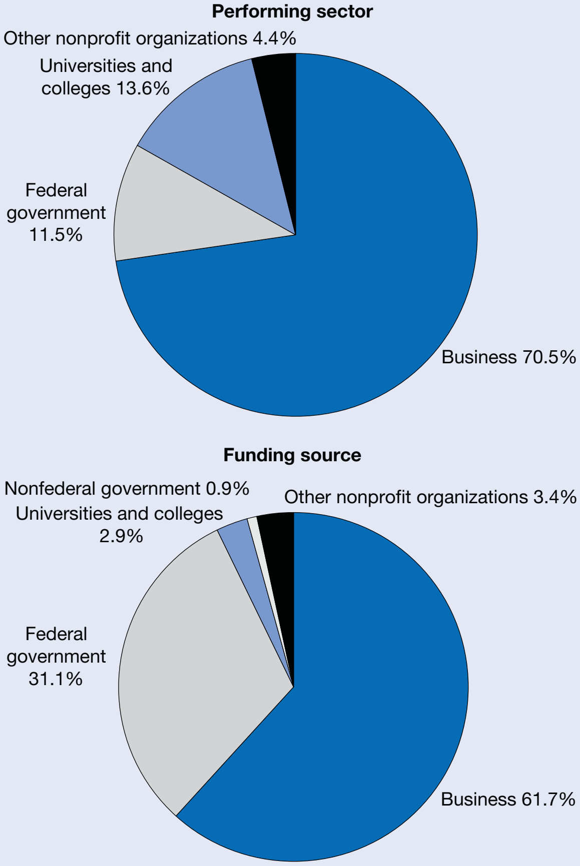
Sources of R&D Funding

Funds that support the conduct of R&D in the United States come from a variety of sources, including businesses, federal and other governments, academic institutions, and other nonprofit organizations. The mix of funding sources varies by performer.

R&D Funding by Business

The business sector, the largest performer of U.S. R&D, is also its largest funder, at about $247.4 billion in 2009 or about 62% of the U.S. total (table 4-1, figure 4-3), virtually all in support of business R&D.[4] The business sector's predominant role in funding R&D began in the early 1980s, when its support began to exceed 50% of all U.S. R&D funding (figure 4-5)—a share that has continually increased over the last 30 years. Just about all business funding for

Figure 4-3
Shares of U.S. total R&D expenditures, by performing sector and funding source: 2009

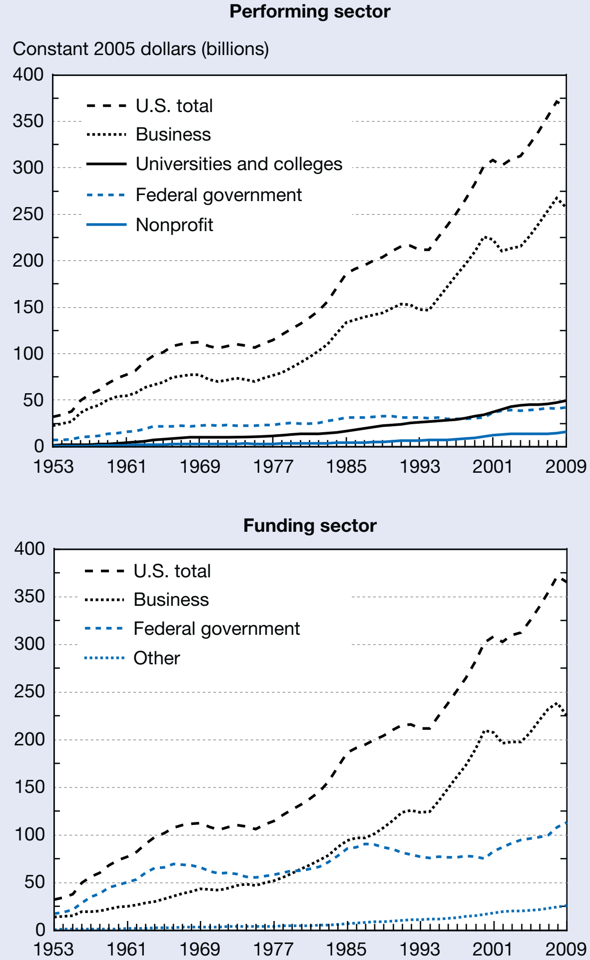


NOTES: Some figures involve estimates and may later be revised. National R&D expenditures are estimated to be $400.5 billion in 2009. Federal performing sector includes federal agencies and federally funded research and development centers. State and local government support to business is included in business support for business performance.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources (annual series). See appendix tables 4-3 and 4-7.

Science and Engineering Indicators 2012

Figure 4-4
U.S. R&D, by performing and funding sectors: 1953–2009



NOTES: Some figures involve estimates and may later be revised. Current dollar figures are converted to constant dollars based on the implicit gross domestic product price deflator. Federal performers of R&D include federal agencies and federally funded research and development centers. Other funding includes support from universities and colleges, nonfederal government, and nonprofit organizations. State and local government funding to businesses is included in business support for business R&D performance.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources (annual series). See appendix tables 4-3 and 4-7.

Science and Engineering Indicators 2012

R&D (98%) is directed toward business R&D performance (table 4-3). The small remainder has gone to academic and other nonprofit performers. (For a fuller discussion, see the “U.S. Business R&D” section later in this chapter.)

R&D Funding by the Federal Government

The federal government was once the predominant sponsor of the nation’s R&D, funding some 67% of all U.S. R&D in 1964 (figure 4-5). But the federal share decreased in subsequent years to less than half in 1979 and to a low of 25% in 2000. Changing business conditions and expanded federal funding of health, defense, and counterterrorism R&D pushed it back up above 30% in 2009.

The federal government remains a major source of funds for all U.S. performer sectors except private business, where its role (while not negligible) is substantially overshadowed by business’s own funds.

In 2009, according to the reports of R&D performers,[5] the federal government provided an estimated $124.4 billion (current dollars) of R&D funds, about 31% of all U.S. spending on R&D that year (table 4-1).

In 2009, the largest recipient of federal R&D funding, $46.2 billion, was federal agencies and their FFRDCs (table 4-3). FFRDCs also received about $400 million from nonfederal sources, less than 1% of their total support.

Table 4-3
U.S. R&D expenditures, by performing sector, source of funds, and character of work: 2009

Performing sector and character of work	Source of funds ($millions) Total	Business	Federal government	Universities and colleges	Other nonprofit organizations	Total expenditures (% distribution)
R&D	400,458	247,357	124,431	15,111	13,559	100.0
Business	282,393	242,820	39,573	**	**	70.5
Federal government	46,150	**	46,150	**	**	11.5
Federal intramural	30,901	**	30,901	**	**	7.7
FFRDCs	15,249	**	15,249	**	**	3.8
Industry administered	6,446	**	6,446	**	**	1.6
U&C administered	4,968	**	4,968	**	**	1.2
Nonprofit administered	3,835	**	3,835	**	**	1.0
Universities and colleges	54,383	3,279	31,575	15,111	4,418	13.6
Other nonprofit organizations	17,532	1,258	7,133	**	9,141	4.4
Percent distribution by source	100.0	61.8	31.1	3.8	3.4	–
Basic research	75,970	16,486	40,451	10,800	8,233	100.1
Business	14,784	13,444	1,340	**	**	19.5
Federal government	11,373	**	11,373	**	**	15.0
Federal intramural	5,507	**	5,507	**	**	7.2
FFRDCs	5,866	**	5,866	**	**	7.7
Industry administered	2,550	**	2,550	**	**	3.4
U&C administered	1,808	**	1,808	**	**	2.4
Nonprofit administered	1,508	**	1,508	**	**	2.0
Universities and colleges	40,544	2,344	24,242	10,800	3,158	53.4
Other nonprofit organizations	9,269	698	3,496	**	5,075	12.2
Percent distribution by source	100.0	21.7	53.2	14.2	10.8	–
Applied research	71,330	34,344	30,101	3,535	3,350	100.1
Business	41,055	33,258	7,797	**	**	57.6
Federal government	12,665	**	12,665	**	**	17.8
Federal intramural	8,006	**	8,006	**	**	11.2
FFRDCs	4,659	**	4,659	**	**	6.5
Industry administered	1,930	**	1,930	**	**	2.7
U&C administered	1,289	**	1,289	**	**	1.8
Nonprofit administered	1,440	**	1,440	**	**	2.0
Universities and colleges	11,912	767	6,577	3,535	1,033	16.7
Other nonprofit organizations	5,698	319	3,062	**	2,317	8.0
Percent distribution by source	100.0	48.1	42.2	5.0	4.7	–
Development	253,161	196,527	53,882	776	1,976	100.0
Business	226,554	196,118	30,436	**	**	89.5
Federal government	22,115	**	22,115	**	**	8.7
Federal intramural	17,389	**	17,389	**	**	6.9
FFRDCs	4,726	**	4,726	**	**	1.9
Industry administered	1,967	**	1,967	**	**	0.8
U&C administered	1,872	**	1,872	**	**	0.7
Nonprofit administered	887	**	887	**	**	0.4
Universities and colleges	1,927	168	756	776	227	0.8
Other nonprofit organizations	2,565	241	575	**	1,749	1.0
Percent distribution by source	100.0	77.6	21.3	0.3	0.8	–

** = small to negligible amount, included in other funding sectors

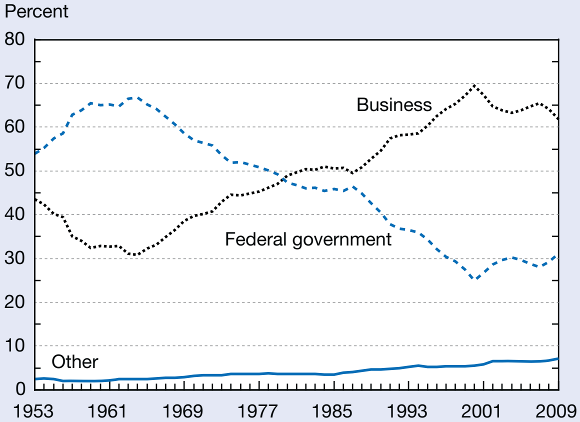
FFRDC = federally funded research and development center; U&C = universities and colleges

NOTES: Funding for FFRDC performance is chiefly federal, but any nonfederal support is included in the federal figures. State and local government support to business is included in business support for business performance. State and local government support to U&C ($3,675 million) is included in U&C support for U&C performance. Some figures for other nonprofit organizations are estimates and may later be revised.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources (annual series). See appendix tables 4-3–4-10.

Science and Engineering Indicators 2012

Figure 4-5
U.S. total R&D expenditures, by source of funding: 1953–2009



NOTES: Some figures involve estimates and may later be revised. Other includes universities and colleges, state and local government, and other nonprofit organizations.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources (annual series). See appendix table 4-7.

Science and Engineering Indicators 2012

The second largest recipient was the business sector, for which, in 2009, the federal government provided $39.6 billion of the $282.4 billion that funded business R&D. Through the early 1960s, more than half of the nation's business R&D had been funded by the federal government. This share fell below 10% by 2000 and had rebounded to 143% by 2009 (appendix table 4-3).

Federal funds to academia provided $31.6 billion (58%) of the $54.4 billion spent on academic R&D in 2009. Of the $17.5 billion spent on R&D by other nonprofit organizations, $7.1 billion (about 41%) was supported by federal funds.

R&D Funding from Other Sources

The balance of R&D funding from other sources is small: $28.6 billion in 2009, or about 7% of all funding. This includes academia's own institutional funds (which support academic institution's own R&D), other nonprofits (the majority of which fund their own R&D, but also contribute to academic research), and state and local governments (primarily for academic research).

Nonetheless, this segment of funding has been growing fairly rapidly for some time. From 1999 to 2009, growth in funding from these sectors averaged 5.4% per year in real-dollar terms—ahead of the pace of funding growth in both the federal and business sectors. Most R&D funded by these nonfederal sources is performed by the academic sector, which also provided about one-fifth of its own total spending on R&D.

R&D by Character of Work

R&D encompasses a range of activities: from fundamental research in the physical, life, and social sciences; to research addressing such critical societal issues as global climate change, energy efficiency, and health care; to the development of platform or general-purpose technologies and new goods and services. Because the activities are so diverse, it helps to classify them in separate categories when analyzing R&D expenditures. The most widely used classifications distinguish among basic research, applied research, and (experimental) development (see definitions in Glossary).[6] Nevertheless, these categories are not always mutually exclusive and any particular R&D activity may have aspects of more than one category.

Basic Research

In 2009, spending on basic research activities amounted to about $76.0 billion (19%) of the $400.5 billion of total U.S. R&D (table 4-4, figure 4-6). The basic research share has gradually moved upward, from about 14% in 1979 to 19% in 2009 (table 4-4).

Universities and colleges continue to occupy a unique position in U.S. basic research. They are the primary performer of U.S. basic research (53% in 2009), while also training the next generation of researchers (table 4-4). The business sector performs nearly 20%; the federal government (agency intramural labs and FFRDC s), 15%; and other nonprofit organizations, 12%.

The federal government remains by far the prime source of funding for basic research, accounting for about 53% of all such funding in 2009 (table 4-3). Universities and colleges themselves provide about 14% of the funding. Other nonprofit organizations provide 11%.

Business's $16.5 billion devoted to basic research is small by comparison to its $247.4 billion of funding for total R&D in 2009, but it still accounted for about 22% of the overall funding for basic research.

Business views about performing basic research involve considerations about the appropriability of results, commercialization risks, and uncertain investment returns. However, involvement in basic research can help boost human capital, attract and retain talent, absorb external knowledge, and strengthen innovation capacity. Businesses that invest most heavily in basic research are those whose new products are most directly tied to ongoing science and technological advances, such as the pharmaceuticals and scientific R&D service sectors.

Applied Research

Applied research activities accounted for about 18% ($71.3 billion) of total U.S. R&D in 2009, modestly under the amount spent on basic research that year (table 4-4). Looking back over two decades, the share of applied research is somewhat lower at present than in the past: 23% 5 years ago, 21% 10 years ago, and 23% 20 years ago.

Table 4-4
U.S. R&D expenditures, by character of work and performing sectors: 1979–2009

Character of work and sector	1979	1989	1999	2004	2009
	$billions				
All R&D	55.4	141.9	245.0	302.5	400.5
Basic	7.8	21.9	38.9	56.1	76.0
Applied	12.1	32.3	52.0	69.2	71.3
Development	35.4	87.7	154.4	177.2	253.2
	Percent distribution				
All R&D	100.0	100.0	100.0	100.0	100.0
Basic	14.1	15.4	15.9	18.5	19.0
Applied	21.8	22.8	21.2	22.9	17.8
Development	63.9	61.8	63.0	58.6	63.2
Basic research	100.0	100.0	100.0	100.0	100.0
Business	13.5	22.0	17.1	14.0	19.5
Federal intramural	14.2	10.5	8.6	8.4	7.2
FFRDCs	14.7	12.9	9.6	8.9	7.7
Universities and colleges	48.9	46.7	54.0	57.0	53.4
Other nonprofit organizations	8.8	7.9	10.8	11.8	12.2
Applied research	100.0	100.0	100.0	100.0	100.0
Business	57.7	69.1	70.4	65.7	57.6
Federal intramural	20.0	11.0	10.6	10.8	11.2
FFRDCs	5.0	3.2	3.2	4.5	6.5
Universities and colleges	11.7	13.0	11.1	13.0	16.7
Other nonprofit organizations	5.6	3.6	4.7	6.1	8.0
Development	100.0	100.0	100.0	100.0	100.0
Business	81.9	82.9	89.9	87.5	89.5
Federal intramural	11.1	10.7	6.0	7.2	6.9
FFRDCs	4.0	4.1	2.1	2.6	1.9
Universities and colleges	1.3	1.4	0.9	1.2	0.8
Other nonprofit organizations	1.7	0.9	1.0	1.5	1.0

FFRDC = federally funded research and development center

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources (annual series).

Science and Engineering Indicators 2012

The business sector performed 58% of all applied research in 2009; the federal government (federal agency intramural labs and FFRDCs), 18%; universities and colleges, another 17%; nonprofit organizations, 8% (table 4-4).

Business provided the bulk of funding for applied research in 2009, 48%. The federal government provided 42%, and academia and other nonprofit organizations each contributed around 5%.

Business sectors that perform relatively large amounts of applied research include chemicals and aerospace. The federal funding is spread broadly across all the performers, with the largest amounts (in 2009) going to federal intramural labs, the business sector, and universities and colleges.

Development

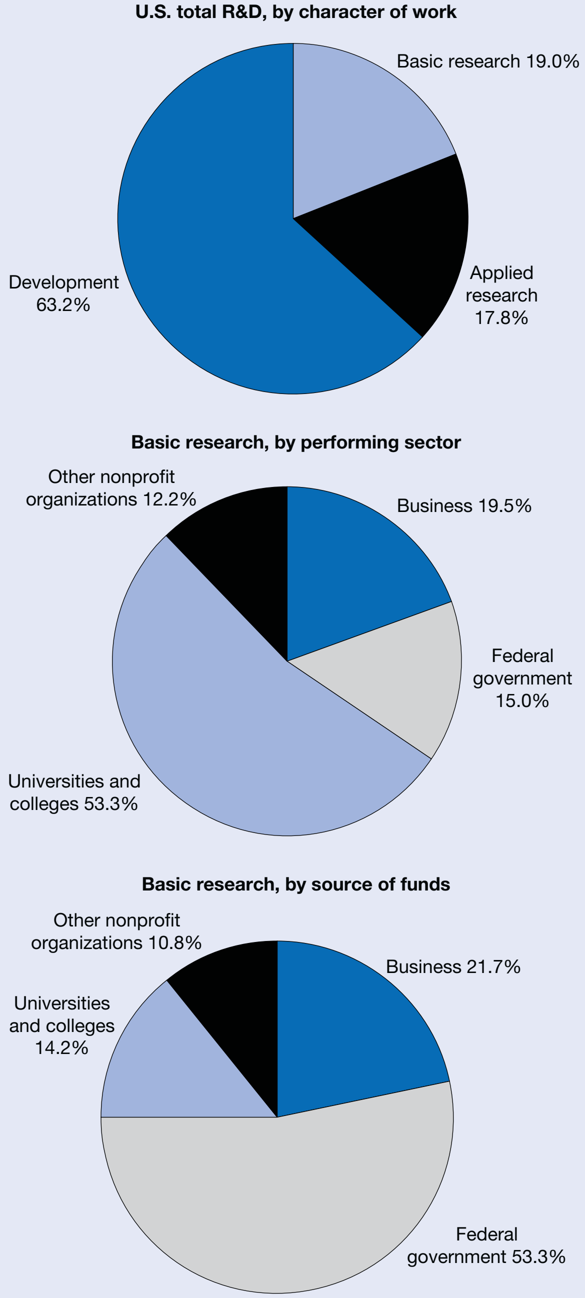
Development, the most sizable component of U.S. R&D, accounted for 63% ($253.2 billion) of total national R&D in 2009 (table 4-4).[7] Development's share of total national R&D has been near or above 60% for several decades.

The business sector performed 90% ($226.6 billion) of this development total, and the federal government (agency intramural labs, FFRDCs), another 9%—much of it defense-related, with the federal government the main consumer. By contrast, academic and other nonprofit organizations perform very little of U.S. development, each performing less than 1% of the total in 2009.

The business sector also provided about three-quarters (78%) of development funding ($196.5 billion) in 2009, nearly all of it in support of business development activities (table 4-3). The federal government provided 21% ($53.9 billion) of the funding, with more than half going to business development—especially in defense-related industries—and most of the remainder going to federal intramural labs and FFRDCs.

Universities and colleges and other nonprofit organizations provide small amounts of funding to support development performance in their own sectors.

Figure 4-6
U.S. R&D by character of work, basic research by performing sector, and basic research by source of funds: 2009



NOTES: Some figures involve estimates and may later be revised. National R&D expenditures estimated at $400.5 billion in 2009. National basic research expenditures estimated at $76.0 billion in 2009. Federal performers include federal agencies and federally funded research and development centers. State and local government support to industry included in industry support for industry performance. State and local government support to universities and colleges included in universities and colleges support of universities and college performance.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources (annual series). See appendix tables 4-3, 4-6, and 4-8.

Science and Engineering Indicators 2012

R&D, GDP Growth, and Innovation-Related Metrics

Intangible inputs such as R&D are important sources of long-term economic growth (Corrado et al. 2006; Jorgenson 2007; Van Ark and Hulten 2007). The role of R&D in U.S. GDP has been estimated based on a methodology published in the Bureau of Economic Analysis (BEA)/NSF R&D Satellite Account (Lee and Schmidt 2010). This methodology treats R&D as an investment rather than as an expense. Using this methodology, a preliminary estimate of R&D on inflation-adjusted GDP from 1959 to 2007 suggests faster average annual GDP growth of 0.07 percentage point over treatment of R&D as an expense.[8]

Over this period, the difference in average growth estimates using these two methodologies was higher in the immediate post-War boom, dropped to almost zero from 1974 to 1994 (a period that includes the productivity slowdown of the 1970s), and then increased relative to the overall average since 1995—years associated with IT-led productivity growth (Jorgenson et al. 2005b) (table 4-5). For other data developments activities, see sidebar, "Recent Developments in Innovation-Related Metrics."

U.S. Business R&D

Businesses engage in R&D with a variety of objectives and partners on a global basis. Most business R&D is aimed at developing new and improved goods, services, and processes; maintaining or increasing market share; and improving operating efficiency. Such activities reflect firms' perceptions of the market's demand and expectations about the profitability of new or newly applied technology.

Businesses located in the United States, both domestic- and foreign-owned, performed $290.7 billion in R&D in the United States in 2008 (table 4-6).[9] Among these, companies that owned firms outside the United States performed an

Table 4-5
U.S. average annual real GDP growth rates, unadjusted and R&D adjusted: 1959–2007
(Percent)

Period	Unadjusted real GDP[a]	R&D-adjusted real GDP[b]	Difference
1959–2007	3.32	3.39	0.07
1959–73	4.20	4.33	0.13
1974–94......	3.02	3.03	0.01
1995–2001...	3.76	3.93	0.17
2002–07......	2.75	2.87	0.12

GDP = gross domestic product

[a]As published in the national income and product accounts.
[b]Real GDP with R&D treated as investment, deflated by aggregate output price index. Double-counting of R&D software removed.

SOURCE: Bureau of Economic Analysis estimates in Lee and Schmidt (2010).

Science and Engineering Indicators 2012

Recent Developments in Innovation-Related Metrics

Innovation is defined as the introduction of new or significantly improved products (goods or services), processes, organizational methods, and marketing methods in internal business practices or in the open marketplace (OECD/Eurostat 2005). R&D and other intangible investments such as investments in software, higher education, and worker training are key inputs driving innovation. Improved and internationally comparable measurements of these inputs and associated outcomes have been identified as important components in evidence-based policymaking. New analytical and policy questions suggest the need for continuous enhancements (NRC 2005, 2007; OECD 2010c, 2010d). Questions include how innovation addresses ultimate social and economic goals, how it may affect (or be affected by) business cycles (economic downturns and recovery), business dynamics (new or small firms), and globalization (Filippetti and Archibugi 2011; Hasan and Tucci 2010; OECD 2010b, 2010c, 2010d; Stiglitz et al. 2009). Ongoing research and data development initiatives in innovation-related metrics include:

- As part of its Innovation Strategy in support of economic growth and recovery, the OECD* has been working on a measurement agenda for innovation, including links between innovation and macroeconomic performance (OECD 2010c). International statistical manuals have been updated or developed. The latter include an updated United Nations System of National Accounts (SNA) manual (EU et al. 2009), which recognizes R&D and other intangibles as investments or capital assets, and a new OECD Handbook on the treatment of intangibles in national economic accounts (OECD 2010a).
- In the United States, the Commerce Department's Bureau of Economic Analysis and NSF's National Center for Science and Engineering Statistics (NCSES) have jointly developed an R&D Satellite Account** which considers R&D as a capital investment with long-term benefits rather than an expense (that is, it capitalizes R&D). This work will guide the incorporation of R&D in U.S. GDP and other national income and product accounts (NIPAs) in 2013, consistent with the revised SNA manual (Aizcorbe et al. 2009; Jorgenson et al. 2006).
- NCSES's new Business R&D and Innovation Survey covers global activities of U.S.-located companies on a broad range of R&D, employment, intellectual property (IP), technology transfer, and innovation variables. See sidebar, "U.S. Business R&D and Innovation Survey."
- NSF Science of Science and Innovation Policy (SciSIP) program supports theoretical and empirical research designed to advance the scientific basis of science and innovation policy. SciSIP-funded research aims to develop, improve, and expand theories, models, analytical tools, data, and metrics bearing on science policy and innovation.
- STAR METRICS (Science and Technology for America's Reinvestment: Measuring the Effect of Research on Innovation, Competitiveness, and Science) is an interagency project conducted under the auspices of the White House Office of Science Technology and Policy (OSTP).*** It seeks to build an infrastructure to integrate data on R&D inputs, outputs, and outcomes in order to analyze the impacts of science investments (Lane and Bertuzzi 2011).

* http://www.oecd.org/innovation/strategy
** http://www.bea.gov/national/newinnovation.htm
*** https://www.starmetrics.nih.gov; http://scienceofscience policy.net

additional $61.5 billion abroad (appendix table 4-14). This section will also cover details on funding sources (appendix table 4-15).

Domestic R&D Performance and Funding Sources

U.S. business R&D performance can be paid with funds from company-owned units, other businesses not owned by the company, and other external sources. Internal and external funders may be located in the United States or abroad.

U.S. business R&D performance totaled $290.7 billion in 2008, including $232.5 billion (80%) from businesses' own funds and $58.2 billion (20%) paid for by others not owned by the company, regardless of the location of funders (table 4-6).

Companies in manufacturing industries performed $203.8 billion of R&D domestically representing 70% of all business R&D performed in the United States in 2008; nonmanufacturing industries performed $86.9 billion. The split between own company funds and funding by others for manufacturing and nonmanufacturing industries was similar to the split for overall business R&D (about 80% and 20%).

Businesses vary in R&D intensity—how much R&D they do relative to production, value added, or sales—across industry and size. In this section, business R&D intensity is the ratio of domestic R&D performed and paid for by the company to domestic net sales. In 2008, the ratio across all businesses within scope of the Business R&D and Innovation Survey (BRDIS) was 3.0%; 3.5% for manufacturers and 2.2% for companies in nonmanufacturing industries (appendix table 4-16). Some industries have considerably higher R&D intensities, such as the computer and electronic products, chemicals, and information industries (figure 4-7).

Table 4-6
Domestic R&D performed by the company, by industry and company size: 2008
(Millions of U.S. dollars)

Industry and company size	NAICS code	Domestic R&D performance: Total	Paid for by company	Paid for by others
All industries	21–23, 31–33, 42–81	290,681	232,505	58,176
Manufacturing industries	31–33	203,754	164,386	39,368
Nonmanufacturing industries	21–23, 42–81	86,925	68,118	18,807
All companies	21–23, 31–33, 42–81	290,681	232,505	58,176
Small companies (number of domestic employees)[a]	—	58,136	46,395	11,741
5–99	—	33,256	24,890	8,366
100–249	—	14,662	12,933	1,729
250–499	—	10,218	8,572	1,646
Medium and large companies (number of domestic employees)	—	232,544	186,110	46,434
500–999	—	11,886	9,673	2,213
1,000–4,999	—	46,337	39,010	7,327
5,000–9,999	—	24,764	20,358	4,406
10,000–24,999	—	48,737	43,049	5,688
25,000 or more	—	100,820	74,020	26,800

NAICS = North American Industry Classification System

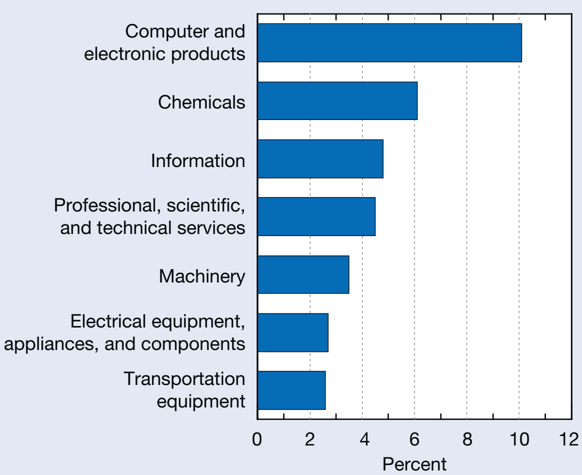
[a]Upper bound based on U.S. Small Business Administration's definition of a small business; Business R&D and Innovation Survey does not include companies with fewer than five domestic employees.

NOTES: Detail may not add to total because of rounding. Industry classification based on dominant business code for domestic R&D performance where available. For companies that did not report business codes, classification used for sampling was assigned.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics and Census Bureau, Business R&D and Innovation Survey (2008).

Science and Engineering Indicators 2012

Figure 4-7
Domestic R&D performed and paid for by the company as a percentage of domestic net sales: 2008



SOURCE: National Science Foundation, National Center for Science and Engineering Statistics and U.S. Census Bureau, Business R&D and Innovation Survey (2008).

Science and Engineering Indicators 2012

Domestic R&D Performance Funded by Others

Of the $58.2 billion (20% of $290.7 billion) in funding by others outside of individual companies, the U.S. federal government accounted for $36.4 billion, independent domestic firms $12.2 billion, and $8.9 billion was funded by companies located outside of the United States (both independent companies and foreign parents). Other nonfederal sources accounted for less than $1 billion.

Federal R&D funding figures prominently in two defense-related industries. The aerospace products and parts industry performed $25.8 billion in federally funded R&D, almost 70% of their $36.9 billion in domestically performed R&D in 2008. The navigational, measuring, electromedical, and control instruments industry performed $3.6 billion in federally funded R&D, almost a quarter of its $15.5 billion of domestic R&D performance (table 4-7 and appendix table 4-15).

Domestic R&D Performance by Size of Company

Small companies, those with 5–499 domestic employees, performed $58.1 billion (20%) of $290.7 billion in U.S. business R&D performance; 80% ($46.4 billion) of the domestic

R&D performance by small companies was paid for with their own funds, the remainder by other business or organizations, regardless of location (table 4-6). The largest companies, those with 25,000 or more domestic employees, performed $100.8 billion (35%) of U.S. business R&D, with 73% of that amount ($74.0 billion) paid for with their own funds.

The domestic operations of small companies were more R&D intensive (6.3%) than the domestic operations of the largest companies (2.3%) in 2008 (appendix table 4-16).[10]

Table 4-7

Sources of funds for domestic R&D performed by the company, by selected industry and company size: 2008

(Millions of U.S. dollars)

Industry and company size	NAICS code	Total	R&D paid for by the company	R&D paid for by others: Total	R&D paid for by others: U.S. federal government	R&D paid for by others: Nonfederal sources[a]
All industries	21–23, 31–33, 42–81	290,681	232,505	58,176	36,360	21,816
Manufacturing	31–33	203,754	164,386	39,368	31,102	8,266
Chemicals	325	58,249	55,042	3,207	197	3,010
Pharmaceuticals and medicines	3254	48,131	45,169	2,962	137	2,825
Other chemicals	other 325	10,118	9,873	245	60	185
Computer and electronic products	334	60,463	52,912	7,551	4,646	2,905
Navigational, measuring, electromedical, and control instruments	3345	15,460	10,463	4,997	3,635	1,362
Other computer and electronic products	other 334	45,003	42,449	2,554	1,011	1,543
Transportation equipment	336	50,552	23,039	27,513	25,941 i	1,572
Aerospace products and parts	3364	36,941	10,371	26,570	25,805 i	765
Other transportation equipment	other 336	13,611	12,668	943	136	807
Other manufacturing	other 31–33	34,490	33,393	1,097	318	779
Nonmanufacturing	21–23, 42–81	86,925	68,118	18,807	5,258	13,549
Professional, scientific, and technical services	54	37,954	20,539	17,415	4,844	12,571
Scientific research and development services	5417	17,913	8,708	9,205	2,115	7,090
Other professional, scientific, and technical services	other 54	20,041	11,831	8,210	2,729	5,481
Other nonmanufacturing	other 21–23, 42–81	48,971	47,579	1,392	414	978
All companies	21–23, 31–33, 42–81	290,681	232,505	58,176	36,360	21,816
Small companies (number of domestic employees)[b]	—	58,136	46,395	11,741	4,117	7,624
5–99	—	33,256	24,890	8,366	2,667	5,699
100–249	—	14,662	12,933	1,729	718	1,011
250–499	—	10,218	8,572	1,646	732	914
Medium and large companies (number of domestic employees)	—	232,544	186,110	46,434	32,243	14,191
500–999	—	11,886	9,673	2,213	747	1,466
1,000–4,999	—	46,337	39,010	7,327	2,162 i	5,165
5,000–9,999	—	24,764	20,358	4,406	1,168	3,238
10,000–24,999	—	48,737	43,049	5,688	3,024	2,664
25,000 or more	—	100,820	74,020	26,800	25,142 i	1,658

i = more than 50% of the estimate is a combination of imputation and reweighting to account for nonresponse

NAICS = North American Industry Classification System

[a]Companies located in the United States funded $12.2 billion; $8.9 billion was funded by companies located outside of the United States, including R&D paid for by the foreign parents of U.S. affiliates. For manufacturing industries, the amounts were $3.4 billion and $4.7 billion, respectively, and for nonmanufacturing industries, $8.7 billion and $4.2 billion, respectively.

[b]Upper bound based on U.S. Small Business Administration's definition of a small business; the Business R&D and Innovation Survey does not include companies with fewer than five domestic employees.

NOTES: Detail may not add to total because of rounding. Industry classification based on dominant business code for domestic R&D performance where available. For companies that did not report business codes, classification used for sampling was assigned.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics and Census Bureau, Business R&D and Innovation Survey (2008).

Science and Engineering Indicators 2012

Largest Domestic R&D-Performing Industries

Business R&D intensity is generally greater in the manufacturing sector (3.5% overall) than in nonmanufacturing (2.2%). Nonetheless, R&D plays a large role in some service industries and R&D intensity in some manufacturing sectors is relatively low (appendix table 4-16).

Six industry groups—four in manufacturing (chemicals, computer and electronic products, aerospace and defense manufacturing, and automotive manufacturing) and two in services (software and computer-related products, and R&D services)—accounted for three-quarters of both 2008 total business R&D performed in the United States ($225.8 billion) and company-funded/company-performed R&D ($173.3 billion) in the United States. They also accounted for 96% ($34.8 billion) of federally funded U.S. business R&D in 2008 (table 4-8).[11]

Chemicals (Including Pharmaceuticals)

The chemical industries accounted for the largest share of business R&D performed in the United States—20% or $58.2 billion of $290.7 billion in 2008 (figure 4-8). Within the chemicals industry, the largest subsector is pharmaceuticals and medicines. In 2008, pharmaceutical companies performed $45.2 billion of company-funded R&D in the United States and $10.9 billion abroad (appendix table 4-14).

Software and Computer-Related Services

Software and computer-related services industries—software publishing, computer systems design and Internet service providers, web search portals and data processing services industries—performed $46.9 billion of domestic R&D in 2008, making it the second largest industry group for domestic R&D performance, and $8.5 billion abroad. The R&D of these industries, 16% of business R&D performance in the United States, combined with that of the computer and electronic product manufacturers (below), accounted for 32% of all business R&D performed in the United States in 2008 (table 4-8). As computing, information technology, and Internet-linked activity has become more integrated with every sector of the economy, the demand for services associated with these technologies has increased.

Computer and Electronic Products

Companies in the computer and electronic product manufacturing industries include producers of communications equipment, semiconductors, computers and computer peripherals, and components for such products.[12] The design and use of integrated circuits and the application of highly specialized miniaturization technologies are common elements in the production processes of the computer and electronic products sector. In 2008, companies in this industry group performed $45.0 billion of R&D, or 15% of all domestic business R&D, and $13.0 billion abroad. Funds for domestic R&D came mostly from the companies themselves ($42.4 billion) and relatively little ($2.6 billion) came from other sources. Two relatively high R&D-intensive 4-digit NAICS (North American Industry Classification System) industries are included in this group, semiconductor and communications equipment manufacturing. Their domestic R&D/domestic sales ratios were 20% and 13%, respectively (appendix table 4-16).

Aerospace and Defense Manufacturing

Although it is common to refer to the "defense industry," the NAICS system does not include such a classification. Thus, to approximate the cost of defense-related R&D, included here are data on aerospace products and parts plus federally funded R&D in the following industries: navigational, measuring, electromedical, and control instruments, as well as other transportation manufacturing industries. Companies in this "defense sector" perform the majority of the Department of Defense's (DOD's) extramural R&D (table 4-8). In 2008, these industries reported performing $40.7 billion of R&D in the United States. Federally funded R&D accounted for 73% ($29.6 billion) of the sector total and 81% of all federally funded business R&D performed in the United States. This total accounts for more than half of the $56.0 billion in DOD outlays for FY 2008 (NSF 2010d).

R&D and Related Services

The R&D and related services group includes companies that provide scientific R&D, engineering, and architectural services to other firms or for their own use.[13] Companies in this group performed $21.3 billion of R&D in the United States during 2008; $10.1 billion paid for from company funds and $11.2 billion paid for by others.[14] Of the $11.2 billion paid for by others, $3.0 billion was funded by the U.S. federal government, the highest amount outside the aerospace and defense manufacturing group (table 4-8).

Automotive Manufacturing

Companies in automotive manufacturing industries reported performing $14 billion of company-funded R&D in 2008, accounting for 5% of all such R&D performed by businesses in the United States (table 4-8). In 2008, out of the about 4,000 companies in the automobiles, bodies, trailers, and parts industries (NAICS 3361, 3362, and 3363), 13 reported domestic R&D performed by the company of $100 million or more, collectively representing 84% of R&D performed by that group of industries.

Business Activities for Domestic R&D

Industry-based data above are the result of classifying each company's R&D in only one industry. However, companies in different industries and even in the same industry perform R&D relating to a variety of different business lines of activities. For example, a company classified as a pharmaceutical company may also perform R&D in medical equipment. A feature of BRDIS is the collection of information on R&D performed by business activity—both R&D paid for by the company and paid for by others. See sidebar,

Table 4-8
Business R&D performed in the United States by the company, paid for by the company and by others, by industry group: 2008
(Millions of U.S. dollars)

Industry	Total	R&D paid for by the company	R&D paid for by others: Total	R&D paid for by others: U.S. federal government	R&D paid for by others: Nonfederal sources
All	290,681	232,505	58,176	36,360	21,816
Highlighted industries	225,813 L	173,318	52,495 L	34,788 L	17,707
Chemicals	58,249	55,042	3,207	197	3,010
Basic chemicals	4,074	4,012	62	33	29
Pharmaceuticals and medicines	48,131	45,169	2,962	137	2,825
Soap, cleaning compound, and toilet preparation	2,108	2,099	9	6	3
Other chemicals	3,936	3,762	174	21	153
Software and computer-related services[a]	46,935	42,727	4,208	961	3,247
Software publishers	28,221	27,665	556	176	380
Computer systems design and related services	12,146	8,569	3,577	784	2,793
Internet service providers, web search portals, and data processing services	6,568	6,493	75	1	74
Computer and electronic products[b]	45,003	42,449	2,554	1,011	1,543
Communications equipment	12,903	11,484	1,419	D	D
Semiconductor and other electronic components	22,324	21,588	736	D	D
Computer and peripheral equipment and other computer and electronic products	9,776	9,377	399	D	D
Aerospace and defense manufacturing[c]	40,712	10,371	30,341 i	29,576 i	765
Aerospace products and parts	36,941	10,371	26,570 i	25,805 i	765
Navigational, measuring, electromedical, and control instruments (U.S. federal government funded only)	3,635	—	3,635	3,635	—
Transportation equipment (U.S. federal government funded only)	136	—	136 i	136 i	—
R&D and related services[d]	21,335	10,086	11,249	3,043	8,206
Architectural, engineering, and related services	3,422	1,378	2,044	928	1,116
Scientific research and development services	17,913	8,708	9,205	2,115	7,090
Automotive manufacturing[e]	13,579 L	12,643	936 L	D	936
Automobiles, bodies, trailers, and parts	13,140 L	12,234	906 L	D	906
Other transportation equipment (not aerospace or defense related)	439 L	409	30 L	D	30
All other	64,868 L	59,187	5,681 L	1,572 L	4,109

D = suppressed to avoid disclosure of confidential information; i = more than 50% of the estimate is a combination of imputation and reweighting to account for nonresponse; L = lower-bound estimate, potential disclosure of individual company operations only allows lower-bound estimates for some industry groups

NAICS = North American Industry Classification System

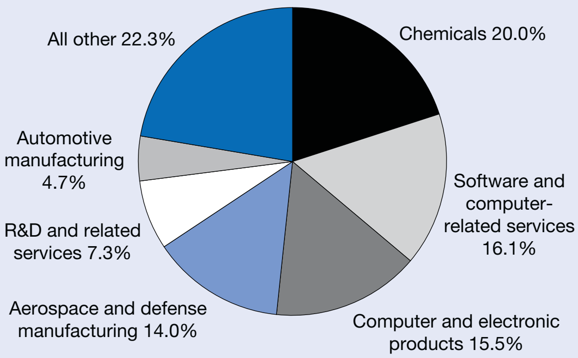
[a]Includes domestic R&D performance for software publishers (NAICS 5112), computer systems design and related service industries (NAICS 5415), and Internet service providers, web search portals, and data processing services (NAICS 518).
[b]Includes domestic R&D performance for the computer and electronics industry (NAICS 334), except for federal R&D for the navigational, measuring, electromedical, and control instruments industry (NAICS 3345), which is included in the aerospace and defense manufacturing sector.
[c]Includes domestic R&D performance for the aerospace products and parts industry (NAICS 3364), plus all federal R&D for the navigational, measuring, electromedical, and control instruments (NAICS 3345) and transportation equipment manufacturing industries.
[d]Includes domestic R&D performance for the architectural, engineering, and related services (NAICS 5413) and scientific R&D services industries (NAICS 5417).
[e]Includes domestic R&D performance for automobiles, bodies, trailers, and parts (NAICS 3361-3363) and transportation equipment (NAICS 336) industries, except federally funded components that are included in the aerospace and defense manufacturing group.

NOTES: Detail may not add to total because of rounding. Industry classification based on dominant business code for domestic R&D performance where available. For companies that did not report business codes, classification used for sampling was assigned.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics and Census Bureau, Business R&D and Innovation Survey (2008).

Science and Engineering Indicators 2012

Figure 4-8
Shares of domestic R&D performed in the United States, by industry group: 2008



SOURCE: National Science Foundation, National Center for Science and Engineering Statistics and U.S. Census Bureau, Business R&D and Innovation Survey (2008).

Science and Engineering Indicators 2012

"U.S. Business R&D and Innovation Survey."[15] The number of these activities is large, as indicated in appendix table 4-17, but most companies performed R&D in only one business activity area. However, some companies, especially large diversified firms, performed R&D in multiple business activity areas. In BRDIS, 92% of companies reported domestic R&D paid for by the company related to only one business activity; 4% related to two business activities, and 4% related to three or more business activities. For domestic R&D paid for by others, the percentages were 91%, 6%, and 3%, respectively.

The top 10 business activities for which companies used their *own* funds to perform R&D in the United States accounted for 60% of these companies' R&D funds ($140.6 billion of $232.5 billion) (table 4-9). The top 10 activities for which companies used *others'* funds to perform R&D accounted for 68% of the total amount of company-performed R&D paid for by others (table 4-10).

U.S. Business R&D and Innovation Survey

To better understand and measure how R&D is conducted in today's innovation- and global-based economy (NRC 2005), NSF and the U.S. Census Bureau launched a new Business R&D and Innovation Survey (BRDIS). BRDIS expands on R&D data collected by its predecessor, the Survey of Industrial Research and Development, to cover (among other areas) global R&D funding or expenses by U.S.-located businesses, and introduces preliminary innovation and intellectual property questions that will be further developed.

Chapters 3, 4, 6, and 8 in this edition of *Science and Engineering Indicators* include selected preliminary data from the 2008 pilot survey. Detailed 2008 estimates and data for subsequent survey cycles are available at http://www.nsf.gov/statistics/industry/. BRDIS questionnaires are available at http://www.nsf.gov/statistics/question.cfm#13. Listed below are the main data collection areas.

- ♦ Company information:
  - Ownership
  - Business activities
- ♦ Measures of R&D activity paid for by the company:
  - Domestic and worldwide sales, revenue, and R&D activity
  - Company-funded R&D by business activity, type of costs, and location
  - Projected R&D costs
  - Capital expenditures for R&D (buildings, software, equipment)
- ♦ Measures related to R&D management and strategy:
  - Character of work (basic research, applied research, and development)
  - R&D applications and R&D in new business areas
  - R&D relationships with others outside the company
- ♦ Measures of company R&D activity funded by others:
  - Funds for worldwide and domestic R&D activity
  - R&D funded by others by business activity, type of organization, type of cost, state, and location (domestic vs. foreign)
- ♦ Measures of R&D employment:
  - R&D headcount (domestic and worldwide) by occupation and sex
  - Number of U.S. R&D employees working under a visa (H-1B, L-1, etc.)
  - R&D full-time equivalent counts
- ♦ Measures of intellectual property (IP), technology transfer, and innovation:
  - Participation in activities to introduce new or significantly improve existing goods, services, methods of production and distribution, or support systems
  - Selected patenting and licensing information
  - Participation in specific technology transfer activities and importance of types of IP protection

For more information see NSF 2008, 2010a, 2010b, and 2010c.

Table 4-9
Domestic R&D performance paid for by the company for top 10 business activities: 2008
(Millions of U.S. dollars)

Business activity	Business code[a]	R&D paid for by the company
All business activities	21100–81390	232,505
Top 10 business activities	—	140,632
Pharmaceutical, medicinal, botanical, and biological products (except diagnostic) manufacturing	32541	41,593
Software publishers (except Internet)	51120	23,860
Semiconductor and other electronic components manufacturing	33440	22,674
Computers and peripheral equipment manufacturing	33410	9,223
Medical equipment and supplies manufacturing	33910	8,521
Scientific research and development services	54170	8,464
Computer systems design and related services	54150	8,384
Motor vehicles manufacturing	33610	8,305
Telephone apparatus manufacturing	33421	5,424
Radio and television broadcasting and wireless communications equipment manufacturing	33422	4,184
All other business activities including undistributed amounts	—	91,873

[a]Business codes and descriptions based on North American Industry Classification System industry definitions.

NOTES: Data tabulated independent of the industry classification of the company. Detail may not add to total because of rounding

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics and Census Bureau, Business R&D and Innovation Survey (2008).

Science and Engineering Indicators 2012

Table 4-10
Domestic R&D performance paid for by others for top 10 business activities: 2008
(Millions of U.S. dollars)

Business activity	Business code[a]	R&D paid for by others
All business activities	21100–81390	58,176
Top 10 business activities	—	39,776
Scientific research and development services	54170	8,093
Aircraft manufacturing	33641	5,881
Architectural, engineering, and related services	54130	5,558
Search, detection, navigation, guidance, aeronautical, and nautical system and instruments manufacturing	33452	4,962
Guided missiles, space vehicles, and parts manufacturing	33644	4,725
Computer systems design and related services	54150	3,085
Pharmaceutical, medicinal, botanical, and biological products (except diagnostic) manufacturing	32541	2,797
Aircraft engine and engine parts manufacturing	33642	1,918
Electromedical, electrotherapeutic, and irradiation apparatus manufacturing	33451	1,899
Radio and television broadcasting and wireless communications equipment manufacturing	33422	858
All other business activities including undistributed amounts	—	18,400

[a]Business codes and descriptions based on North American Industry Classification System industry definitions.

NOTES: Data tabulated independent of the industry classification of the company. Detail may not add to total because of rounding.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics and Census Bureau, Business R&D and Innovation Survey (2008).

Science and Engineering Indicators 2012

R&D Performed Abroad by U.S.-Owned Companies

Foreign operations of U.S. businesses performed $61.5 billion in R&D outside the United States, based on 2008 BRDIS pilot survey. Of this performance abroad, $56.9 billion was paid by the own company and $4.6 billion was paid by others outside of the company (table 4-11).[16]

By far, the industry that performed the most R&D outside of the United States was the pharmaceuticals and medicines industry ($10.9 billion), based on BRDIS data (appendix table 4-14). Other industries with high levels of R&D performed abroad were automobiles, automobile bodies, trailers, and parts manufacturers ($8.4 billion), semiconductor and other electronic components manufacturers ($7.1 billion), and software publishers ($6.3 billion).

R&D by Multinational Companies

This section covers statistics on R&D performed by majority-owned affiliates of foreign multinational corporations (MNCs) located in the United States, and R&D performed by U.S. MNCs and their majority-owned foreign affiliates, collected by the Bureau of Economic Analysis (BEA). See sidebar, "Foreign Direct Investment in R&D."

R&D arising from foreign direct investment (FDI) activities is quantitatively important since MNCs are the largest performers of business R&D in the United States (discussed below) and in other economies (Dunning and Lundan 2009). Both home country and international opportunities and policies affect R&D and other innovation-related activities by MNCs (Breznitz 2009; Athukorala and Kohpaiboon 2010). In turn, MNC activities influence the ultimate impacts of national and international R&D on national economic growth and productivity.

The majority of R&D by U.S. MNCs continues to be performed in the United States. Outside the United States, R&D by U.S.-owned foreign affiliates is performed mostly in Western Europe, Canada, and Japan, followed more recently by other locations in the Asia-Pacific region. Information on character of work for MNCs' R&D is presented in the sidebar, "Linking MNC Data from International Investment and Business R&D Surveys."

Foreign Direct Investment in R&D

Foreign direct investment (FDI) is one of several channels for the creation, exploitation, and diffusion of new knowledge along with international trade, licensing, and technology partnerships (Saggi 2002). Direct investment is defined as ownership or control of 10% or more of the voting securities of a business (affiliate) in another country. The cross-country location of R&D activities via FDI is driven by factors ranging from costs and long-term market and technological opportunities to infrastructure and policy considerations, such as human resources and intellectual property protection.

Statistics on R&D by affiliates of foreign companies located in the United States, and by foreign affiliates of U.S. MNCs and their parent companies, are from BEA's Survey of Foreign Direct Investment in the United States (FDIUS) and BEA's Survey of U.S. Direct Investment Abroad (USDIA). Affiliate data presented in this section cover majority-owned affiliates, that is, those in which the ownership stake of parent companies totals more than 50%. Annual changes in FDI R&D reflect a combination of mergers and acquisitions; newly built factories, service centers, or laboratories; and activities in existing facilities. Data exclude commercial banks, savings institutions, credit unions, bank holding companies, and financial holding companies

U.S. Affiliates of Foreign Companies

Majority-owned affiliates of foreign MNCs located in the United States (U.S. affiliates) performed $40.5 billion of R&D or 13.9% of the $290.7 in U.S. business R&D performed in 2008 (preliminary BEA estimate).[17] Since 1999, the share of these companies in U.S.-located business R&D,

Table 4-11
R&D performed abroad by U.S.-owned companies: 2008
(Millions of U.S. dollars)

Industry	NAICS code	Foreign performance: Total	Paid for by company	Paid for by others
All industries	21–23, 31-33, 42–81	61,475	56,899	4,576
Manufacturing industries	31–33	46,572	45,274	1,298
Nonmanufacturing industries	21–23, 42–81	14,903	11,625	3,278

NAICS = North American Industry Classification System

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics and Census Bureau, Business R&D and Innovation Survey (2008).

Science and Engineering Indicators 2012

Linking MNC Data from International Investment and Business R&D Surveys

In 2007, the nature of R&D carried out by U.S. affiliates of foreign-owned MNCs was very similar to U.S.-based R&D of U.S. MNC parents: 4.4%–4.5% of R&D expenditures was devoted to basic research, 19.4%–19.9% to applied research, and 75.8%–76.1% to development.

This new insight into the distribution of character of work of MNCs R&D is made possible by linking and comparing reports for 2004–07 from the same set of companies responding to NSF/Census Survey of Industrial Research and Development (SIRD),* the predecessor of BRDIS, with two different BEA surveys: Foreign Direct Investment in the United States and U.S. Direct Investment Abroad.

* http://www.nsf.gov/statistics/industry/

as collected in NSF R&D surveys, has fluctuated narrowly between 13% and 15%. About 90% of R&D by U.S. affiliates of foreign MNCs is performed by firms owned by European, Japanese, and Canadian parent companies (appendix table 4-18).

The share of U.S. affiliates' R&D performed by manufacturing companies has decreased from over 80% in the late 1990s to 74.7% in 2007 and 69.6% in 2008. Country ownership patterns and industry focus have remained relatively unchanged, with Swiss- and British-owned companies, for example, performing close to two-thirds of R&D by U.S. affiliates classified in chemicals (which includes pharmaceuticals) and German-owned companies performing close to one-quarter of R&D by U.S. affiliates classified in transportation equipment in 2008 (table 4-12). Among the largest nonmanufacturing R&D-performing industries for U.S. affiliates in 2008 were wholesale trade in electrical goods ($2.4 billion); professional, scientific, and technical services ($2.3 billion); and information services ($2.1 billion) (see appendix tables 4-19, 4-20, and 4-21).

U.S. MNCs Parent Companies and Their Foreign Affiliates

In 2008, parent companies of U.S. MNCs performed $199.1 billion of the $290.7 billion of R&D performed by businesses in the United States. Their majority-owned foreign affiliates performed $37.0 billion according to preliminary BEA data (see table 4-13 and appendix tables 4-22 through 4-26).).[18] Since 1999, U.S. MNCs have performed, on average, about 86% of their annual global R&D in the United States. In turn, U.S. MNC parents accounted, on average, for about 72% of annual U.S. business R&D performed over the same period.

Table 4-12
R&D performed by majority-owned affiliates of foreign companies in the United States, by selected NAICS industry of affiliate and country: 2008
(Millions of current U.S. dollars)

		Manufacturing						Nonmanufacturing		
Country	All industries	Total	Chemicals	Machinery	Computer and electronic products	Electrical equipment	Transportation equipment	Information	Professional, technical, scientific services	Wholesale trade
All countries	40,519	28,190	14,121	2,535	4,259	499	4,015	2,108	2,347	7,404
Canada	1,435	429	124	D	D	D	194	D	D	D
France	5,978	4,672	1,408	D	D	D	102	D	91	D
Germany	5,520	4,763	2,017	D	101	21	930	D	D	227
Netherlands	1,789	D	D	D	236	4	16	0	3	D
Switzerland	6,926	5,743	5,435	43	11	D	9	3	934	245
United Kingdom	7,369	6,683	3,665	47	292	6	D	D	106	D
Japan	4,637	1,643	516	64	515	42	282	11	678	2,242
Other	6,865	D	D	595	D	D	D	D	D	2,911

D = suppressed to avoid disclosure of confidential information

NAICS = North American Industry Classification System

NOTES: Preliminary 2008 estimates for majority-owned (>50%) nonbank affiliates of nonbank U.S. parents by country of ultimate beneficial owner and industry of affiliate. Expenditures included for R&D conducted by foreign affiliates, whether for themselves or others under contract. Expenditures excluded for R&D conducted by others for affiliates under contract.

SOURCE: Bureau of Economic Analysis, Survey of Foreign Direct Investment in the United States (annual series), http://www.bea.gov/international/index.htm#omc, accessed 4 February 2011.

Science and Engineering Indicators 2012

Table 4-13
R&D performed by U.S. multinational companies: 1999–2008

	Location of R&D performed (current US$millions)			Shares of U.S. MNCs R&D performance (%)	
Year	United States (by parents of U.S. MNCs)	Outside United States (by MOFAs)	Total by U.S. MNCs	United States	Outside United States
1999	126,291	18,144	144,435	87.4	12.6
2000	135,467	20,457	155,924	86.9	13.1
2001	143,017	19,702	162,719	87.9	12.1
2002	136,977	21,063	158,040	86.7	13.3
2003	139,884	22,793	162,677	86.0	14.0
2004	164,189	25,840	190,029	86.4	13.6
2005	177,598	27,653	205,251	86.5	13.5
2006	184,428	29,583	214,011	86.2	13.8
2007	203,678	34,446	238,124	85.5	14.5
2008	199,105	36,991	236,096	84.3	15.7

MNC = multinational company; MOFA = majority-owned foreign affiliate

NOTE: MOFAs are affiliates in which combined ownership of all U.S. parents is >50%.

SOURCE: Bureau of Economic Analysis. Survey of Foreign Direct Investment in the United States (annual series).

Science and Engineering Indicators 2012

R&D by foreign affiliates of U.S. MNCs has gradually shifted from traditional host countries, including Japan, towards other Asian venues. The combined share of Europe, Canada, and Japan as hosts of R&D by U.S.-owned foreign affiliates declined from about 90% in the mid- and late 1990s to around 80% since 2006. European-located affiliates have performed about two-thirds of R&D by affiliates of U.S. MNCs since 2003, after declining in the late 1990s and early 2000s (figure 4-9 and appendix table 4-22).

On the other hand, the share of R&D performed by Asia-located affiliates (other than in Japan) increased from about 5% to 14% from 1997 to 2008. In particular, the share of U.S.-owned affiliates' R&D performed in China, South Korea, Singapore, and India rose from a half percentage point or less in 1997 to 4% for China, just under 3% for South Korea, and just under 2% each for Singapore and India in 2008.

Manufacturing affiliates accounted for 80% of foreign affiliates' R&D in 2008, including two-thirds performed in three industries: transportation equipment (25%), chemicals (including pharmaceuticals) (24%), and computer and electronic products (17%) (table 4-14). Professional, technical, and scientific services accounted for another 11% and information services for 5% (see appendix tables 4-23 and 4-24).

The country and industry distribution of U.S. MNCs' foreign R&D is related, among other factors, to historical S&T strengths in the host countries. United Kingdom and Germany, for example, hosted 20.4% and 12.0% of U.S.-owned overseas R&D in chemicals (which includes pharmaceuticals), whereas affiliates located in Germany performed almost two-fifths of R&D by transportation equipment affiliates (table 4-14).

Within the professional, technical, and scientific services industry, affiliates located in the UK performed 22.3% of foreign affiliates' R&D total, followed by Canada (12.5%) and India (6.3%), according to available country detail. Lastly, about four-fifths of affiliates' R&D in information services (which includes software and Internet publishing and telecommunications) in 2008 was performed in three areas: Ireland (30.7%), Canada (22.3%), and Asia outside Japan (25.5%).

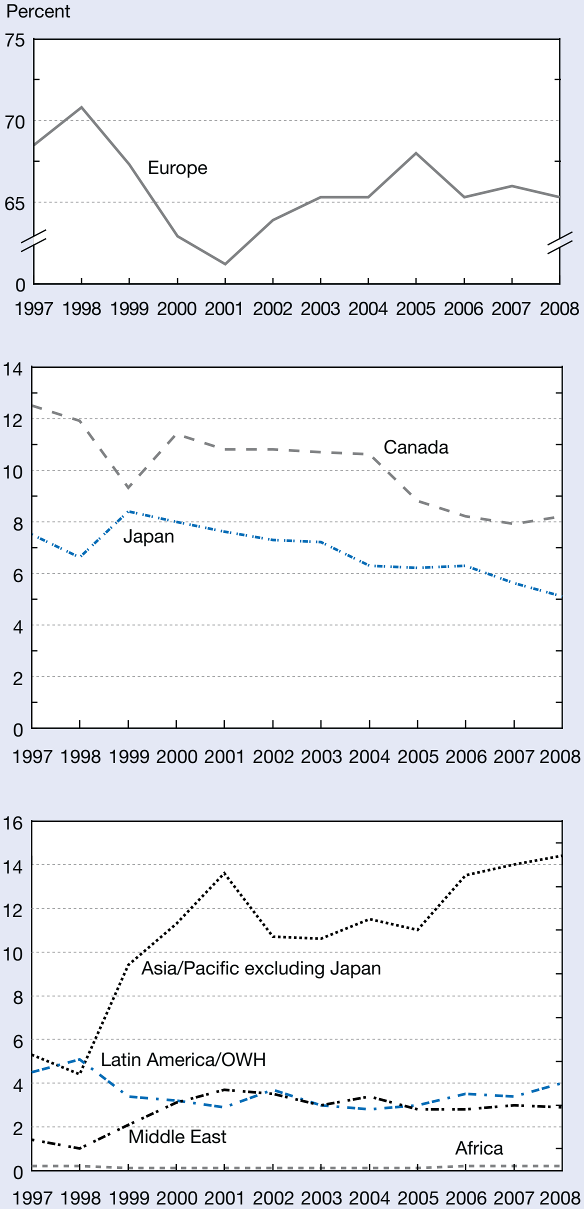
Exports and Imports of R&D-Related Services

Cross-border transactions of business services, published by BEA as part of international transactions accounts, include research, development, and testing (RDT) services under the category of business, professional, and technical services. RDT services include commercial and noncommercial research as well as product development and testing services. In 2009, U.S. RDT exports and imports stood at $18.2 billion and $15.8 billion, respectively, for a balance of $2.5 billion (appendix table 4-27).[19]

Transactions in RDT services provide insights into business R&D-related transactions, including exchanges among unaffiliated or independent companies (unaffiliated trade) and trade within MNCs (affiliated trade). As described below, most transactions in these R&D-related services occur within multinational corporations. Further, the patterns of U.S. RDT exports and imports differ for U.S. and foreign MNCs.

Most RDT trade occurs within companies. Since 2001, when affiliated RDT trade data were first available, transactions among MNCs members (parent companies and subsidiaries) have represented around 85% of total RDT exports annually. This share is consistent with the large role of MNCs (including U.S. parents and foreign-owned

Figure 4-9
Regional shares of R&D performed abroad by foreign affiliates of U.S. MNCs: 1997–2008



MNC = multinational company; OWH = other Western Hemisphere

NOTES: Data for majority-owned affiliates. Preliminary estimates for 2008.

SOURCE: Bureau of Economic Analysis, Survey of U.S. Direct Investment Abroad (annual series).

Science and Engineering Indicators 2012

companies) in U.S. business R&D performance. (See section “R&D by Multinational Companies.”) Likewise, within-company imports accounted for 66% to 78% of total RDT imports annually over the same period. The large share of this affiliated or within-company RDT trade reflects the need for management control and proprietary protection in cross-border transactions involving intangible assets.

Foreign MNCs with operations in the U.S. are exporting more RDT services to their foreign parents (and other members of the foreign MNCs) compared with their level of imports. Foreign MNCs with activities in the U.S. reported average annual net exports of $3.9 billion between 2006 and 2009, with net exports fluctuating between $3.4 billion to $4.5 billion over this period. On the other hand, U.S. MNC parents imported annually about the same or slightly more of those services relative to their exports over the same period (table 4-15).[20] In 2009, U.S. parents imported $602 million more RDT services from their foreign affiliates than they exported to their affiliates.

Europe accounted for about half of U.S. total RDT exports and imports in 2009 (appendix table 4-27). Latin America was the second largest destination of RDT exports (23%) whereas Asia was the second largest origin of RDT imports (about 30%). The latter included 9.1% of RDT imports from India in 2009 (compared with 4.6% in 2006), 8.6% from Japan (compared with 5.9% in 2006), and 5.4% from China (compared with 1.0% in 2006).

Federal R&D

The U.S. government supports the nation’s R&D system through various policy tools. The most direct is federal performance and funding of R&D. This section provides statistics on these federally performed or funded activities, including budget authority by national objectives, obligations by agency, and obligations by research field (for definition of these terms see sidebar, “Federal Budgetary Concepts and Related Terms”). This section also covers federal tax credits for business R&D.

Federal R&D Budget by National Objectives

Federal support for the nation’s R&D spans a range of broad objectives, including defense, health, space, energy, natural resources/environment, general science, and various other categories. To assist the president and Congress in planning and setting the federal budget and its components, the Office of Management and Budget classifies agency budget requests into specific categories called *budget functions*. These functions include a number of categories that distinguish the various R&D objectives. Descriptions of the budget authority provided annually to federal agencies in terms of these R&D budget functions afford a useful picture of the present priorities and trends in federal support for U.S. R&D.

In FY 2009, budget authority for federal agency spending on R&D totaled an estimated $156.0 billion, including a one-time $15.1 billion increase provided under the American Recovery and Investment Act of 2009 (appendix tables 4-28 and 4-29).

Defense-Related R&D

As in previous years, defense was the largest of the R&D budget functions, accounting for 55% ($85.2 billion) of the total. Defense R&D is supported primarily by the Department

Table 4-14
R&D performed abroad by majority-owned foreign affiliates of U.S. parent companies, by selected NAICS industry of affiliate and region/country/economy: 2008
(Millions of current U.S. dollars)

		Manufacturing						Nonmanufacturing		
Region/country/ economy	All industries	Total	Chemicals	Machinery	Computer and electronic products	Electrical equipment, appliances, and components	Transportation equipment	Information	Professional, technical, scientific services	Wholesale trade
All countries	36,991	29,385	8,754	1,457	6,354	586	9,163	1,954	3,963	1,461
Canada	3,040	1,981	685	28	482	19	653	436	494	78
Europe	24,155	19,416	6,255	1,076	2,762	313	6,601	870	2,680	1,089
Belgium	1,259	891	783	24	D	15	14	*	350	12
France	2,171	1,878	448	133	501	35	456	45	188	53
Germany	7,039	6,485	1,051	388	858	132	3,527	D	194	D
Ireland	1,503	848	438	0	313	0	2	599	D	D
Italy	582	475	246	52	22	4	73	*	D	D
Netherlands	1,484	1,267	778	41	73	D	D	D	D	D
Sweden	1,576	1,478	33	12	59	D	D	D	D	7
Switzerland	1,123	728	262	88	173	24	D	D	229	118
United Kingdom	5,157	3,844	1,790	185	464	49	912	76	884	341
Latin America/ OWH	1,465	1,354	371	40	191	D	642	1	37	29
Brazil	791	770	175	35	D	0	444	1	4	16
Mexico	329	D	80	4	7	D	169	*	D	3
Africa	57	44	14	1	*	0	23	2	*	2
South Africa	43	34	13	*	*	0	D	2	*	2
Middle East	1,063	869	D	D	650	0	0	5	174	15
Israel	1,060	867	D	D	650	0	0	D	174	D
Asia and Pacific	7,210	5,722	D	D	2,268	D	1,244	640	578	247
Australia	923	851	234	10	6	20	D	7	20	41
China	1,517	1,180	D	24	965	66	40	D	D	43
Hong Kong	102	52	9	0	10	5	0	5	37	7
India	582	222	58	D	D	D	32	D	250	D
Japan	1,872	1,529	930	64	244	D	81	142	D	D
Malaysia	360	358	3	*	345	1	0	0	*	2
Singapore	621	390	30	1	343	1	2	D	D	9
South Korea	966	931	34	17	207	D	D	7	7	D
Taiwan	102	D	D	1	48	5	2	D	8	8
Thailand	69	67	7	3	27	0	17	0	0	2

* = ≤ $500,000; D = suppressed to avoid disclosure of confidential information

NAICS = North American Industry Classification System; OWH = other Western Hemisphere

NOTES: Preliminary 2008 estimates for majority-owned (>50%) nonbank affiliates of nonbank U.S. parents by country of ultimate beneficial owner and industry of affiliate. Expenditures included for R&D conducted by foreign affiliates, whether for themselves or others under contract. Expenditures excluded for R&D conducted by others for affiliates under contract.

SOURCE: Bureau of Economic Analysis, Survey of U.S. Direct Investment Abroad (annual series), http://www.bea.gov/international/index.htm#omc, accessed 4 February 2011.

Science and Engineering Indicators 2012

of Defense (DOD), but also includes some R&D by the Department of Energy (DOE) and the Department of Justice (where some R&D by the Federal Bureau of Investigation comes under a defense category).

Defense has accounted for the majority of R&D budget authority throughout the last two decades (figure 4-10, appendix table 4-28); the share has fluctuated year to year in the 50%–70% range. In FY 1980, it roughly equaled nondefense R&D, but by FY 1985 it was more than double. From 1986 to 2001, nondefense R&D surged, and the share of defense R&D shrank to 53%. After September 11, 2001, defense R&D became more prominent, accounting for 59% of the federal R&D budget in FY 2008. The drop to 55% in FY 2009 reflects chiefly the effect of the one-time ARRA

Table 4-15
U.S. trade balance in research, development, and testing services, by affiliation: 2006–09
(Millions of current U.S. dollars)

Affiliation	2006	2007	2008	2009
Total	3,534	2,593	1,142	2,481
Unaffiliated	–660	–1,008	–1,473	–1,020
Affiliated	4,193	3,601	2,615	3,500
By U.S. parents from/to their foreign affiliates	–334	185	–1,100	–602
By U.S. affiliates from/to their foreign parent groups[a]	4,528	3,416	3,715	4,103

[a]In addition to transactions with its foreign parent, U.S. affiliates' exports and imports include transactions with other members of their foreign parent group.

NOTES: Trade balance is exports minus imports. Positive amounts represent a trade surplus; negative amounts represent a trade deficit.

SOURCE: Bureau of Economic Analysis, U.S. International Services, http://www.bea.gov/international/international_services.htm, accessed 4 February 2011.

Science and Engineering Indicators 2012

spending authority that expanded health, energy, and general science research.

Nondefense R&D

Budget authority for nondefense R&D totaled $70.8 billion in FY 2009, or about 45% of the total that year (appendix table 4-28). Nondefense R&D includes health, space research/technology, energy, general science, natural resources/environment, transportation, agriculture, education, international affairs, veterans' benefits, and a number of other small categories related to economic and governance matters.

The most striking change in federal R&D priorities over the past two decades has been the considerable increase in health-related R&D—which now accounts for well over half of all nondefense R&D (figure 4-10). Health R&D has risen from about 12% of total federal R&D budget authority in FY 1980 to 21% in FY 2008 and 26% in FY 2009 because of the ARRA increment. The increase in share accelerated after 1998, when policymakers set the National Institutes of Health (NIH) budget on course to double by FY 2003.

The budget allocation for space-related R&D peaked in the 1960s, during the height of the nation's efforts to surpass the Soviet Union in space exploration. It stood at 10%–11% of total R&D authority throughout the 1990s. The loss of the space shuttle *Columbia* and its entire crew in February 2003 prompted curtailment of manned space missions. In FY 2005, the space R&D share was down to about 6%; by FY 2009, it had declined to around 4%.

Federal nondefense R&D classified as general science had about a 4% share of total federal R&D in the mid 1990s, growing to 8% in FY 2009. However, this change reflected chiefly a reclassification, starting in FY 1998, of several DOE programs from energy to general science.

Federal Budget for Basic Research

In FY 2009, federal budget authority for all basic research totaled $36.4 billion (appendix table 4-29). This represented some 23% of the $156.0 billion of total federal budget authority for R&D that year. The vast majority of basic research reflects the budgets of agencies with nondefense objectives, such as general science (notably NSF), health (NIH), and space research and technology (NASA).

Over the past several years, budget authority levels for basic research have been mostly flat, after adjusting for inflation, excepting the 2009 ARRA boost. In FY 2002, basic research budget authority was $25.8 billion (constant 2005 dollars); in FY 2008, $26.4 billion; and $33.0 billion in FY 2009.

Federal Budgetary Concepts and Related Terms

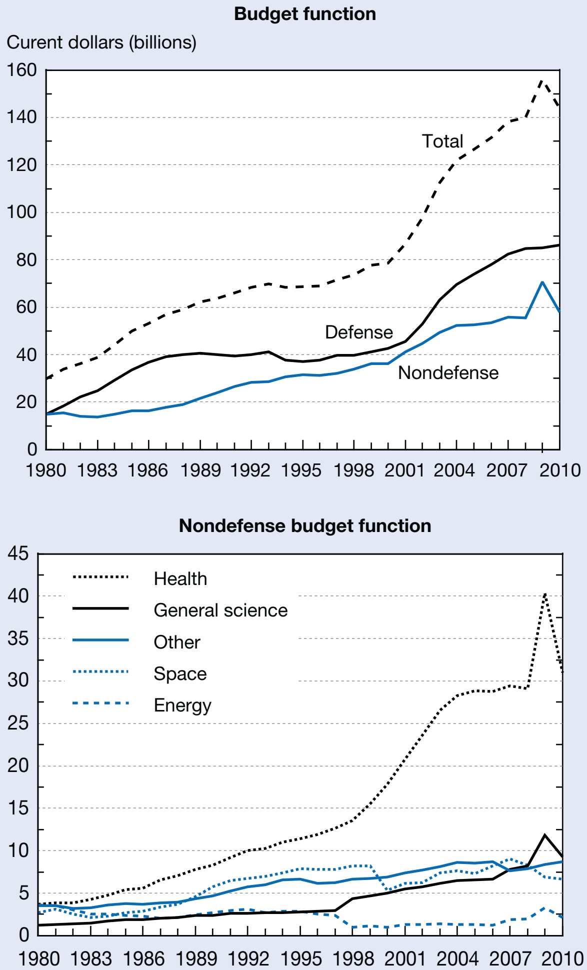
Budget authority. This refers to the funding authority conferred by federal law to incur financial obligations that will result in outlays. The basic forms of budget authority are appropriations, contract authority, and borrowing authority.

Obligations. Federal obligations represent the dollar amounts for orders placed, contracts and grants awarded, services received, and similar transactions during a given period, regardless of when funds were appropriated or payment was required.

Outlays. Federal outlays represent the dollar amounts for checks issued and cash payments made during a given period, regardless of when funds were appropriated or obligated.

R&D plant. In general, R&D plant refers to the acquisition of, construction of, major repairs to, or alterations in structures, works, equipment, facilities, or land for use in R&D activities. Data included in this section refer to obligated federal dollars for R&D plant.

Figure 4-10
Federal budget authority for R&D, by budget function: FY 1980–2010



NOTES: Data for FY 2010 are preliminary. Data for FY 2009 include the additional federal funding for R&D appropriated by the American Recovery and Reinvestment Act of 2009. Other includes all nondefense functions not separately graphed, such as agriculture and transportation.1998 increase in general science and decrease in energy, and 2000 decrease in space were results of reclassification.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Federal R&D Funding by Budget Function (FY 2009–11). See appendix table 4-28.

Science and Engineering Indicators 2012

Federal Spending on R&D by Agency

Budget authority, discussed above, lays out the themes of the broad federal spending plan. Federal obligations reflect federal dollars as they are spent, that is, the implementation of the plan by federal agencies (see appendix tables 4-30 and 4-31).

In FY 2009, federal obligations for R&D and R&D plant together totaled an estimated $137.0 billion: $133.3 billion for R&D and an additional $3.6 billion for R&D plant (table 4-16). Federal obligations for R&D have, in general, increased annually on a current-dollar basis since the mid-1990s (figure 4-11). Earlier figures are $68.2 billion for R&D in FY 1995 and an additional $2.3 billion for R&D plant, $75.9 billion and $4.5 billion in FY 2000, $118.9 billion and $3.8 billion in FY 2005 (appendix table 4-30). When adjusted for inflation, however, the growth has been slower after FY 2005. NSF's latest statistics indicate that the boost to R&D from the ARRA appropriations translated to an additional $10.1 billion of federal R&D obligations in FY 2009—$8.7 billion for R&D, another $1.4 billion for R&D plant, with the main recipients the Department of Health and Human Services (HHS), NSF, and DOE (table 4-16).

(The figures for federal funding of U.S. R&D cited in table 4-1 earlier in this chapter are somewhat lower. These earlier figures are based on performers' reports of their R&D expenditures from federal funds. This difference between performer and source of funding reports of the level of R&D expenditures has been present in the U.S. data for more than 15 years and reflects various technical issues. See sidebar, "Tracking R&D: The Gap between Performer- and Source-Reported Expenditures.")

Fifteen federal departments and a dozen other agencies engage in and/or fund R&D in the U.S.[21] Seven departments/agencies that reported spending on R&D in excess of $1 billion annually accounted for 97% of the total (table 4-16). Another eight of the departments/agencies reported spending above $100 million annually.

Department of Defense

In FY 2009, DOD obligated a total of $68.2 billion for R&D and R&D plant (table 4-16)—which represented half (50%) of all federal spending on R&D and R&D plant that year. Nearly the entire DOD total was R&D spending ($68.1 billion) with the remainder spent on R&D plant.

Twenty-seven percent ($18.7 billion) of the total was spending by the department's intramural labs, related agency R&D program activities, and FFRDCs (table 4-16). Extramural performers—private businesses, universities/colleges, state/local governments, other nonprofit organizations, and foreign performers—accounted for 73% ($49.5 billion) of the obligations, with the bulk going to business firms ($46.3 billion).

Considering just the R&D component, relatively small amounts were spent on basic research ($1.7 billion, 3%) and applied research ($5.1 billion, 7%) in FY 2009 (table 4-17). The vast majority of obligations, $61.3 billion (90%), went to development. Furthermore, the bulk of this DOD development ($54.9 billion) was allocated for "major systems development," which includes the main activities in developing, testing, and evaluating combat systems (figure 4-12). The remaining DOD development ($6.4 billion) was allocated for "advanced technology development," which is more similar to other agencies' development obligations.

Department of Health and Human Services

HHS is the main federal source of spending for health-related R&D. In FY 2009, the department obligated an estimated $35.7 billion for R&D and R&D plant, or 26% of the

Table 4-16

Federal obligations for R&D and R&D plant, by agency and performer: FY 2009

(Millions of dollars)

				ARRA funds		Total by performers			
Agency	Total	R&D	R&D plant	R&D	R&D plant	Intramural and FFRDCs	Percent of total	Extramural performers	Percent of total
All agencies	136,996.5	133,349.0	3,647.5	8,714.1	1,367.8	42,954.7	31.4	94,041.8	68.6
Department of Defense	68,230.2	68,113.0	117.2	184.2	0.0	18,695.1	27.4	49,535.1	72.6
Department of Health and Human Services	35,735.9	35,584.0	151.9	4,889.0	49.7	7,546.7	21.1	28,189.2	78.9
Department of Energy	11,562.2	9,889.9	1,672.3	1,393.4	813.2	8,853.3	76.6	2,709.0	23.4
National Science Foundation	6,924.8	6,095.2	829.6	1,807.6	388.5	303.8	4.4	6,618.2	95.6
National Aeronautics and Space Administration	5,937.1	5,937.0	0.1	314.7	0.0	1,958.1	33.0	3,979.0	67.0
Department of Agriculture	2,347.2	2,269.7	77.5	0.4	11.0	1,576.9	67.2	770.3	32.8
Department of Commerce	1,533.3	1,146.9	386.4	46.0	98.7	1,181.4	77.0	351.9	23.0
Department of Homeland Security	983.6	672.5	311.1	0.0	0.0	596.5	60.6	387.0	39.3
Department of Transportation	846.3	826.0	20.3	0.0	0.0	280.5	33.2	565.7	66.8
Department of the Interior	738.8	732.4	6.4	59.6	0.0	602.5	81.6	136.3	18.4
Environmental Protection Agency	552.8	552.8	0.0	0.0	0.0	414.1	74.9	138.8	25.1
Department of Veterans Affairs	510.0	510.0	0.0	0.0	0.0	510.0	100.0	0.0	0.0
Department of Education	322.4	322.4	0.0	0.0	0.0	15.6	4.8	306.7	95.2
Smithsonian Institution	226.7	152.0	74.7	0.0	6.7	226.7	100.0	0.0	0.0
Agency for International Development	160.1	160.1	0.0	0.0	0.0	10.6	6.6	149.5	93.4
All other agencies	385.1	385.1	0.0	19.2	0.0	183.0	47.5	204.9	53.2

FFRDC = federally funded research and development center

NOTES: Table lists all agencies with R&D obligations greater than $100 million in FY 2009. Data include obligations from the additional federal R&D funding appropriated by the American Recovery and Reinvestment Act of 2009. R&D is basic research, applied research, and development; does not include R&D plant. Intramural activities include actual intramural R&D performance and costs associated with planning and administration of both intramural and extramural programs by federal personnel. Extramural performers includes federally funded R&D performed in the United States and U.S. territories by industry, universities and colleges, other nonprofit institutions, state and local governments, and foreign organizations. All other agencies includes Department of Housing and Urban Development, Department of Justice, Department of Labor, Department of State, Department of the Treasury, Appalachian Regional Commission, Federal Communications Commission, Federal Trade Commission, Library of Congress, National Archives and Records Commission, Nuclear Regulatory Commission, and Social Security Administration.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Federal Funds for Research and Development (FY 2009–11). See appendix table 4-31.

Science and Engineering Indicators 2012

total of federal obligations that year. Nearly all of this was for R&D ($35.6 billion). Furthermore, much of the total, $34.6 billion, represented the R&D activities of the NIH. Obligations from the ARRA-appropriated funds totaled $4.9 billion for HHS in FY 2009, the largest by far of all the federal agencies (table 4-16). Again, nearly all of this was NIH R&D.

For the department as a whole, R&D and R&D plant obligations for agency intramural activities and FFRDCs accounted for 21% ($7.5 billion) of the total. Extramural performers accounted for 79% ($28.2 billion). Universities and colleges ($20.5 billion) and other nonprofit organizations ($5.3 billion) conducted the most sizable of these extramural activities (appendix table 4-31).

Nearly all of HHS R&D funding is allocated to research—almost 53% for basic research and 47% for applied research (table 4-17).

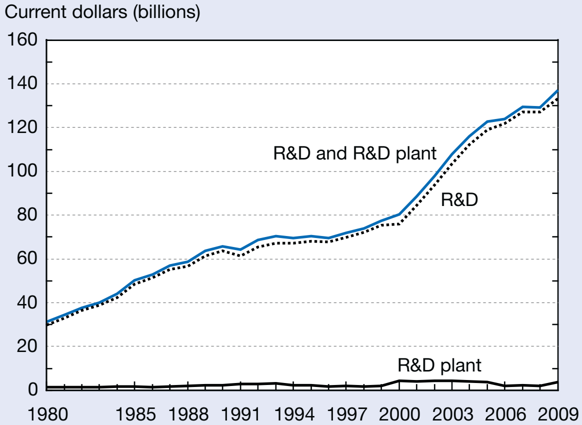
Department of Energy

DOE obligated an estimated $11.6 billion for R&D and R&D plant in FY 2009, about 8% of the federal obligations total that year. Of this amount, $9.9 billion was for R&D and $1.7 billion for R&D plant. Obligations this year stemming from the ARRA appropriation totaled $2.2 billion, the third largest among the agencies (behind HHS and NSF).

The department's intramural laboratories and FFRDCs accounted for 77% of the total obligations. Many of DOE's research activities require specialized equipment and facilities available only at its intramural laboratories and FFRDCs. Accordingly, DOE invests more resources in its intramural laboratories and FFRDCs than other federal agencies. The 23% of obligations to extramural performers were chiefly to businesses and universities/colleges.

For the $9.9 billion obligated to R&D, basic research accounted for 41%, applied research 32%, and development 27%. DOE R&D activities are rather evenly distributed among defense (much of it funded by the department's

Figure 4-11
Federal obligations for R&D and R&D plant: FY 1980–2009



NOTES: Data for FY 2009 include obligations from the additional federal R&D funding appropriated by the American Recovery and Reinvestment Act of 2009.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Federal Funds for Research and Development (FY 2009–11). See appendix table 4-30.

Science and Engineering Indicators 2012

National Nuclear Security Administration), energy, and general science (much of which is funded by the department's Office of Science).

National Science Foundation

NSF obligated $6.9 billion for R&D and R&D plant in FY 2009, or 5% of the federal total. Extramural performers, chiefly universities and colleges ($6.6 billion), represented 96% of this total. ARRA-related obligations were $2.2 billion (R&D and R&D plant), the second largest among the agencies. Basic research accounted for about 92% of the R&D component. NSF is the federal government's primary source of funding for academic basic science and engineering research and the second-largest federal source (after HHS) of R&D funds for universities and colleges.

National Aeronautics and Space Administration

NASA obligated an estimated $5.9 billion to R&D in FY 2009, 4% of the federal total. Sixty-seven percent of these obligations were for extramural R&D, given chiefly to industry performers. Agency intramural R&D and that by FFRDCs represented 33% of the NASA obligations total. By character of work, 71% of the NASA R&D obligations funded development activities; 17%, basic research; and 12%, applied research.

Department of Agriculture

USDA obligated an estimated $2.3 billion for R&D in FY 2009, with the main focus on life sciences. The agency is also one of the largest research funders in the social sciences, particularly agricultural economics. Of USDA's total obligations for FY 2009, about 67% ($1.6 billion) funded R&D by agency intramural performers, chiefly the Agricultural Research Service. Basic research accounts for about 41%; applied research, 51%; and development, 8%.

Department of Commerce

DOC obligated an estimated $1.5 billion for R&D in FY 2009, most of which represented the R&D and R&D plant spending of the National Oceanic and Atmospheric Administration (NOAA) and the National Institute of Standards and Technology (NIST). Seventy-seven percent of this total was for agency intramural R&D; 23% went to extramural performers, primarily businesses and universities/colleges. For the R&D component, 12% was basic research; 72%, applied research; and 16%, development.

Department of Homeland Security

DHS obligated an estimated $1.0 billion for R&D and R&D plant in FY 2009, nearly all of which was for activities by the department's Science and Technology Directorate. Sixty-one percent of this obligations total was for agency intramural and FFRDC activities. Just over 39% was conducted by extramural performers—mainly businesses, but also universities/colleges and other nonprofit organizations. Of the obligations for R&D, 15% was basic research; 37%, applied research; and 48%, development.

Other Agencies

The eight other departments/agencies obligating more than $100 million annually for R&D in FY 2009 were the Departments of Education, Interior, Justice, Transportation, and Veterans Affairs; and the Environmental Protection Agency, Agency for International Development, and Smithsonian Institution (tables 4-16 and 4-17). These agencies varied with respect to the character of the research and the roles of intramural, FFRDC, and extramural performers.

Federal Spending on Research by Field

Federal agencies' research covers the whole range of science and engineering fields. These fields vary in their funding levels and have different growth paths (see appendix tables 4-34 and 4-35).

Funding for basic and applied research combined accounted for $63.7 billion (about 48%) of the $133.3 billion total of federal obligations for R&D in FY 2009 (table 4-17). Of this amount, $33.3 billion (52% of $63.7 billion) supported research in the life sciences (figure 4-13; appendix table 4-34). The fields with the next-largest amounts were engineering ($10.3 billion, 16%) and the physical sciences ($5.8 billion, 9%), followed by environmental sciences ($3.8 billion, 6%), and mathematics and computer sciences ($3.6 billion, 6%). The balance of federal obligations for research in FY 2009 supported psychology, the social sciences, and all other sciences ($7.0 billion overall, or 11% of the total for research).

HHS accounted for the largest share (56%) of federal obligations for research in FY 2009 (appendix table 4-34). Most

Tracking R&D: The Gap between Performer- and Source-Reported Expenditures

In the United States—and in some other OECD countries—the figures for total government support of R&D reported by government agencies differ from those reported by the performers of R&D. In keeping with international guidance and standards, most countries provide totals and time series of national R&D expenditures based primarily on data reported by R&D performers (OECD 2002). Differences in the data provided by funders and performers can arise for numerous reasons, such as the different calendars for reporting government obligations (fiscal years) and performance expenditures (calendar years). In the U.S., there has been a sizable gap between performer and funder data for federal R&D over the past decade or more.

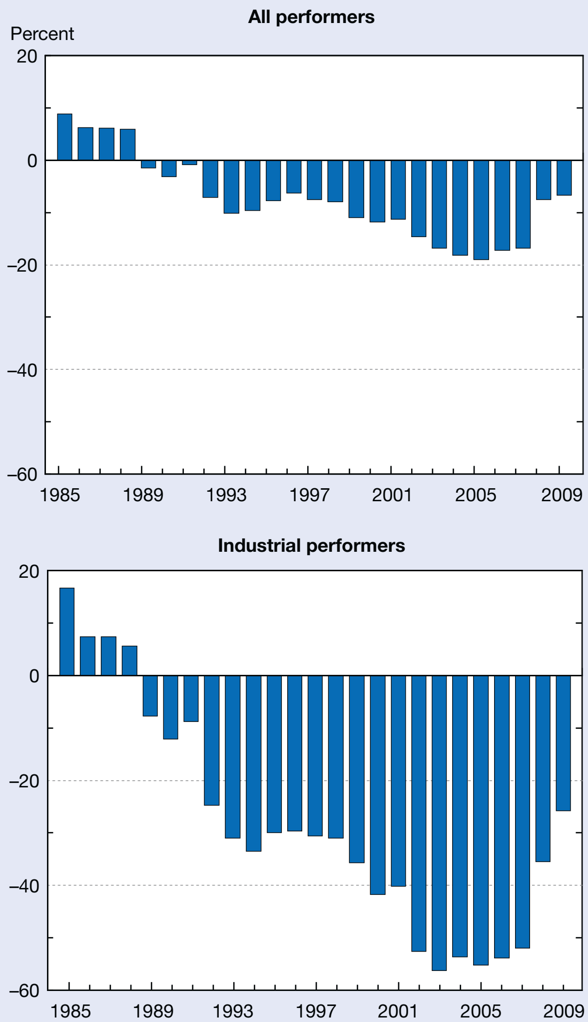
In the mid-1980s, performer-reported federal R&D in the United States exceeded federal reports of funding by $3 billion to $4 billion annually (5%–10% of the government total). This pattern reversed itself, however at the end of the decade: in 1989, the government-reported R&D total exceeded performer reports by almost $1 billion. The government-reported excess increased noticeably from then through to 2007, when federal agencies reported obligating $127 billion in total R&D to all R&D performers ($55 billion to the business sector) compared with $106 billion in federal funding reported by the performers of R&D ($27 billion by businesses). In other words, the business-reported total was some 50% smaller than the federally reported R&D support to industry in FY 2007 (see figure 4-A and appendix table 4-32). These differences in federal R&D totals were seen primarily in DOD funding of development activities by industry. The figures for 2008 and 2009 suggest a narrowing of the federal agency reporting excess, but are primarily the result of a manual imputation procedure for business R&D performers in these years.

Several investigations into the possible causes for the data gap have produced insights but no conclusive explanation. According to a General Accounting Office investigation (GAO 2001):

> Because the gap is the result of comparing two dissimilar types of financial data [federal obligations and performer expenditures], it does not necessarily reflect poor quality data, nor does it reflect whether performers are receiving or spending all the federal R&D funds obligated to them. Thus, even if the data collection and reporting issues were addressed, a gap would still exist.

Echoing this assessment, the National Research Council (2005) noted that comparing federal outlays for R&D (as opposed to obligations) to performer expenditures results in a smaller discrepancy. (In FY 2009, federal agencies reported total R&D outlays of $127 billion, compared to a total R&D figure of $124 billion reported by all performers that year. In FY 2007, federal agencies reported R&D outlays of $109 billion, compared to the performer-reported total of $106 billion.)

Figure 4-A
Differences in U.S. performer-reported and agency-reported federal R&D: 1985–2009



NOTE: Difference is defined as percent of federally reported R&D, with a positive difference indicating that performer-reported R&D exceeds agency-reported R&D.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics (NSF/NCSES), National Patterns of R&D Resources (annual series); and NSF/NCSES, Federal Funds for Research and Development (FY 2009–11). See appendix table 4-32.

Science and Engineering Indicators 2012

Table 4-17
Federal obligations for R&D, by agency and character of work: FY 2009
(Millions of current dollars)

Agency	Total R&D	Basic research	Applied research	Development	Percent of total R&D: Basic research	Percent of total R&D: Applied research	Percent of total R&D: Development
All agencies	133,349.0	32,877.9	30,830.9	69,640.2	24.7	23.1	52.2
Department of Defense	68,113.0	1,735.0	5,071.4	61,306.5	2.5	7.4	90.0
Department of Health and Human Services	35,584.0	18,772.2	16,717.7	94.1	52.8	47.0	0.3
Department of Energy	9,889.9	4,061.0	3,127.2	2,701.8	41.1	31.6	27.3
National Science Foundation	6,095.2	5,623.9	471.3	0.0	92.3	7.7	0.0
National Aeronautics and Space Administration	5,937.0	1,021.6	681.8	4,233.5	17.2	11.5	71.3
Department of Agriculture	2,269.7	924.0	1,154.0	191.7	40.7	50.8	8.4
Department of Commerce	1,146.9	138.3	820.8	187.8	12.1	71.6	16.4
Department of Transportation	826.0	0.0	586.7	239.2	0.0	71.0	29.0
Department of the Interior	732.4	47.1	610.5	74.8	6.4	83.4	10.2
Department of Homeland Security	672.5	101.3	245.9	325.3	15.1	36.6	48.4
Environmental Protection Agency	552.8	83.7	384.4	84.7	15.1	69.5	15.3
Department of Veterans Affairs	510.0	203.3	274.0	32.7	39.9	53.7	6.4
Department of Education	322.4	4.2	198.4	119.7	1.3	61.5	37.1
Agency for International Development	160.1	0.6	159.6	0.0	0.4	99.7	0.0
Smithsonian Institution	152.0	152.0	0.0	0.0	100.0	0.0	0.0
All other agencies	385.1	9.7	327.2	48.4	2.5	85.0	12.6

NOTES: Table lists all agencies with R&D obligations greater than $100 million in FY 2009. Data include obligations from the additional federal R&D funding appropriated by the American Recovery and Reinvestment Act of 2009 (ARRA). ARRA funds obligated for R&D totaled $8,714.1 million in FY 2009: $5,115.9 million for basic research, $2,611.3 million for applied research, and $987 million for development. All other agencies includes Department of Housing and Urban Development, Department of Justice, Department of Labor, Department of State, Department of the Treasury, Appalachian Regional Commission, Federal Communications Commission, Federal Trade Commission, Library of Congress, National Archives and Records Commission, Nuclear Regulatory Commission, and Social Security Administration.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Federal Funds for Research and Development (FY 2009–11). See appendix table 4-31.

Science and Engineering Indicators 2012

of this amount funded research in medical and related life sciences, primarily through NIH. The five next-largest federal agencies for research funding that year were DOE (11%), DOD (11%), NSF (10%), USDA (3%), and NASA (3%).

DOE's $7.2 billion in research obligations provided funding for research in the physical sciences ($2.6 billion) and engineering ($2.5 billion), along with mathematics and computer sciences ($1.0 billion). DOD's $6.8 billion of research funding emphasized engineering ($3.5 billion), but also included mathematics and computer sciences ($0.9 billion), physical sciences ($0.8 billion) and life sciences ($0.9 billion). NSF—not a mission agency in the traditional sense—is charged with "promoting the health of science." Consequently, it had a relatively diverse $6.1 billion research portfolio that allocated about $1.0 billion to $1.3 billion in each of the following fields: environmental, life, mathematics/computer, and physical sciences; and engineering. Lesser amounts were allocated to psychology and the social and other sciences. USDA's $2.1 billion was directed primarily at the life (agricultural) sciences ($1.7 billion). NASA's $1.7 billion for research emphasized engineering ($0.6 billion), followed by the physical sciences ($0.5 billion) and environmental sciences ($0.4 billion).

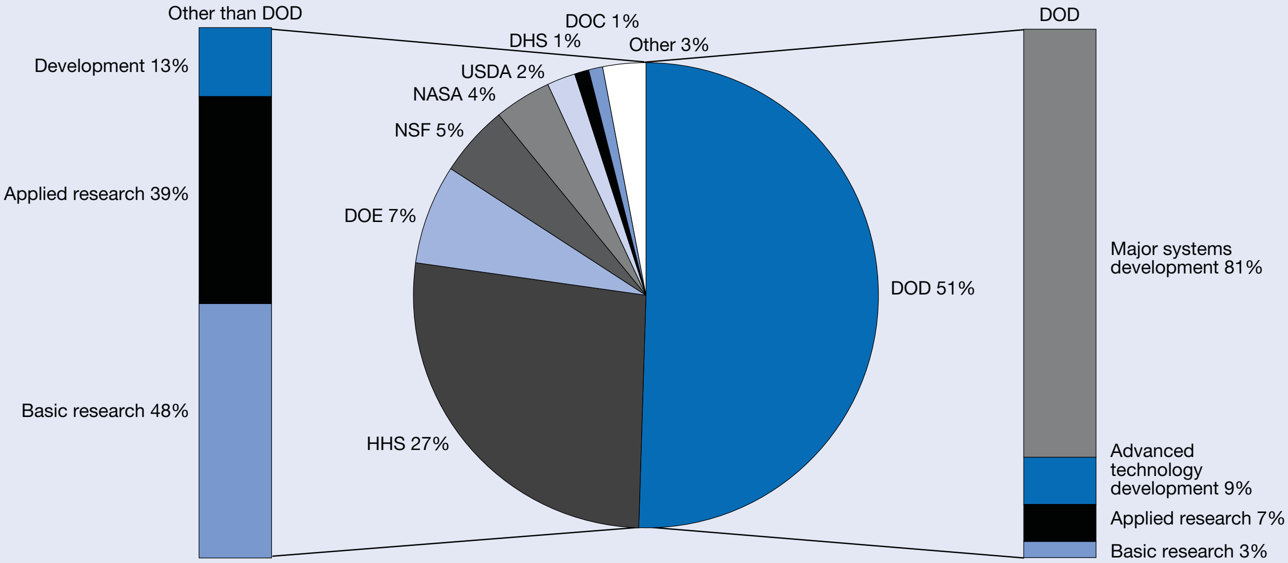
Growth in federal research obligations has slowed since 2004. Federal obligations for research in all S&E fields expanded on average at 3.6% annually (in current dollars) over the last 5 years (FY 2004–09), a much higher 6.6% over the last 10 years, and 5.8% over the last 20 years (appendix table 4-35). Adjusted for inflation, the 2004–09 average growth turns into an average annual increase of only 0.9%, which contrasts with a 10-year real growth of 4.1% and 3.3% over the last 20 years.

Since the late 1990s, growth in federal research obligations in the life sciences and psychology has exceeded the S&E average, leading to growing shares for these fields. Growth for the mathematics and computer sciences was just below the S&E average. The shares of research funding going to physical sciences, behavioral and other social sciences, and engineering, declined. Environmental sciences grew slower than both total research and inflation.

Federal R&E Tax Credits

The federal government makes available tax credits for companies that expand their R&D activities, as a way of counteracting potential business underinvestment in R&D.

Figure 4-12
Federal obligations for R&D, by agency and character of work: FY 2009



DOC = Department of Commerce; DOD = Department of Defense; DOE = Department of Energy; DHS = Department of Homeland Security; HHS = Department of Health and Human Services; NASA = National Aeronautics and Space Administration; NSF = National Science Foundation; USDA = Department of Agriculture

NOTES: Detail may not add to total because of rounding. Includes obligations from the additional federal R&D funding appropriated by the American Recovery and Reinvestment Act of 2009.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Federal Funds for Research and Development (FY 2009–11). See appendix table 4-31.

Science and Engineering Indicators 2012

Governments stimulate the conduct of R&D through tax incentives—allowances, exemptions, deductions, or tax credits—each of which can be designed with differing criteria for eligibility, allowable expenses, and baselines (OECD 2003). In the United States, federal tax incentives for qualified business R&D expenditures include a deduction under Internal Revenue Code (IRC) Section 174 (C.F.R. Title 26) and a research and experimentation (R&E) tax credit under Section 41.[22] The latter was established in 1981 by the Economic Recovery Tax Act (Public Law 97-34). It was last renewed by the Tax Relief, Unemployment Insurance Reauthorization, and Job Creation Act of 2010, through 31 December 2011.[23] The Obama administration has proposed making this credit permanent (U.S Department of Treasury 2011).

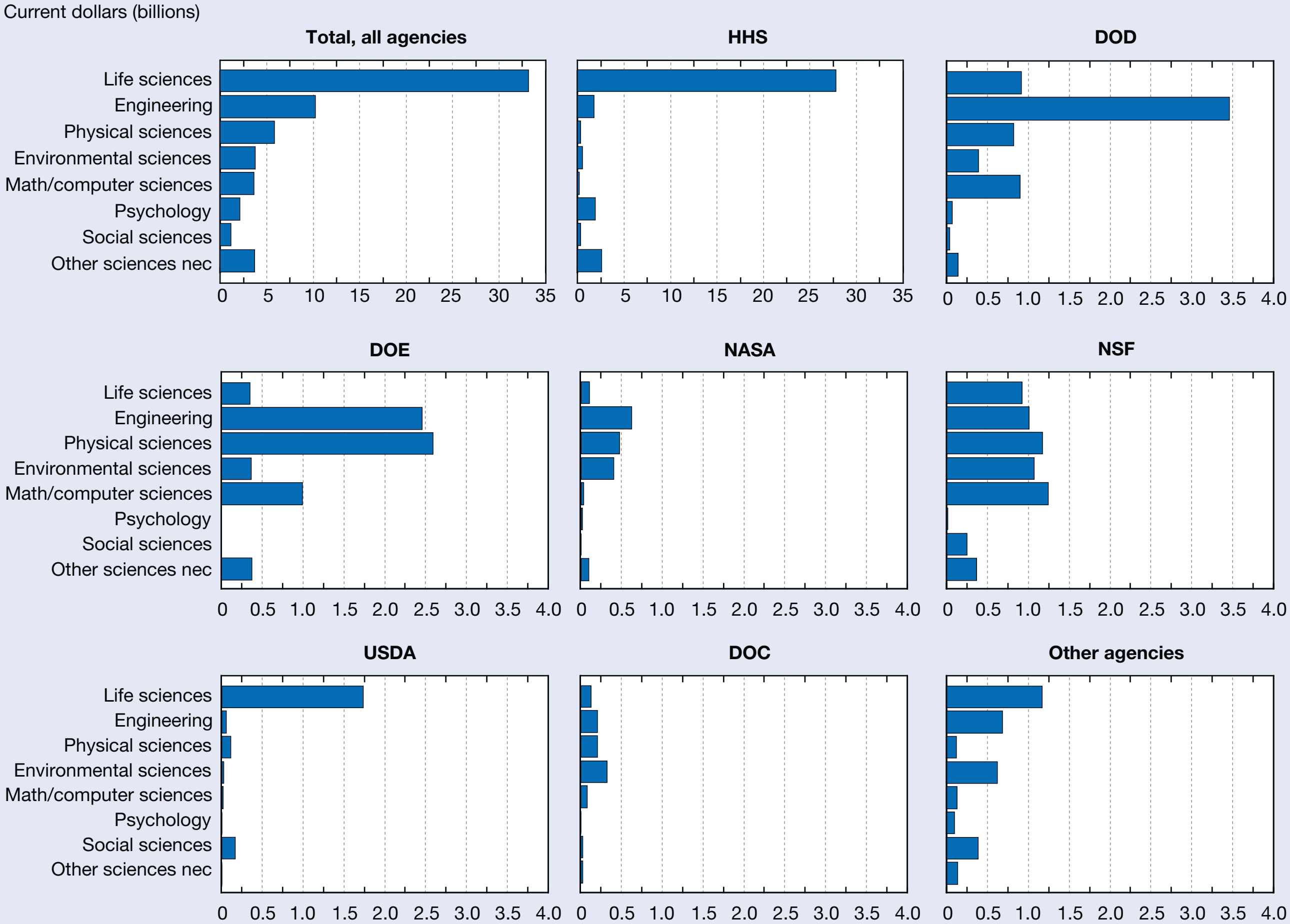
Along with the United States, over 20 OECD countries offer fiscal incentives for business R&D (OECD 2011b). Fiscal incentives for R&D are typically predicated on R&D's role in economic growth along with the recognition that R&D can generate social benefits well beyond those captured by companies investing in such activities (see Hemphill 2009 and references therein).

In the United States there were about $8.3 billion in business R&E tax credit claims both in 2007 and in 2008 (see appendix table 4-36).[24] Five industries accounted for 75% of these claims in 2008: computer and electronic products; chemicals, including pharmaceuticals, and medicines; transportation equipment, including motor vehicles and aerospace; information, including software; and professional, scientific, and technical services, including computer and R&D services.

Since 1998, R&E credit claims have grown at about the same average annual rate as has company-funded domestic R&D, keeping the ratio of R&E credit claims to company-funded domestic R&D in a narrow range (3.3% in 2008).[25] In 2008, more than 12,700 corporate returns claimed at least one component of the R&E tax credit (appendix table 4-37). Corporations with more than $250 million in business receipts accounted for 14% of returns claiming the credit in 2008 and 82% of the dollar value of all claims. In 2001, they had accounted for 9% of returns and 73% of dollar claims.[26]

The federal R&E tax credit encompasses a regular credit and as many as two forms of alternative credit formulas since 1996.[27] Under the regular credit, companies can take a 20% credit for qualified research above a base amount for activities undertaken in the United States (IRC section 41(a)(1)). Thus, the regular credit is characterized as a fixed-base incremental credit. An incremental design is intended to encourage firms to spend more on R&D than they otherwise would by lowering after-tax costs (Guenther forthcoming). Expenses paid or incurred for qualified research include company-funded expenses for wages paid, supplies used in the conduct of qualified research, and certain

Figure 4-13
Federal obligations for research, by agency and major S&E field: FY 2009



DOC = Department of Commerce; DOD = Department of Defense; DOE = Department of Energy; HHS = Department of Health and Human Services; NASA = National Aeronautics and Space Administration; nec = not elsewhere classified; NSF = National Science Foundation; USDA = Department of Agriculture

NOTES: Scale differs for Total, all agencies and HHS compared to other agencies listed. Includes obligations from the additional federal R&D funding appropriated by the American Recovery and Reinvestment Act of 2009. Research includes basic and applied research.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Federal Funds for Research and Development (FY 2009–11). See appendix table 4-34.

Science and Engineering Indicators 2012

contract expenses. Further, research "must be undertaken for discovering information that is technological in nature, and its application must be intended for use in developing a new or improved business component."[28] The credit covers U.S.-performed R&D by both domestic and foreign-owned firms and excludes R&D conducted abroad by U.S. companies. Activities generally disallowed for the purposes of the credit include those conducted after the beginning of commercial production and adapting an existing product or process. Research in the social sciences, arts, or humanities and research funded by another entity is also excluded.

Federal Technology Transfer and Other Innovation-Related Programs

This section reviews data on two types of federal programs that support public-private collaboration for technology transfer and innovation.[29] (For academic patents and related knowledge diffusion indicators, see chapter 5; for international business licensing fees and royalties, see chapter 6.) The first type includes federal programs for technology transfer from R&D funded and performed by agencies and laboratories. The second type supports new or small U.S. companies in R&D or technology deployment with R&D funds or technical assistance.

In the late 1970s, concerns about the strength of U.S. industries and their ability to be competitive in the global economy intensified. Issues included the question of whether inventions from federally funded academic research were adequately exploited for the benefit of the national economy and the need to create or strengthen public-private R&D partnerships. Since the 1980s, several U.S. policies have facilitated cross-sector R&D collaboration and technology transfer. One major policy thrust was to enhance formal mechanisms for transferring knowledge arising from federally funded and performed R&D (Crow and Bozeman 1998; NRC 2003). Other policies addressed federally funded academic R&D, the transition of early-stage technologies into the marketplace, and R&D and innovation by small or minority-owned businesses. For an overview of these initiatives, see sidebar, "Major Federal Legislation Related to Technology Transfer and Commercializing R&D."

Federal Technology Transfer

Federal technology transfer refers to the various processes through which inventions and other intellectual assets arising from federal laboratory R&D are conveyed to outside parties for further development and commercial applications. Technology transfer may also involve linking R&D capabilities and the resources of federal laboratories with outside public or private organizations for mutual benefit (FLC 2006).

In response to the Stevenson-Wydler Act of 1980 (as amended) federal agencies with laboratory operations have active efforts to engage in technology transfer as defined above, identify and manage intellectual assets created by their R&D, and participate in collaborative R&D relationships with nonfederal parties (including private businesses, universities, nonprofit organizations) consistent with agency mission goals. Federal labs have also been required to have technology transfer offices (termed an Office of Research and Technology Applications or ORTA) to assist in identifying transfer opportunities and establishing appropriate arrangements for relationships with nonfederal parties (see sidebar "Federal Technology Transfer: Activities and Metrics").

Six agencies continue to account for most of the annual total of federal technology transfer activities: DOD, HHS, DOE, NASA, USDA, and DOC. Statistics for these six agencies in FYs 2004 and 2009, spanning the main activity areas of invention disclosures and patenting, intellectual property licensing, and collaborative relationships for R&D, appear in table 4-18.[30] (Similar statistics for a larger set of agencies, going back over time to FY 2001, appear in appendix table 4-38.)

As is apparent in the distribution of the statistics across the activity types in table 4-18, most agencies engage in all of the transfer activity types to some degree, but there are differences in the emphases. Some agencies are more intensive in patenting and licensing activities (such as HHS, DOE, and NASA); some place greater emphasis on transfer through collaborative R&D relationships (such as USDA and DOC). Some agencies have unique transfer authorities which can confer practical advantages. NASA, for example, can establish collaborative R&D relationships through special authorities it has under the Space Act of 1958; USDA has a number of special options for establishing R&D collaborations other than through CRADAs; DOE's contractor-operated national labs, with their nonfederal staffs, are not constrained by the normal federal limitation on copyright by federal employees and are able to use copyright to protect and transfer computer software. In general, the mix of technology transfer activities pursued by each agency reflects a broad range of considerations such as agency mission priorities, technologies principally targeted for development, intellectual property protection tools and policies, and the types of external parties through which transfer and collaboration are chiefly pursued.

Small Business Innovation-Related Programs

This section focuses on several small business programs. The Small Business Innovation Research (SBIR) program was established by the Small Business Innovation Development Act of 1982[31] to stimulate technological innovation by increasing the participation of small companies in Federal R&D projects, increase private sector commercialization of innovation derived from federal R&D, and foster participation by minority and disadvantaged persons in technological innovation. The Small Business Technology Transfer (STTR) program was created in 1992 to stimulate cooperative R&D and federal technology transfer.[32] SBIR and STTR are both administered by the Small Business Administration (SBA). The last portion of this section covers the Technology Innovation Program (TIP), created by the America COMPETES Act of 2007 and administered by NIST.

The focus on smaller or startup R&D-based companies in these programs is an example of the promotion of innovation-based entrepreneurship via public-private partnerships that enable not only financing but also R&D collaboration and commercialization opportunities (Gilbert et al. 2004; Link and Scott 2010).

According to the SBIR statute, federal agencies with extramural R&D obligations exceeding $100 million must set aside a fixed percentage of such obligations (2.5% since FY 1997) for projects involving small business (those with fewer than 500 employees). In FY 2009, SBIR awards totaled $1.9 billion (SBA 2010). In FY 2008, 11 federal agencies awarded a total of $1.8 billion to about 5,400 SBIR projects (appendix tables 4-39 and 4-40). DOD provides about 50% of total SBIR funds annually, followed by HHS (around 30% since 1999), consistent with their large extramural R&D budgets.

The SBIR program is structured in three phases. Phase I evaluates the scientific and technical merit and feasibility of ideas. Phase II builds on phase I findings, is subject to further scientific and technical review, and requires a commercialization plan. During phase III, the results from phase II R&D are further developed and introduced into private markets or federal procurement using private or non-SBIR

Major Federal Legislation Related to Technology Transfer and Commercializing R&D

Technology Innovation Act of 1980 (Stevenson-Wydler Act) (Public Law 96-480)—established technology transfer as a federal government mission by directing federal labs to facilitate the transfer of federally-owned and originated technology to nonfederal parties.

University and Small Business Patent Procedures Act of 1980 (Bayh-Dole Act) (Public Law 96-517)—permitted small businesses, universities, and nonprofits to obtain titles to inventions developed with federal funds. Also permitted government-owned and government-operated laboratories to grant exclusive patent rights to commercial organizations.

Small Business Innovation Development Act of 1982 (Public Law 97-219)—established the Small Business Innovation Research (SBIR) program, which required federal agencies to set aside funds for small businesses to engage in R&D connected to agency missions.

National Cooperative Research Act of 1984 (Public Law 98-462)—encouraged U.S. firms to collaborate in generic precompetitive research by establishing a rule of reason for evaluating the antitrust implications of research joint ventures.

Patent and Trademark Clarification Act of 1984 (Public Law 98-620)—provided further amendments to the Stevenson-Wydler Act and the Bayh-Dole Act regarding the use of patents and licenses to implement technology transfer.

Federal Technology Transfer Act of 1986 (Public Law 99-502)—enabled federal laboratories to enter cooperative research and development agreements (CRADAs) with outside parties and to negotiate licenses for patented inventions made at the laboratory.

Executive Order 12591, Facilitating Access to Science and Technology (1987)—issued by President Reagan, this executive order sought to ensure that the federal laboratories implemented technology transfer.

Omnibus Trade and Competitiveness Act of 1988 (Public Law 100-418)—in addition to measures on trade and intellectual property protection, the act directed attention to public-private cooperation on R&D, technology transfer, and commercialization. It also established NIST's Manufacturing Extension Partnership (MEP) program.

National Competitiveness Technology Transfer Act of 1989 (Public Law 101-189)—amended the Federal Technology Transfer Act to expand the use of CRADAs to include government-owned, contractor-operated federal laboratories and to increase nondisclosure provisions.

Small Business Innovation Development Act of 1992 (Public Law 102-564)—extended the existing SBIR program, increased the percentage of an agency's budget to be devoted to SBIR, and increased the amounts of the awards. Also established the Small Business Technology Transfer (STTR) program to enhance the opportunities for collaborative R&D efforts between government-owned/contractor-operated federal laboratories and small businesses, universities, and nonprofit partners.

National Cooperative Research and Production Act of 1993 (Public Law 103-42)—relaxed restrictions on cooperative production activities, which enable research joint venture participants to work together in the application of technologies that they jointly acquire.

National Technology Transfer and Advancement Act of 1995 (Public Law 104-113)—amended the Stevenson-Wydler Act to make CRADAs more attractive to federal laboratories, scientists, and private industry.

Technology Transfer Commercialization Act of 2000 (Public Law 106-404)—broadened CRADA licensing authority to make such agreements more attractive to private industry and increase the transfer of federal technology. Established procedures for performance reporting and monitoring by federal agencies on technology transfer activities.

America COMPETES Act of 2007 (America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Sciences [COMPETES] Act) (Public Law 110-69)—authorized increased investment in R&D; strengthened educational opportunities in science, technology, engineering, and mathematics from elementary through graduate school; and further developed the nation's innovation infrastructure. Among other measures, the act established NIST's Technology Innovation Program (TIP) and called for a President's Council on Innovation and Competitiveness.

America COMPETES Reauthorization Act of 2010 (Public Law 111–358)—updates the America COMPETES Act of 2007 and authorizes additional funding to science, technology, and education programs over the succeeding 3 years. The Act's numerous provisions broadly directed strengthening the foundation of the U.S. economy, creating new jobs, and increasing U.S. competitiveness abroad.

Federal Technology Transfer: Activities and Metrics

Federal technology transfer can take a variety of forms (FLC 2006), including the following:

Commercial transfer. Movement of knowledge or technology developed by a federal lab to private organizations in the commercial marketplace.

Scientific dissemination. Publications, conference papers, and working papers, distributed through scientific/technical channels; other forms of data dissemination.

Export of resources. Federal lab personnel made available to outside organizations with R&D needs through collaborative agreements or other service mechanisms.

Import of resources. Outside technology or expertise brought in by a federal lab to enhance the existing internal capabilities.

Dual use. Development of technologies, products, or families of products with both commercial and federal applications.

Federal tech transfer metrics cover activities among three main classes of intellectual asset management and transfer:

Invention disclosure and patenting. Counts of invention disclosures filed (typically, an inventing scientist or engineer filing a written notice of the invention with the lab's technology transfer office), patent applications filed with the U.S. Patent and Trademark Office (or abroad), and patents granted.

Licensing. Licensing of intellectual property, such as patents or copyrights, to outside parties.

Collaborative relationships for R&D. Including, but not limited to, Cooperative Research and Development Agreements (CRADAs)

In addition, the statutory annual tech transfer performance reporting by agencies with federal labs, established by the Technology Transfer Commercialization Act of 2000, provides data on downstream outcomes and impacts.

federal funding.[33] Several participating R&D agencies also offer bridge funding to phase III and other commercialization support for startups (NRC 2008:208–216).[34]

Federal agencies with extramural R&D budgets exceeding $1 billion are required to set aside 0.3% of their extramural R&D budget for STTR awards. The program is also structured in three phases and involves R&D performed jointly by small businesses, universities, and nonprofit research organizations. In FY 2008, federal agencies awarded 734 STTR grants valued at $240 million (appendix tables 4-39 and 4-41).

The Technology Innovation Program was set up for "the purpose of assisting U.S. businesses and institutions of higher education or other organizations, such as national laboratories and nonprofit research institutions, to support, promote, and accelerate innovation in the United States through high-risk, high-reward research in areas of critical national need."[35] Two areas of focus in recent funding competitions were advanced manufacturing materials and advanced sensors to support monitoring and assessment of civil infrastructure, such as water pipelines, roads, bridges, and tunnels. From FY 2008 to FY 2010, TIP made 38 competitive awards involving 78 participants including small businesses and universities. Over this period, awards reached $281 million, including $136 million from TIP and $145 million in industry-cost sharing funds (appendix table 4-42).

International R&D Comparisons

Data on R&D expenditures by country and region provide a broad picture of the changing distribution of R&D capabilities and activities around the world. R&D data available from the OECD cover the organization's 34 member countries and 7 nonmembers.[36] The United Nations Educational, Scientific, and Cultural Organization's (UNESCO's) Institute for Statistics provides data on additional countries. The discussion in this section draws on both of these datasets.

International comparisons necessarily involve currency conversions. The analysis in this section follows the international convention of converting foreign currencies into U.S. dollars via purchasing power parity (PPP) exchange rates. (See sidebar, "Comparing International R&D Expenditures.")

Global Patterns of R&D Expenditures

Worldwide R&D expenditures totaled an estimated $1,276 billion (purchasing power parities) in 2009. The corresponding estimate, 5 years earlier in 2004 was $873 billion. Ten years earlier, in 1999, it was $641 billion. By these figures, growth in these global totals has been rapid, averaging nearly 8% annually over the last 5 years and 7% over the last 10 years.

Overall, global R&D performance remains highly concentrated in three geographic regions, North America, Asia, and Europe (figure 4-14). North America (United States, Canada, Mexico) accounted for 34% ($433 billion) of worldwide R&D performance in 2009; the combination of East/Southeast and South Asia (including China, Taiwan, Japan, India, South Korea), 32% ($402 billion); and Europe, including (but not limited to) European Union (EU) countries, 25% ($319 billion). The remainder, approximately 10%, reflects the R&D of countries in the regions of Central and South America, Central Asia, Middle East, Australia/Oceania, and Africa.

Table 4-18

Federal laboratory technology transfer activity indicators, total and selected U.S. agencies: FY 2004 and FY 2009

Technology transfer activity	All federal labs	DOD	HHS	DOE	NASA	USDA	DOC
	FY 2009						
Invention disclosures and patenting							
Inventions disclosed	4,422	831	389	1,439	1,373	153	49
Patent applications	2,080	690	156	919	126	117	19
Patents issued	1,494	404	397	520	114	21	7
Licensing							
All licenses, total active in fiscal year	10,913	432	1,584	5,752	2,497	316	40
Invention licenses	4,226	386	1,304	1,452	504	316	40
Other intellectual property licenses	6,730	46	327	4,300	1,993	0	0
Collaborative relationships for R&D							
CRADAs, total active in fiscal year	7,733	2,870	457	744	1	233	2,386
Traditional CRADAs	4,219	2,247	284	744	1	191	77
Other collaborative R&D relationships	16,319	1	0	0	2,743	9,960	3,608
	FY 2004						
Invention disclosures and patenting							
Inventions disclosed	5,454	1,369	461	1,617	1,612	142	25
Patent applications	1,768	517	216	661	207	81	12
Patents issued	1,391	426	167	520	189	50	12
Licensing							
All licenses, total active in fiscal year	7,567	369	1,424	4,345	861	296	125
Invention licenses	3,804	364	1,173	1,362	338	296	125
Other intellectual property licenses	3,775	5	251	2,983	523	0	0
Collaborative relationships for R&D							
CRADAs, total active in fiscal year	6,015	2,833	220	610	0	205	1,969
Traditional CRADAs	3,546	2,425	119	610	0	185	67
Other collaborative R&D relationships	7,454	0	0	0	3,987	1,166	2,301

CRADA = Cooperative Research and Development Agreement; DOC = Department of Commerce; DOD = Department of Defense; DOE = Department of Energy; HHS = Department of Health and Human Services; NASA = National Aeronautics and Space Administration; USDA = U.S. Department of Agriculture

NOTES: Other federal agencies not listed but included in the All federal labs totals are the Department of Homeland Security, Department of the Interior, Department of Transportation, Department of Veterans Affairs, and Environmental Protection Agency. Invention licenses refers to inventions that are patented or could be patented. Other intellectual property (IP) refers to IP protected through mechanisms other than a patent, e.g., copyright. Total CRADAs refers to all agreements executed under CRADA authority (15 USC 3710a). Traditional CRADAs are collaborative R&D partnerships between a federal lab and one or more nonfederal organizations. Federal agencies have varying authorities for other kinds of collaborative R&D relationships.

SOURCE: National Institute of Standards and Technology, *Federal Laboratory Technology Transfer, Fiscal Year 2009 Summary Report to the President and the Congress*, March 2011, http://www.nist.gov/tpo/publications/upload/Federall-Lab-TT-Report-FY2009.pdf See also appendix table 4-38.

Science and Engineering Indicators 2012

The geographic concentration is more apparent when looking at specific countries (table 4-19). Three countries account for more than half of global R&D. The United States is by far the largest R&D performer ($402 billion in 2009), accounting for about 31% of the global total, but down from 38% in 1999. China became the second largest performer ($154 billion) in 2009, accounting for about 12% of the global total. Japan moved down to third, at 11% ($138 billion). The largest EU performers spend comparatively less: Germany ($83 billion, 6%), France ($48 billion, 4%), and the United Kingdom ($40 billion, 3%). The most recent figure available for South Korea is 2008, with $44 billion of R&D—in recent years South Korea has typically been among the top seven R&D performing countries, representing 3%–4% of the global total. Taken together, these top seven countries account for about 71% of the global total. Russia, Italy, Canada, India, Brazil, Taiwan, and Spain comprise a next lower rung, with national R&D expenditures ranging from $20 billion to $33 billion.

Besides the generally vigorous pace at which the global total of R&D is now growing, the other major trend has been the rapid expansion of R&D performance in the regions of East/Southeast Asia and South Asia, including countries such as China, India, Japan, Malaysia, Singapore, South Korea, Taiwan, and Thailand. The R&D performed in these two Asian regions represented only 24% of the global R&D total in 1999, but accounted for 32% in 2009, including China (12%) and Japan (11%).

China continues to exhibit the most dramatic R&D growth pattern (figure 4-15). The World Bank revised China's PPP exchange rate in late 2007, significantly lowering the dollar value of its R&D expenditures. Nonetheless, the pace of real growth over the past 10 years (1999–2009) in China's overall R&D remains exceptionally high at about 20% annually.

Comparing International R&D Expenditures

Comparisons of international R&D statistics are hampered by the lack of R&D-specific exchange rates. Two approaches are commonly used to facilitate international R&D comparisons: (1) express national R&D expenditures as a percentage of GDP or (2) convert all expenditures to a single currency. The first method is straightforward but permits only gross comparisons of R&D intensity. The second method permits absolute level-of-effort comparisons and finer-grain analyses but entails choosing an appropriate method of currency conversion. The choice is between market exchange rates (MERs) and purchasing power parities (PPPs), both of which are available for a large number of countries over an extended period.

MERs represent the relative value of currencies for cross-border trade of goods and services but may not accurately reflect the cost of non-traded goods and services. They are also subject to currency speculation, political events, wars or boycotts, and official currency intervention.

PPPs were developed to overcome these shortcomings (Ward 1985). They take into account the cost differences of buying a similar market basket of goods and services covering tradables and nontradables. The PPP basket is assumed to be representative of total GDP across countries. PPPs are the preferred international standard for calculating cross-country R&D comparisons and are used in all official R&D tabulations of the OECD.*

Because MERs tend to understate the domestic purchasing power of developing countries' currencies, PPPs can produce substantially larger R&D estimates than MERs for these countries. For example, China's 2006 R&D expenditures (as reported to the OECD) are $38 billion using MERs but $87 billion using PPPs. (Appendix table 4-2 lists the relative difference between MERs and PPPs for a number of countries.)

However, PPPs for large, developing countries such as India and China are often rough approximations and have other shortcomings. For example, structural differences and income disparities between developing and developed countries may result in PPPs based on markedly different sets of goods and services. In addition, the resulting PPPs may have very different relationships to the cost of R&D in different countries.

R&D performance in developing countries often is concentrated geographically in the most advanced cities and regions in terms of infrastructure and level of educated workforce. The costs of goods and services in these areas can be substantially greater than for the country as a whole.

*Recent research raises some questions about the use of GDP PPPs for deflating R&D expenditures. In analyzing the manufacturing R&D inputs and outputs of six industrialized OECD countries, Dougherty et al. (2007) conclude that "the use of an R&D PPP will yield comparative costs and R&D intensities that vary substantially from the current practice of using GDP PPPs, likely increasing the real R&D performance of the comparison countries relative to the United States." The issue remains unresolved.

The rate of growth in South Korea's R&D has also been relatively high, averaging nearly 10% annually over the 10-year period. Growth in Japan has been slower, at an annual average rate of 4.0%.

By comparison, while the U.S. remains atop the list of the world's R&D performing nations, its pace of growth in R&D performance has averaged 5.0% over the same 1999–2009 period, and its share of global R&D has declined from 38% to 31% over this time. Total R&D by EU nations has been growing (current dollars) over the same 10 years at an average annual rate of 5.8%. The pace of growth during the same period for Germany, France, and the United Kingdom has been somewhat slower, averaging 5.3%, 4.5%, and 4.5%, respectively. The EU countries accounted for 23% total global R&D in 2009, down from 27% in 1999.[37]

Comparison of Country R&D Intensities

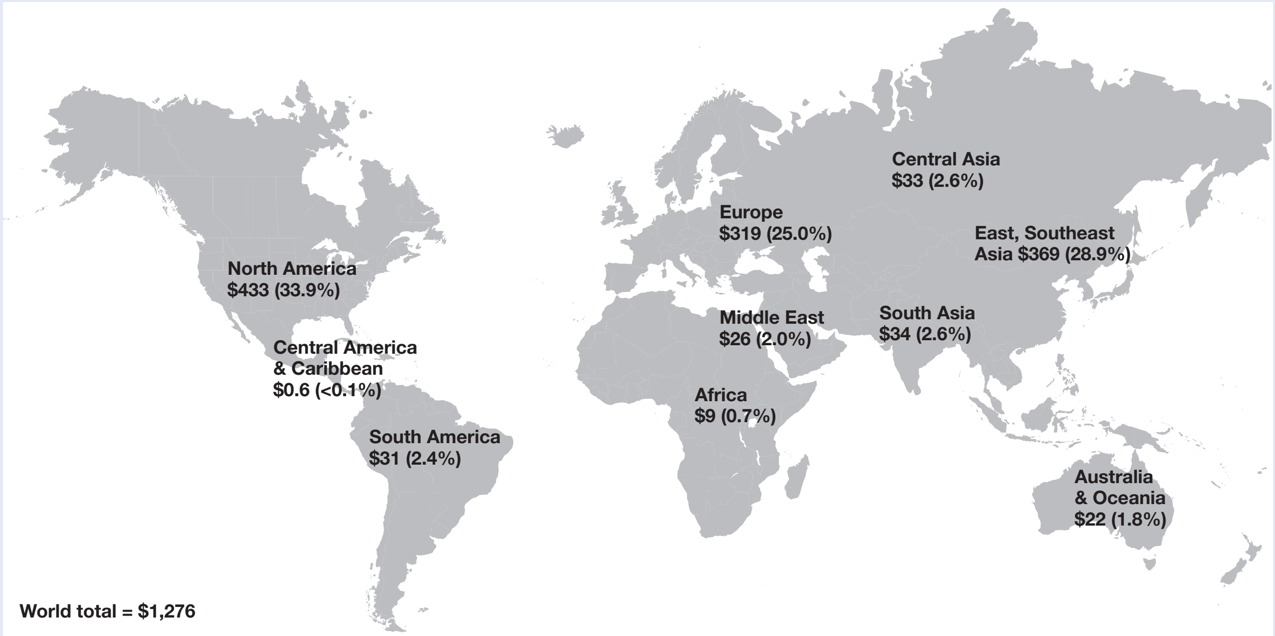
R&D intensity provides another basis for international comparisons of R&D performance. This approach does not require conversion of a country's currency to a standard international benchmark yet still provides a way to adjust for differences in the sizes of national economies. (For additional background on R&D intensity and how it is affected by the economic make-up of a country, see sidebar, "R&D Intensity and the Composition of Gross Domestic Product.")

Total R&D/GDP Ratios

The U.S. R&D/GDP ratio was just under 2.9% in 2009 (table 4-19). At this level, the United States is eighth among the economies tracked by the OECD and UNESCO. Israel continues to have the highest ratio, at 4.3%—although Finland is not far back at 4%. Sweden, Japan, and South Korea all have ratios well above 3%; Switzerland and Taiwan are slightly above the U.S. figure.

The R&D/GDP ratio in the United States has ranged from 1.4% in 1953 to a high of 2.9% in 1964, and has fluctuated in the range of 2.6% to 2.7% in recent years (figure 4-16). Most of the growth over time in the U.S. R&D/GDP ratio can be attributed to increases in nonfederal R&D spending, financed primarily by business. Nonfederally financed R&D increased from about 0.6% of GDP in 1953 to about 2.0% of GDP in 2009. This increase in the nonfederal R&D/GDP ratio reflects the growing role of business R&D in the national R&D system and, more broadly, the growing prominence of R&D-derived products and services in the national and global economies.

Figure 4-14
Global R&D expenditures by region: 2009
U.S. PPP dollars (billions)



PPP = purchasing power parity

NOTES: Foreign currencies converted to U.S. dollars through purchasing power parities. Some country figures are estimated. Countries are grouped according to the regions described by *The World Factbook*, www.cia.gov/library/publications/the-world-factbook/index.html

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, estimates, July 2011. Based on data from Organisation for Economic Co-operation and Development, Main Science and Technology Indicators (2011/1); and United Nations Educational, Scientific, and Cultural Organization (UNESCO) Institute for Statistics, http://stats.uis.unesco.org/unesco/ReportFolders/ReportFolders.aspx, table 25, accessed 13 July 2011.

Science and Engineering Indicators 2012

Among other top seven R&D-performing countries, total R&D/GDP ratios over the 1999–2009 period show mixed trends (figure 4-16). Compared with 1999 R&D/GDP ratios, the 2009 ratios were substantially higher in Japan, Germany, and South Korea. (However, Japan's rising ratio reflects the confluence of declining GDP and largely flat R&D spending.) Most notably, China's ratio more than doubled over this 10-year period. For the United Kingdom, the 2009 ratio remained about the same, and for France, it slightly increased.

In addition to the United States, countries in Nordic and Western Europe and the most advanced areas of Asia have R&D/GDP ratios above 1.5%. This pattern broadly reflects the global distribution of wealth and level of economic development. Countries with high incomes tend to emphasize the production of high-technology goods and services and are also those that invest heavily in R&D activities. Private sectors in low-income countries often have a low concentration of high-technology industries, resulting in low overall R&D spending and, therefore, low R&D/GDP ratios.

Nondefense R&D and Basic Research

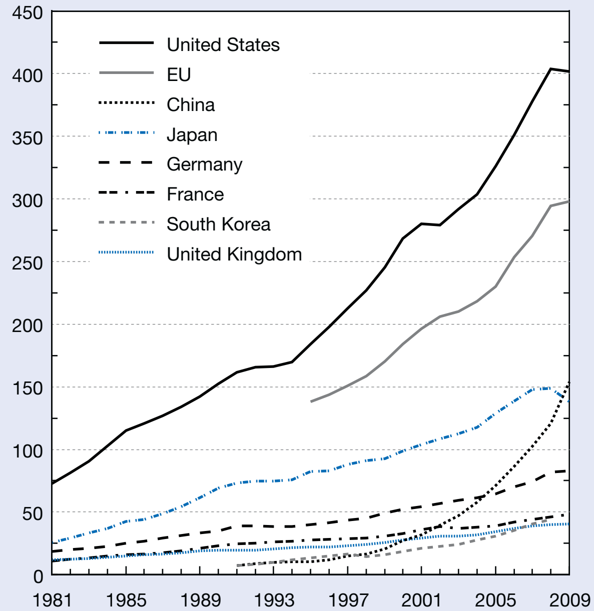
Further perspective is provided by the ratio of nondefense R&D expenditures to GDP. This ratio more directly measures civilian R&D intensity and is useful when comparing nations with substantially different financial commitments to national defense. Table 4-20 provides such figures for the top seven R&D performing nations, for 2009 or most recent data year. The U.S. ratio (2.3% in 2009) ranks ahead of that for the United Kingdom and France but lags behind Japan, South Korea, and Germany. (Data on this metric for China are not currently available.)

Another perspective comes from the extent to which spending on basic research accounts for a country's total R&D/GDP ratio. Estimates of the relative volume of basic research spending can provide a glimpse of the extent to which R&D resources are directed toward advancing the scientific knowledge base.

In 2009, the U.S. basic research/R&D ratio is about 0.6% and accounts for about a fifth of the total R&D/GDP ratio (table 4-20). France's basic research ratio is slightly below the U.S. figure and accounts for just over a quarter of its total ratio. South Korea's basic research ratio is close to the U.S. and French figures. The basic research ratios for Japan, the United Kingdom, and, especially, China are below the U.S. figure.

Figure 4-15
Gross domestic expenditures on R&D by the United States, EU, and selected other countries: 1981–2009

Constant PPP dollars (billions)



EU = European Union; PPP = purchasing power parity

NOTES: Data not available for all countries in all years. Data for United States in this figure reflect international standards for calculating gross expenditures on R&D, which vary slightly from NSF approach to tallying U.S. total R&D. Data for Japan for 1996 onward may not be consistent with earlier data due to changes in methodology. EU data for all years based on current 27 EU member countries.

SOURCE: Organisation for Economic Co-operation and Development, Main Science and Technology Indicators (2011/1). See appendix table 4-43.

Science and Engineering Indicators 2012

R&D by Performing Sector and Source of Funds

The business sector is the predominant R&D performer for all seven of the top R&D performing nations (table 4-21).[38] For the U.S., the business sector accounted for 70% of gross expenditures on R&D in 2009. Japan's business sector was the highest, accounting for almost 76% of the country's total R&D. China and South Korea were also well above the U.S. level. France and the United Kingdom were somewhat lower, at, respectively, 62% and 60%.

R&D performance by the government ranges over 9%–19% of total national R&D for the seven countries. Japan (9%) and the United Kingdom (9%) are on the lower end of this range. China (19%) and France (16%) are at the high end. The U.S., South Korea, and Germany lie in between.

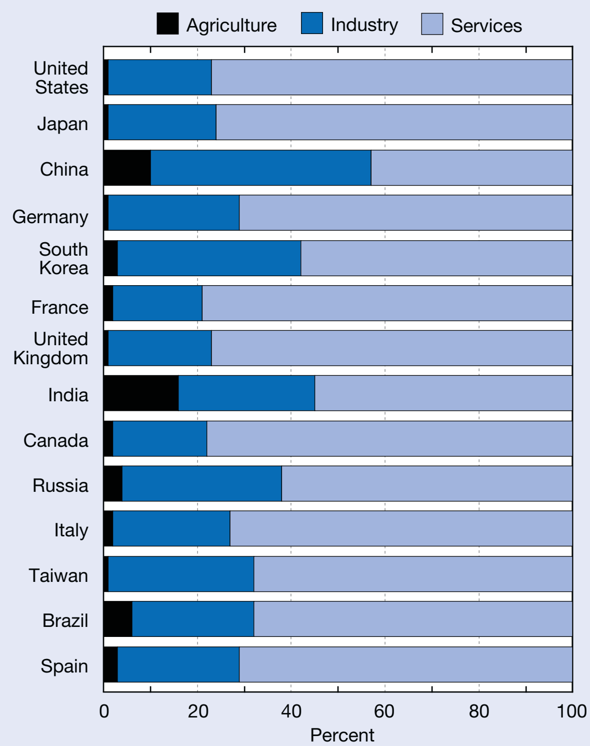
Academic R&D ranges from 8% to 28% of total national R&D performance for these countries. China is the low point, at 8%. The United Kingdom is the highest, at 28%. The U.S. (14%), Japan (13%), and South Korea (11%) have lower shares; Germany (18%) and France (21%), higher shares.

R&D Intensity and the Composition of Gross Domestic Product

The structure of a nation's economy can be a consideration in interpreting and comparing national R&D intensity statistics. That is, the relative prominence of major sectors such as agriculture, manufacturing, and services can directly influence the ratio of overall R&D expenditures to gross domestic product. Businesses and organizations differ widely in their relative need for investment in the latest science and technology. So, countries whose overall GDP depends more heavily on advanced technology industries will typically exhibit higher R&D/GDP ratios than other countries.

Agriculture is a comparatively small component (6% or less) for all but 2 of the top 14 R&D performing countries (figure 4-B). The exceptions are India, where agriculture currently accounts for about 16% of its GDP, and China, where it is 10%. Industrial production (manufacturing) is 20%–30% of GDP for all but three of the countries. China is a much higher 47%; South Korea is 39% and Russia 34%. Services are 60%–70% of national GDP for all but 2 of the 14 countries. China is substantially less services-dependent, at 44% of GDP, and India is somewhat less so, at 55%.

Figure 4-B
Composition of gross domestic product, for selected countries/economies, by sector: 2010



NOTES: Data are estimates. Latest data for South Korea are 2008. Fourteen largest R&D performing countries (see table 4-20).

SOURCE: Central Intelligence Agency, *The World Factbook*, https://www.cia.gov/library/publications/the-world-factbook/index.html, accessed 16 March 2011.

Science and Engineering Indicators 2012

Table 4-19
International comparisons of gross domestic expenditures on R&D and R&D share of gross domestic product, by region and selected country/economy: 2009 or most recent year

Region/country/economy	GERD (PPP $millions)	GERD/GDP (%)
North America		
United States (2009)[a]	401,576.5	2.88
Canada (2009)	24,551.3	1.92
Mexico (2007)	5,719.6	0.37
South America		
Brazil (2008)	21,649.4	1.08
Argentina (2007)	2,678.8	0.51
Chile (2004)	1,227.7	0.68
Europe		
Germany (2009)	82,730.7	2.78
France (2009)	47,953.5	2.21
United Kingdom (2009)	40,279.5	1.85
Italy (2009)	24,752.6	1.27
Spain (2009)	20,496.4	1.38
Sweden (2009)	12,494.9	3.62
Netherlands (2009)	12,273.8	1.82
Switzerland (2008)	10,512.7	3.00
Austria (2009)	8,931.3	2.75
Belgium (2009)	7,684.9	1.96
Finland (2009)	7,457.8	3.96
Denmark (2009)	6,283.8	3.02
Norway (2009)	4,734.1	1.76
Poland (2009)	4,874.9	0.68
Portugal (2009)	4,411.0	1.66
Czech Republic (2009)	4,094.8	1.53
Ireland (2009)	3,164.6	1.79
Ukraine (2009)	2,485.7	0.86
Hungary (2009)	2,333.8	1.15
Romania (2009)	1,471.5	0.47
Greece (2007)	1,867.9	0.59
Belarus (2009)	813.3	0.65
Slovenia (2009)	1,043.6	1.86
Croatia (2009)	743.1	0.84
Luxembourg (2009)	708.5	1.68
Slovak Republic (2009)	595.5	0.48

Region/country/economy	GERD (PPP $millions)	GERD/GDP (%)
Middle East		
Israel (2009)	8,810.1	4.28
Turkey (2009)	8,681.2	0.85
Iran (2008)	6,465.2	0.79
Africa		
South Africa (2008)	4,689.3	0.93
Egypt (2009)	997.3	0.21
Morocco (2006)	765.1	0.64
Tunisia (2009)	1,048.5	1.21
Central Asia		
Russian Federation (2009)	33,368.1	1.24
South Asia		
India (2007)	24,439.4	0.76
Pakistan (2009)	2,055.2	0.46
East, Southeast Asia		
Japan (2009)	137,908.6	3.33
China (2009)	154,147.4	1.70
South Korea (2008)	43,906.4	3.36
Taiwan (2009)	21,571.8	2.93
Singapore (2009)	5,626.5	2.35
Malaysia (2006)	2,090.9	0.64
Thailand (2007)	1,120.8	0.21
Australia, Oceania		
Australia (2008)	18,755.0	2.21
New Zealand (2007)	1,422.5	1.17
Selected country groups		
EU (2009)	297,889.6	1.90
OECD (2008)	965,629.1	2.33
G-20 countries (2009)	1,181,263.7	2.01

EU = European Union; GDP = gross domestic product; GERD = gross expenditures (domestic) on R&D; OECD = Organisation for Economic Co-operation and Development; PPP = purchasing power parity

[a] Figures for the United States in this table may differ slightly from those cited earlier in the chapter. Data here reflect international standards for calculating GERD, which vary slightly from NSF protocol for tallying U.S. total R&D.

NOTES: Year of data listed in parentheses. Foreign currencies converted to dollars through purchasing power parities. Countries with annual GERD of $500 million or more. Countries are grouped according to the regions described by the *The CIA World Factbook,* www.cia.gov/library/publications/the-world-factbook/index.html. No countries in the Central America/Caribbean region had annual GERD of $500 million or more. Data for Israel are civilian R&D only. See sources below for GERD statistics on additional countries.

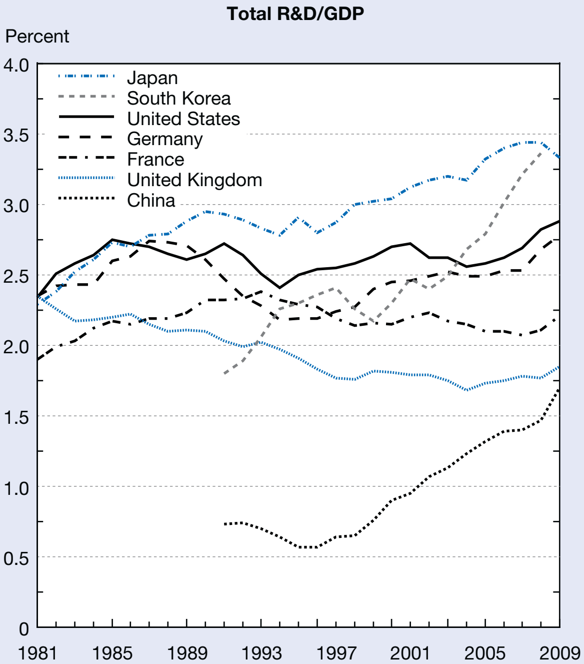
SOURCES: OECD, Main Science and Technology Indicators (2011/1); United Nations Educational, Scientific, and Cultural Organization (UNESCO) Institute for Statistics, http://stats.uis.unesco.org/unesco/ReportFolders/ReportFolders.aspx, table 25, accessed 13 July 2011.

Science and Engineering Indicators 2012

With regard to the funding of R&D, the business sector is again the predominant source for all seven of the top R&D performing nations (table 4-22). In 2009, funding for about 75% of Japan's total national R&D came from the business sector. The corresponding figures for South Korea, China, and Germany are also high, in the 67%–73% range. R&D funding from business is lower, but still predominant, in the U.S., at 60%. The corresponding figures for France (51%) and the United Kingdom (45%) are notably lower.

Government is the second major source of R&D funding for these seven countries. France is the highest, at 39%. The lowest is Japan at 18%. The United Kingdom (33%),

Figure 4-16
Gross expenditures on R&D as share of gross domestic product, for selected countries: 1981–2009



GDP = gross domestic product

NOTES: Top seven R&D performing countries. Data not available for all countries for all years. Figures for the United States reflect international standards for calculating gross expenditures on R&D, which differ slightly from the NSF protocol for tallying U.S. total R&D. Data for Japan, for 1996 onward, may not be consistent with earlier data due to changes in methodology.

SOURCE: Organisation for Economic Co-operation and Development, Main Science and Technology Indicators (2011/1). See appendix table 4-43.

Science and Engineering Indicators 2012

Germany (28%), and United States (31%) are on the higher side. South Korea (25%) and China (23%) are in between.

Funding from abroad refers to funding from businesses, universities, governments, and other organizations located outside of the country. Table 4-22 shows this funding category for selected OECD countries. For the U.S., data on funding from abroad is available only for the business sector.

Government R&D Priorities

The mix of government funding for R&D across differing objectives (e.g., defense, health, space, general research) provides insights into government R&D priorities. The OECD compiles such statistics annually on its member countries and selected others: government budget appropriations or outlays for R&D (GBAORD). GBAORD indicators for the United States and other top R&D performing countries appear in table 4-23, broken down by a number of major socioeconomic objectives.

Defense is an objective for government funding of R&D for all the top R&D-performing countries, but the share varies widely (table 4-23). Defense accounted for 52% of U.S. federal R&D support in 2009, but was markedly lower elsewhere: a smaller but still sizable 28% in France and 18% in the United Kingdom, 17% in South Korea, and below 6% in both Germany and Japan.

Defense has remained the focus of more than 50% of the federal R&D budget in the United States for much of the past 25 years. It was 63% in 1990 as the long Cold War period drew to a close, but dropped in subsequent years. The defense share of government R&D funding for the other countries over the past 25 years has generally declined or remained at a stable, low level.

The health and environment objective now accounts for some 56% of nondefense federal R&D budget support in the United States and 29% in the United Kingdom. For both countries, the share has expanded dramatically over the share prevailing several decades ago. The health and environment share is currently 19% in South Korea, 15% in France, and 10% or less in Germany and Japan. The funding under this objective goes primarily into the health arena in the United States and the United Kingdom (appendix table 4-45). In the other countries, it is more balanced between health and the environment.

The economic development objective encompasses agriculture, fisheries and forestry, industry, infrastructure, and energy. The share of nondefense government R&D support allocated to economic development has generally declined over the past 25 years across the OECD countries. In the United States, it was 36% of all nondefense federal support for R&D in 1981, dropping to 13% in 2009.[39] In the United Kingdom, it was 39% in 1981, declining to 9% in 2009. Despite a decline, support for this objective remains substantial in some countries: 23% in Germany and 24% in France (both with particular attention to industrial production and technology) and 31% in Japan (notably in energy and industrial production and technology). South Korea currently has by far the largest share for this objective, 52%, with a particularly strong emphasis in recent years on industrial production and technology.

The civil space objective now accounts for 11% of nondefense federal R&D funding in the United States. The share has been above or around 20% in the United States for much of the past 25 years. The share in France is currently about 13%, and has been around that level for almost 20 years. The share has been well below 10% for the rest of the top R&D countries.

Both the non-oriented research and general university funds (GUF) objectives reflect government funding for R&D by academic, government, and other performers that is directed chiefly at the general advancement of knowledge in the natural sciences, engineering, social sciences, humanities, and related fields. For some of the countries, the sum of these two objectives currently represents by far the largest part of nondefense GBAORD: Germany (58%), Japan (54%), the United Kingdom (54%), and France (45%). The corresponding 2009 shares for the United States (18%) and South Korea (23%) are substantially smaller. Nevertheless, cross-national comparisons of these particular indicators can be difficult, since some countries (notably the U.S.) do not use the GUF mechanism to

Table 4-20
Expenditures on R&D as share of gross domestic product for all R&D, nondefense R&D, and basic research, by selected country/economy: 2009 or most recent year

Country/economy	All R&D/GDP	Nondefense R&D/GDP	Fraction of all (%)	Basic research R&D/GDP	Fraction of all (%)
United States (2009)[a]	2.88	2.3	81	0.55	19
China (2009)	1.70	NA	NA	0.08	5
Japan (2009)	3.33	3.3	99	0.42	13
Germany (2008)	2.68	2.6	97	NA	NA
France (2008)	2.11	1.9	90	0.54	26
South Korea (2008)	3.36	3.2	95	0.54	16
United Kingdom (2009)	1.85	1.7	92	0.21	11
Russian Federation (2009)	1.24	NA	NA	0.25	20
India (2007)	0.76	NA	NA	NA	NA
Italy (2009)	1.27	1.3	102	0.33	26
Canada (2009)	1.92	NA	NA	NA	NA
Brazil (2008)	1.08	NA	NA	NA	NA
Taiwan (2009)	2.93	2.9	99	0.30	10
Spain (2008)	1.35	1.3	96	0.23	17

NA = not available
GDP = gross domestic product

[a]Figures for United States in this table reflect international standards for calculating gross expenditures on R&D, which vary slightly from NSF protocol for tallying U.S. total R&D.

NOTES: Top 14 countries globally in annual gross expenditures on R&D. Year of data listed in parentheses.

SOURCE: Organisation for Economic Co-operation and Development, Main Science and Technology Indicators (2011/1). Data for Brazil and India from United Nations Educational, Scientific, and Cultural Organization (UNESCO) Institute for Statistics, http://stats.uis.unesco.org/unesco/ReportFolders/ReportFolders.aspx, table 26, accessed 13 July 2011.

Science and Engineering Indicators 2012

Table 4-21
Gross expenditures on R&D by performing sector, by selected country/economy: 2009 or most recent year
(Percent)

Country/economy	Business	Government	Higher education	Private nonprofit
United States (2009)[a]	70.3	11.7	13.5	4.4
China (2009)	73.2	18.7	8.1	0.0
Japan (2009)	75.8	9.2	13.4	1.6
Germany (2009)	67.5	14.9	17.6	**
France (2009)	61.9	16.3	20.6	1.2
South Korea (2008)	75.4	12.1	11.1	1.4
United Kingdom (2009)	60.4	9.2	27.9	2.5
Russian Federation (2009)	62.4	30.3	7.1	0.2
India (2007)	33.9	61.7	4.4	**
Italy (2009)	51.5	13.9	31.4	3.2
Canada (2009)	51.7	10.1	37.6	0.6
Brazil (2004)	40.2	21.3	38.4	0.1
Taiwan (2008)	70.1	16.8	12.8	0.4
Spain (2009)	51.9	20.1	27.8	0.2

** = included in other performing sectors

[a]Figures for the United States in this table reflect international standards for calculating gross expenditures on R&D, which vary slightly from NSF protocol for tallying U.S. total R&D.

NOTES: Top 14 R&D performing countries. Year of data listed in parentheses. Percentages may not add to 100 due to rounding.

SOURCES: Organisation for Economic Co-operation and Development, Main Science and Technology Indicators (2011/1). Data for Brazil and India from United Nations Educational, Scientific, and Cultural Organization (UNESCO) Institute for Statistics, http://stats.uis.unesco.org/unesco/ReportFolders/ReportFolders.aspx, table 27, accessed 18 July 2011.

Science and Engineering Indicators 2012

Table 4-22
Gross expenditures on R&D by funding source, by selected country/economy: 2009 or most recent year
(Percent)

Country/economy	Business	Government	Other domestic	From abroad
United States (2009)[a]	59.7	31.3	7.2	1.9
China (2009)	71.7	23.4	NA	1.3
Japan (2009)	75.3	17.7	6.6	0.4
Germany (2008)	67.3	28.4	0.3	4.0
France (2008)	50.7	38.9	2.3	8.0
South Korea (2008)	72.9	25.4	1.4	0.3
United Kingdom (2009)	44.5	32.6	6.3	16.6
Russian Federation (2009)	26.6	66.5	0.5	6.5
India (2007)	33.9	66.1	**	NA
Italy (2008)	45.2	42.9	4.1	7.8
Canada (2009)	47.6	33.4	12.1	6.9
Brazil (2008)	43.9	54.0	2.2	NA
Taiwan (2009)	69.7	28.9	1.3	*
Spain (2008)	45.0	45.6	3.8	5.7

NA = not available; * = <0.05%.; ** = included in other funding sectors

[a]Figures for the United States in this table reflect international standards for calculating gross expenditures on R&D, which vary slightly from NSF protocol for tallying U.S. total R&D. Figures for funding from abroad based primarily on funding for business R&D.

NOTES: Top 14 R&D performing countries. Year of data listed in parentheses. Percentages may not add to 100 due to rounding. For the United States, data on R&D funding from abroad are not separately identified and instead are included in sector totals. In most other countries, funding from abroad is a distinct and separate category.

SOURCES: Organisation for Economic Co-operation and Development, Main Science and Technology Indicators (2011/1). Data for Brazil and India from United Nations Educational, Scientific, and Cultural Organization (UNESCO) Institute for Statistics, http://stats.uis.unesco.org/unesco/ReportFolders/ReportFolders.aspx, table 28, accessed 18 July 2011.

Science and Engineering Indicators 2012

fund general advancement of knowledge R&D, do not separately account for GUF funding (e.g., South Korea), and/or more typically direct R&D funding to project-specific grants or contracts (which are then assigned to the more specific socioeconomic objectives). For a further discussion of this topic, see the sidebar "Government Funding Mechanisms for Academic Research" later in this chapter.

Finally, the education and society objective represents a comparatively small component of nondefense government R&D funding for all seven of the countries. However, it is notably higher in Germany (4%), France (4%), and the United Kingdom (6%), than in the United States (2%) and Japan (1%). South Korea is in between at 3%.

Business R&D Focus

Business R&D varies substantially among countries in terms of both industry concentration and sources of funding. Because businesses account for the largest share of total R&D performance in the United States and most OECD countries, differences in business structure can help explain international differences in more aggregated statistics such as R&D/GDP. For example, countries with higher concentrations of R&D-intensive industries (such as communication, television, and radio equipment manufacturing) are likely to also have higher R&D/GDP ratios than countries whose business structures are weighted more heavily toward less R&D-intensive industries.

Using internationally comparable data, no one industry accounted for more than 19% of total business R&D in the United States in 2008[40] (figure 4-17 and appendix table 4-46), based on OECD's Analytical Business Enterprise R&D-Statistical Analysis Database (ANBERD-STAN) (OECD 2011a). This is largely a result of the size of business R&D expenditures in the United States, which makes it difficult for any one sector to dominate. However, the diversity of R&D investment by industry in the United States is also an indicator of how the nation's accumulated stock of knowledge and well-developed S&T infrastructure have made it an attractive location for R&D performance in a broad range of industries.

Compared with the United States, smaller economies shown in figure 4-17 display much higher concentration in particular industries. For example, in South Korea, one of the world's top producers of communication, TV, and radio equipment industry, which includes semiconductors, this industry accounted for 46% of the country's business R&D.[41]

The spread of global production networks and value chains is also reflected in these indicators. Automotive manufacturers rank among the largest R&D-performing companies in the world (see sidebar, "Global R&D Expenses of Public Corporations"). The automotive industry has also highly distributed production and technical sites globally. Thus, countries that are home to major automotive MNCs and/or serve as host countries for MNCs affiliates, their

Table 4-23
Government R&D support by major socioeconomic objectives, by selected region/country: 1981–2009

Region/country and year	GBAORD (current US$ millions, PPP)	Percent of GBAORD		Percent of nondefense					
		Defense	Nondefense	Economic development programs	Health and environment	Education and society	Civil space	Non-oriented research	General university funds (GUF)
United States									
1981	33,735.0	54.6	45.4	36.1	31.2	3.6	20.3	8.7	na
1990	63,781.0	62.6	37.4	22.2	40.2	3.4	24.2	10.1	na
2000	83,612.5	51.6	48.4	13.4	49.9	1.8	20.9	13.8	na
2009	164,292.0	51.6	48.4	13.3	55.9	1.5	11.4	17.8	na
EU									
1981	na	na	na	na	na	na	na	na	na
1990	na	na	na	na	na	na	na	na	na
2000	73,559.9	13.1	86.9	22.7	11.6	3.4	6.1	15.7	34.9
2008	110,238.5	9.6	90.4	23.5	14.8	5.9	4.9	17.3	33.8
Germany									
1981	8,572.5	8.9	91.1	34.9	9.6	4.5	4.5	46.5	0.0
1990	13,269.1	13.5	86.5	25.9	10.8	2.9	6.8	15.2	37.6
2000	16,806.2	7.8	92.2	21.6	9.4	3.9	5.1	17.5	42.4
2009	25,857.8	5.7	94.3	23.0	10.3	4.1	5.4	18.2	39.6
France									
1981	8,531.3	38.4	61.6	37.9	13.3	2.0	6.7	39.1	0.0
1990	13,228.6	40.0	60.0	32.8	9.3	0.8	13.0	24.6	18.9
2000	14,738.0	21.4	78.6	17.7	9.7	1.1	13.2	27.4	28.5
2008	16,171.9	28.3	71.7	24.3	15.0	3.6	12.5	6.4	39.0
United Kingdom									
1981	6,731.2	46.3	53.7	38.5	13.1	1.5	3.8	10.6	29.6
1990	8,113.8	43,5	56.5	31.9	18.1	4.0	5.5	10.3	29.8
2000	10,357.6	36.2	63.8	12.1	28.3	6.4	3.5	18.8	30.4
2009	15,146.3	18.3	81.7	9.3	28.8	5.7	2.3	23.8	30.1
Japan									
1981	NA	NA	NA	NA	NA	NA	NA	NA	NA
1990	10,142.0	5.4	94.6	33.9	4.5	1.1	6.9	8.4	45.1
2000	21,223.0	4.1	95.9	33.4	6.6	1.0	5.8	14.6	37.0
2009	31,072.5	3.7	96.3	30.5	7.2	1.0	7.5	18.3	35.5
China									
1981	NA	NA	NA	NA	NA	NA	NA	NA	NA
1990	NA	NA	NA	NA	NA	NA	NA	NA	NA
2000	NA	NA	NA	NA	NA	NA	NA	NA	NA
2009	NA	NA	NA	NA	NA	NA	NA	NA	NA
South Korea									
1981	NA	NA	NA	NA	NA	NA	NA	NA	NA
1990	NA	NA	NA	NA	NA	NA	NA	NA	NA
2000	5,024.7	20.5	79.5	53.4	14.8	3.8	3.1	24.9	**
2009	13,209.6	16.7	83.3	52.0	18.6	2.8	3.7	22.8	**

** = included in other categories; na = not applicable; NA = not available

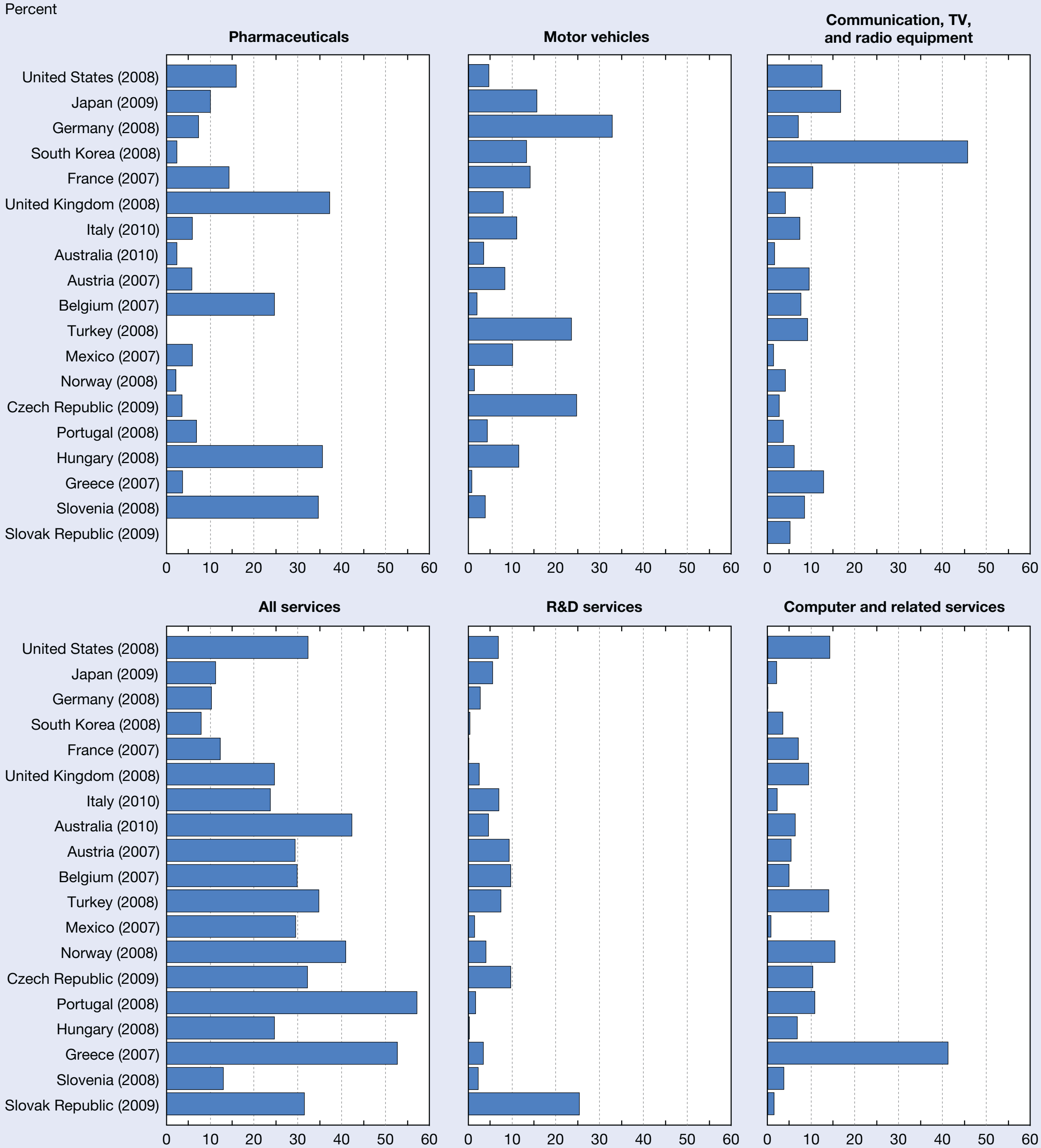
EU = European Union; GBAORD = government budget appropriations or outlays for R&D; PPP = purchasing power parity

NOTES: Foreign currencies converted to dollars through purchasing power parities. Most recent data available for France and the EU are 2008. EU data for all years based on current 27 member countries. GBAORD data are not yet available for China. The socioeconomic objective categories are aggregates of the 14 categories identified by Eurostat's 2007 Nomenclature for the Analysis and Comparison of Scientific Programs and Budgets (NABS).

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (August 2010) of federal R&D budget authority by spending category; Organisation for Economic Co-operation and Development, Main Science and Technology Indicators (2011/1). See appendix table 4-45.

Science and Engineering Indicators 2012

Figure 4-17
Share of industrial R&D, by industry sector and selected country: 2007–10



NOTES: Source data for U.S. business R&D in this figure are preliminary (NSF 2010a); final U.S. statistics were used elsewhere in chapter 4. Countries listed in descending order by amount of total business R&D. Data years are in parentheses.

SOURCES: Organisation for Economic Co-operation and Development, Analytical Business Enterprise R&D (ANBERD)-Statistical Analysis Database (STAN)-R&D Expenditure in Industry, http://www.oecd.org/document/17/0,3746,en_2649_34451_1822033_1_1_1_1,00.html, accessed 27 July 2011; National Science Foundation, National Center for Science and Engineering Statistics and U.S. Census Bureau, Business R&D and Innovation Survey (2008).

Science and Engineering Indicators 2012

part suppliers, or technical contractors, may have relatively larger share of motor vehicles R&D, as shown for Germany, the Czech Republic, and Turkey.

A significant trend in both U.S. and international business R&D activity has been the growth of R&D in the service sector. According to national statistics for recent years, the service sector accounted for 30% or more of all business R&D in 8 of the 19 OECD countries shown in figure 4-17 and less than 10% in only one of the countries. In the United States, service industries accounted for 32% of all business R&D in 2008.[42]

Internationally comparable data for selected non-OECD members are also available from the same database (ANBERD-STAN) (OECD 2011a). Percentage shares by industry of total business R&D for China, the Russian Federation, Singapore, South Africa, and Taiwan are given in appendix table 4-46. Among these economies, the communication, television, and radio equipment industry, which includes semiconductors, accounted for over 50% of all business R&D in Singapore (2008). Motor vehicle R&D accounted for 5% of business R&D in South Africa (2007); pharmaceutical R&D accounted for 3% in China (2009) and R&D in the computer, office and accounting machines industry accounted for 3% of the business R&D performed in Taiwan (2009). Among OECD countries, the service sector accounted for as little as 8% of business R&D

Global R&D Expenses of Public Corporations

Most firms that make significant investments in R&D track their R&D expenses separately in their accounting records and financial statements. The annual reports of public corporations often include data on these R&D expenses. Research organizations and consulting companies interested in tracking and ranking businesses compile R&D expenditures and related operations and performance data. According to one such ranking, the 20 public corporations with the largest reported worldwide R&D expenditures spent $129 billion on R&D in 2009 (Booz & Company 2010). The six companies with the largest reported R&D expenses—Roche Holding, Microsoft, Nokia, Toyota, Pfizer, and Novartis—each spent between $7.4 billion and $9.1 billion (table 4-B). Eight companies in the computing and electronic sector spent a total of $50.4 billion (39% of the total for the top 20). Seven companies in the health sector spent a total of $49.5 billion (38% of the total). The remaining five companies on the list are automobile manufacturers and they reported combined spending of $29.1 billion on R&D (23% of the total). The top 20 companies are headquartered in 8 countries, with 9 headquartered in the United States. In addition, most companies in this list have production, distribution, and/or research and technical facilities in multiple countries. (For related industry-level information, see "R&D by Multinational Companies" in this chapter and chapter 6.)

Table 4-B
Global R&D spending by top 20 corporations: 2009

R&D rank	Company	Country	R&D expense ($millions)	Sales ($millions)	R&D intensity (%)
1	Roche Holding AG	Switzerland	9,120	45,606	20.1
2	Microsoft Corp	United States	9,010	58,437	15.4
3	Nokia OYJ	Finland	8,240	57,150	14.4
4	Toyota Motor Corp	Japan	7,822	204,363	3.8
5	Pfizer Inc	United States	7,739	50,009	15.5
6	Novartis AG	Switzerland	7,469	44,267	16.9
7	Johnson & Johnson	United States	6,986	61,897	11.3
8	Sanofi-Aventis SA	France	6,391	40,866	15.6
9	GlaxoSmithKline PLC	United Kingdom	6,187	44,422	13.9
10	Samsung Electronics Co Ltd	South Korea	6,002	109,541	5.5
11	General Motors Co	United States	6,000	104,589	5.7
12	International Business Machines	United States	5,820	95,759	6.1
13	Intel Corp	United States	5,653	35,127	16.1
14	Merck & Co Inc	United States	5,613	27,428	20.5
15	Volkswagen AG	Germany	5,359	146,677	3.7
16	Siemens AG	Germany	5,285	103,866	5.1
17	Cisco Systems Inc	United States	5,208	36,117	14.4
18	Panasonic Corp	Japan	5,143	79,994	6.4
19	Honda Motor Co Ltd	Japan	4,996	92,516	5.4
20	Ford Motor Co	United States	4,900	118,308	4.1

SOURCE: Booz & Company, The global innovation1000-how the top innovators keep winning (2010). http://www.booz.com/media/file/sb61_10408-R.pdf and http://www.booz.com/media/file/keep_winning_11_2010.pdf. Both accessed 10 August 2011.

Science and Engineering Indicators 2012

in South Korea (2008) to as much as 65% in Israel (2010). For the non-OECD economies examined here, the percentage of business R&D accounted for by the service sectors ranged from 7% in Taiwan (2009) to 86% in the Russian Federation (2009).

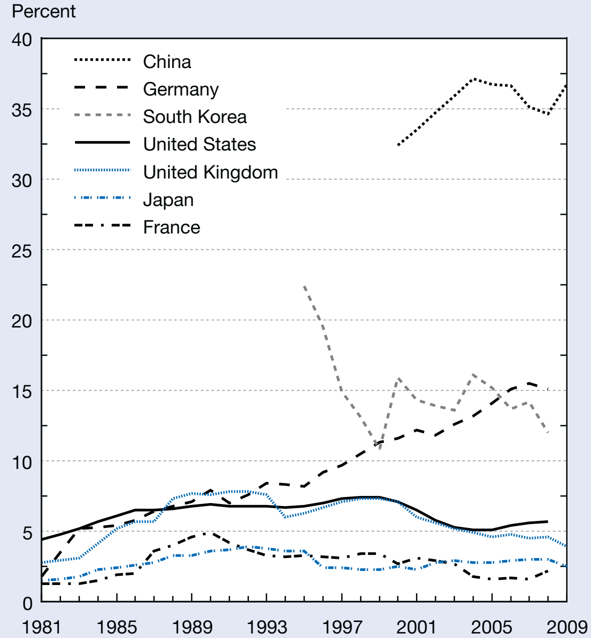
Business Support for Academic R&D

For most countries, the government is (and has long been) the largest source of academic research funding. (See sidebar, "Government Funding Mechanisms for Academic Research.") Nevertheless, business support for academic R&D has increased over the past 25 years among the OECD countries as a whole. It was around 3% in the early 1980s, nearly 6% in 1990, almost 7% in 2000, and still around 7% in 2007.

In the United States, business support for academic R&D was about 4% in the early 1980s and rose to about 7% later in that decade and through the 1990s, but has dropped to below 6% since 2000. Some commentators note concern about this recent trend of decline, given the significant role that academic basic research plays in providing a foundation for technological innovation that is important to the national economy.

The proportion of academic R&D financed by business is more varied among the other top R&D-performing countries (figure 4-18). Among the other top seven R&D-performing countries, the highest figure for business support of academic R&D is currently in China (37%). The figures are also high in Germany (15%) and South Korea (12%), whereas Japan, France, and the United Kingdom occupy the low end, with figures under 5%.

Figure 4-18
Academic R&D financed by business, for selected countries: 1981–2009



NOTES: Top seven R&D performing countries. Data not available for all countries for all years. Data for Japan for 1996 onward may not be consistent with earlier data due to changes in methodology. Data for China for 2001 and 2002 are estimated by National Science Foundation.

SOURCE: Organisation for Economic Co-operation and Development, Main Science and Technology Indicators (2011/1).

Science and Engineering Indicators 2012

Government Funding Mechanisms for Academic Research

U.S. universities generally do not maintain data on departmental research (i.e., research that is not separately budgeted and accounted). As such, U.S. R&D totals are understated relative to the R&D effort reported for other countries. The national totals for Europe, Canada, and Japan include the research component of general university fund (GUF) block grants provided by all levels of government to the academic sector. These funds can support departmental R&D programs that are not separately budgeted. GUF is not equivalent to basic research. The U.S. federal government does not provide research support through a GUF equivalent, preferring instead to support specific, separately budgeted R&D projects. However, some state government funding probably does support departmental research, not separately accounted, at U.S. public universities.

The treatment of GUF is one of the major areas of difficulty in making international R&D comparisons. In many countries, governments support academic research primarily through large block grants that are used at the discretion of each higher education institution to cover administrative, teaching, and research costs. Only the R&D component of GUF is included in national R&D statistics, but problems arise in identifying the amount of the R&D component and the objective of the research. Moreover, government GUF support is in addition to support provided in the form of earmarked, directed, or project-specific grants and contracts (funds that can be assigned to specific socioeconomic categories).

In several large European countries (France, Germany, Italy, and the United Kingdom), GUF accounts for 50% or more of total government R&D funding to universities. In Canada, GUF accounts for about 38% of government academic R&D support. Thus, international data on academic R&D reflect not only the relative international funding priorities but also the funding mechanisms and philosophies regarded as the best methods for financing academic research.

Conclusion

Growth in global R&D has been rapid, averaging 7% annually over the last 10 years, reaching an estimated $1,276 billion (in purchasing power parities) in 2009. The United States is by far the largest R&D performer, accounting for about 31% of the global total, but down from 38% in 1999. Average annual growth in U.S. R&D spending has outpaced U.S. GDP growth over the last several decades. However, in 2009 U.S. R&D spending was somewhat below the 2008 level. The 2009 slowdown primarily reflects a drop in business R&D in the face of the 2008–09 financial crisis and the economic recession. On the other hand, U.S. R&D spending in other performing sectors continued to rise, notably for federal and academic R&D, in part because of the one-time federal R&D funding increase appropriated in the American Recovery and Reinvestment Act of 2009.

The other major trend has been the rapid expansion of R&D performance in Asia. The region represented 24% of the global R&D total in 1999 but accounted for 32% in 2009, including China (12%) and Japan (11%). The pace of real growth over the past 10 years in China's overall R&D remains exceptionally high at about 20% annually. The rate of growth in South Korea's R&D has also been relatively high, averaging nearly 10% annually over the 10-year period. Growth in Japan has been slower, at an annual average rate of 4.0%.

The R&D/GDP ratio, or R&D intensity, constitutes another basis for international comparisons. The U.S. ratio was about 2.9% in 2009 and has fluctuated between 2.6% and 2.8% during the prior 10 years, largely reflecting changes in business R&D spending. In 2009, the United States ranked eighth in R&D intensity—surpassed by Israel, Sweden, Finland, Japan, South Korea, Switzerland, and Taiwan (but all perform far less R&D annually than the U.S.). China's ratio remains relatively low, at 1.7%, but has more than doubled from 0.8% in 1999.

The majority of R&D by U.S. MNCs continues to be performed in the United States. Indeed, parent companies of U.S. MNCs performed just over two-thirds of U.S. business R&D. U.S. MNCs performed most of their foreign R&D in Europe, Canada, and Japan. However, from 1997 to 2008 the share of R&D performed by U.S. majority-owned affiliates in Asia (other than Japan) more than doubled, including increases in the share performed in China, South Korea, Singapore, and India.

Notes

1. America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science [COMPETES] Act (Public Law 110-69, January 4, 2007) and America COMPETES Reauthorization Act of 2010 (Public Law 111-358, January 4, 2011).

2. For an annotated compilation of definitions of R&D by U.S. statistical agencies, tax statutes, accounting bodies, and other official sources, see NSF (2006).

3. Adjustments for inflation reported in this chapter are based on the GDP implicit price deflator. GDP deflators are calculated on an economy-wide rather than an R&D-specific basis. As such, they should be interpreted as measures of real resources engaged in R&D rather than in other activities, such as consumption or physical investment. They are not a measure of cost changes in performing R&D. See appendix table 4-1 for GDP deflators used in this chapter.

4. R&D funding by business in this section refers to nonfederal funding for domestic business R&D plus business funding for U.S. academic R&D and nonprofit R&D performers.

5. Federal support for R&D reported by federal agencies in the form of obligations differs from expenditures of federal R&D funds reported by R&D performers. For a discussion of the reasons for, and the magnitude of these discrepancies, see sidebar "Tracking R&D: The Gap Between Performer- and Source-Reported Expenditures" later in this chapter.

6. Contemporary discussions often note the extensive feedback loops among basic research, applied research, and development that prevail in the conduct of R&D. On this basis, there is often-heard criticism that this standard trio is simplistic and erroneously implies a linear progression. Even so, an alternative framework has yet to be identified to wide acceptance. Accordingly, the chapter relies for its analysis on the standard trio of categories, which have been longstanding, widely used, and internationally comparable (OECD 2002).

7. The OECD notes that in measuring R&D, the greatest source of error often is the difficulty of locating the cutoff point between experimental development and the related activities required to realize an innovation (OECD 2002, paragraph 111). Most definitions of R&D set the cutoff at the point when a particular product or process reaches "market readiness." At this point, the defining characteristics of the product or process are substantially set (at least for manufacturers if not also for services), and further work is primarily aimed at developing markets, engaging in preproduction planning, and streamlining the production or control system.

8. These estimates measure solely the direct impact of R&D investment. Although indirect productivity impacts of R&D are included in BEA's industry output measures, estimates of the impact of R&D based on the R&D Satellite Account do not separately identify spillovers, the indirect benefits to firms that did not pay for the R&D. For R&D spillovers in the context of national accounts measures, see Sveikauskas (2007).

9. The sample for the Business R&D and Innovation Survey (BRDIS) was selected to represent all for-profit nonfarm companies with five or more domestic employees, publicly or privately held, that perform or fund R&D or engage in innovative activities in the United States. For worldwide expense data from this survey, see appendix table 4-13.

10. Recall that BRDIS excludes companies with fewer than five domestic employees.

11. Because federal R&D funding is concentrated among a few companies in a small number of industries than is R&D in general, estimates for federally funded business R&D are often suppressed. Consequently, the percentage of federally funded business R&D for these six industry groups is based on a lower bound estimate.

12. Estimates for computer and electronic product manufacturing in this section refer to NAICS 334 except the federally funded R&D component of navigational, measuring, electromedical, and control instruments industry (NAICS 3345), which is included in aerospace and defense manufacturing.

13. Specifically, this industry group includes domestic R&D performance for architectural, engineering, and related services (NAICS 5413) and scientific R&D services industries (NAICS 5417).

14. Although companies in the R&D and related-services sector and their R&D activities are classified as nonmanufacturing, they serve many manufacturing industries. For example, many biotechnology companies in this sector license their technology to companies in the pharmaceutical manufacturing industry. The R&D of a research firm that is a subsidiary of a manufacturing company rather than an independent contractor would be classified as R&D in a manufacturing industry. Consequently, growth in R&D services may, in part, reflect a more general pattern of industry's increasing reliance on outsourcing and contract R&D.

15. Data are tabulated independent of the industry classification of the company.

16. Funded by others outside the company includes funded by foreign parents.

17. See appendix tables 4-18 through 4-21.

18. The BEA estimate for R&D performance by majority-owned foreign affiliates of U.S. MNCs is much lower than the $61.5 billion based on BRDIS 2008. BEA, NSF, and the Census Bureau are researching measures of R&D by foreign affiliates as part of the R&D linking project, which is discussed in sidebar "Linking MNC Data from International Investment and Business R&D Surveys." This research should lead to improvements in both data sets.

19. Data in this section cover international transactions in RDT services by U.S.-located companies from BEA's Survey of Transactions in Selected Services and Intangible Assets with Foreign Persons. Separate data for R&D versus "testing" services are not available (further, testing services may have both R&D and non-R&D components). Other fee-based measures on intangibles trade include international licensing and royalty payments and receipts (see chapter 6). RDT services cover activities by companies in any industrial classification, *not* just companies classified in services or in NAICS 5417 (Scientific research and development services). For further methodological information, see http://www.bea.gov/surveys/iussurv.htm.

20. U.S. RDT exports by foreign MNCs in 2008 were about 16% of their U.S. R&D performance as reported in the section "R&D by Multinational Companies," whereas the corresponding ratio for U.S. parents was 4%. Thus a substantial share of foreign-owned R&D in the U.S. is apparently devoted to service foreign parents and other members of the foreign MNC. See Moris (2009) for caveats on these cross-survey comparisons.

21. Federal agencies also sponsor FFRDCs; see appendix table 4-33.

22. For information on R&D credits at the state level, see NSB (2008, chapter 4) and Wilson (2009).

23. See Section 731 of H. R. 4853, Public Law 111-312. The statute also renewed the credit retroactively for activities after December 31 2009, given that the credit had expired on the latter date according to the Emergency Economic Stabilization Act of 2008 (H.R.1424, Public Law 110-343, Division C, Title III, Section 301). This credit has now been extended 14 times despite its temporary status since its inception.

24. Based on data from the Internal Revenue Service/Statistics of Income (IRS/SOI). Data are sample-based estimates and are subject to sampling and nonsampling errors. For statistical methodology, see section 3 in IRS (2010).

25. This percentage is based on company and other nonfederal funds for business R&D.

26. Based on IRS/SOI figures B and C in http://www.irs.gov/taxstats/article/0,,id=164402,00.html (accessed 25 February 2011). See also IRS (2008).

27. The alternative incremental tax credit was in place from 1996 to 2008; a simplified alternative credit has been in place since 2006. See IRS (2008) and Guenther (forthcoming).

28. See IRS tax form 6765 at http://www.irs.gov/pub/irs-pdf/f6765.pdf.

29. Science or research parks, another example of public-private collaboration, may facilitate knowledge diffusion, technology development and deployment, and entrepreneurship by involving universities, government laboratories, and business startups. Two recent U.S. workshops focused on science parks. A December 2007 NSF workshop was aimed at fostering a better understanding and measurement of science parks' activities, including the role of science parks in the national innovation system. Participants identified a need for systematic studies on topics such as the social benefits of public investment in science parks, ways in which the university-science park interaction engenders entrepreneurial activity, and lessons that U.S. science parks can learn from comparative studies with European and Asian parks. For material from this workshop, see http://www.nsf.gov/statistics/workshop/sciencepark07. A subsequent workshop sponsored by the National Academies explored international models and best practices in science parks (NRC 2009).

30. Notably missing among these indicators are technical articles published in professional journals, conference papers, and other kinds of scientific communications. Most federal lab scientists, engineers, and managers view this traditional form of new knowledge dissemination as an essential tech transfer component. Nevertheless, few agencies and

their associated federal labs regularly tabulate and report this information.

31. P.L. 97–219. At the time of writing, SBIR was authorized until November 18, 2011 (Public Law 112–36).

32. Small Business Technology Transfer Act of 1992 (Public Law 102-564, Title II).

33. To obtain federal funding under this program, a small company applies for a phase I SBIR grant of up to $100,000 for up to 6 months to assess the scientific and technical feasibility of ideas with commercial potential. If the concept shows further potential, the company may receive a phase II grant of up to $750,000 over a period of up to 2 years for further development.

34. SBA's Federal and State Technology (FAST) partnership program also provides support associated with SBIR/STTR. The Consolidated Appropriations Act of 2010 (Public Law 111-117) authorized $2 million for FAST. In October 2010, SBA granted $100,000 awards to 20 state and local economic development agencies, business development centers, and colleges and universities. The program is designed to help socially and economically disadvantaged firms compete in SBIR and STTR. The project and budget periods are for 12 months, starting September 30, 2010. See SBA Press Release No. 10-62, http://www.sba.gov/about-sba-services/7367/11391, accessed 4 March 2011.

35. Public Law 110-69, Section 3012. See NSB (2010) pages 4–57 and appendix table 4-47 of that publication for information and data on the predecessor program, the Advanced Technology Program.

36. See appendix tables 4-43 through 4-46.

37. EU real growth over 1999–2009 and the 1999 share are based on all current 27 EU member countries.

38. For related 2008 data, see appendix table 4-44.

39. Some analysts argue that the low nondefense GBAORD share for economic development in the United States reflects the expectation that businesses will finance industrial R&D activities with their own funds. Moreover, government R&D that may be useful to industry is often funded with other purposes in mind, such as defense and space, and is therefore classified under other socioeconomic objectives.

40. Data for the United States included in the Organisation for Economic Co-operation and Development's Analytical Business Enterprise R&D (ANBERD)-Statistical Analysis Database (STAN) are preliminary (NSF 2010a); final statistics were used for the business R&D analyses earlier in chapter 4.

41. For information on global valued added, trade, and related statistics for high technology industries, see chapter 6.

42. Share in OECD/ANBERD based on preliminary U.S. business R&D data (NSF 2010a); final U.S. statistics were used elsewhere in chapter 4.

Glossary

Affiliate: A company or business enterprise located in one country but owned or controlled (in terms of 10% or more of voting securities or equivalent) by a parent company in another country; may be either incorporated or unincorporated.

Applied research: The objective of applied research is to gain knowledge or understanding to meet a specific, recognized need. In industry, applied research includes investigations to discover new scientific knowledge that has specific commercial objectives with respect to products, processes, or services.

Basic research: The objective of basic research is to gain more comprehensive knowledge or understanding of the subject under study without specific applications in mind. Although basic research may not have specific applications as its goal, it can be directed in fields of present or potential interest. This is often the case with basic research performed by industry or mission-driven federal agencies.

Development: Development is the systematic use of the knowledge or understanding gained from research directed toward the production of useful materials, devices, systems, or methods, including the design and development of prototypes and processes.

Company-funded R&D: R&D paid for with a company's own funds, no matter the location of R&D activity or who performs or conducts the R&D (the company itself or others outside the funding company). Company-funded R&D is also known as R&D expense for certain tax, accounting, and data collection purposes.

EU: Prior to 2004, the European Union (EU) consisted of 15 member nations: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, and the United Kingdom. In 2004, the membership expanded to include an additional 10 countries: Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, and Slovenia. Bulgaria and Romania were added in January 2007, bringing the total of current EU member countries to 27.

Federally funded research and development center (FFRDC): R&D-performing organizations that are exclusively or substantially financed by the federal government either to meet a particular R&D objective or, in some instances, to provide major facilities at universities for research and associated training purposes. Each FFRDC is administered by an industrial firm, a university, or a nonprofit institution.

Foreign affiliate: Company located outside the United States but owned by a U.S. parent company.

Foreign direct investment (FDI): Ownership or control of 10% or more of the voting securities (or equivalent) of a business located outside the home country.

General university fund (GUF): Block grants provided by all levels of government in Europe, Canada, and Japan to the academic sector that can be used to support departmental R&D programs that are not separately budgeted; the

U.S. federal government does not provide research support through a GUF equivalent.

Gross domestic product (GDP): The market value of goods and services produced within a country. It is one of the main measures in the NIPAs.

Innovation: The introduction of new or significantly improved products (goods or services), processes, organizational methods, and marketing methods in internal business practices or in the open marketplace (OECD/Eurostat 2005).

Majority-owned affiliate: Company owned or controlled, by more than 50% of the voting securities (or equivalent), by its parent company.

Multinational company (MNC): A parent company and its foreign affiliates.

National income and product accounts (NIPAs): The economic accounts of a country that display the value and composition of national output and the distribution of incomes generated in this production.

Organisation for Economic Co-operation and Development (OECD): An international organization of 34 countries, headquartered in Paris, France. The member countries are Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom, and United States. Among its many activities, the OECD compiles social, economic, and science and technology statistics for all member and selected nonmember countries.

Public-private partnership: Collaboration between private or commercial organizations and at least one public or nonprofit organization such as a university, research institute, or government laboratory. Examples include cooperative research and development agreements (CRADAs), industry-university alliances, and science parks.

R&D: Research and development, also called research and experimental development; comprises creative work undertaken on a systematic basis to increase the stock of knowledge—including knowledge of man, culture, and society—and its use to devise new applications (OECD 2002).

R&D intensity: A measure of R&D expenditures relative to size, production, financial, or other characteristic for a given R&D-performing unit (e.g., country, sector, company). Examples include R&D to GDP ratio, company-funded R&D to net sales ratio, and R&D expenditures per employee.

Technology transfer: The process by which technology or knowledge developed in one place or for one purpose is applied and exploited in another place for some other purpose. In the federal setting, technology transfer is the process by which existing knowledge, facilities, or capabilities developed under federal research and development funding are utilized to fulfill public and private needs.

U.S. affiliate: Company located in the United States but owned by a foreign parent.

References

Aizcorbe AM, Moylan CE, Robbins CA. 2009. Toward better measurement of innovation and intangibles. *Survey of Current Business* 89 (January):10–23. http://www.bea.gov/national/newinnovation.htm. Accessed 1 November 2011.

Athukorala P, Kohpaiboon A. 2010. Globalization of R&D by US-based multinational enterprises. *Research Policy* 39:1335–47.

Booz & Company. 2010. *The Global Innovation 1000—How the Top Innovators Keep Winning.* http://www.booz.com/media/file/sb61_10408-R.pdf and http://www.booz.com/media/file/keep_winning_11_2010.pdf. Both accessed 10 August 2011.

Breznitz D. 2009. National institutions and the globalized political economy of technological change: An introduction. *Review of Policy Research* 26(1, 2):1–11.

Corrado CA, Hulten CR, Sichel DE. 2006. Intangible capital and economic growth. Finance and Economics Discussion Series. Washington, DC: Federal Reserve Board.

Crow M, Bozeman B. 1998. *Limited by Design—R&D Laboratories in the U.S. National Innovation System.* New York: Columbia University Press.

Dougherty S, Inklarr R, McGuckin R, Van Ark B. 2007. International comparisons of R&D expenditures: Does an R&D PPP make a difference? National Bureau of Economic Research Working Paper 12829. Cambridge, MA.

Dunning JH, Lundan SM. 2009. The internationalization of corporate R&D: A review of the evidence and some policy implications for home countries. *Review of Policy Research* 26(1, 2):13–33.

European Commission (EU), International Monetary Fund, Organisation for Economic Co-operation and Development, United Nations, and World Bank. 2009. *System of National Accounts 2008*. New York.

Federal Laboratory Consortium (FLC) for Technology Transfer. 2006. *FLC Technology Transfer Desk Reference*. Cherry Hill, NJ. http://www.federallabs.org/pdf/T2_Desk_Reference.pdf. Accessed 1 November 2011.

Filippetti A, Archibugi D. 2011. Innovation in times of crisis: National systems of innovation, structure, and demand. *Research Policy* 40(2):179–92.

General Accounting Office (GAO). 2001. *Research and Development: Reported Gap Between Data From Federal Agencies and Their R&D Performers: Results From Noncomparable Data*. GAO-01-512R. Washington, DC.

Gilbert BA, Audretsch DB, McDougall PP. 2004. The emergence of entrepreneurship policy. *Small Business Economics* 22(3, 4):313–23.

Guenther G. Forthcoming. Research and Experimentation Tax Credit. Washington, DC: Congressional Research Service.

Hasan I, Tucci CL. 2010. The innovation–economic growth nexus: Global evidence. *Research Policy* 39(10):1264–76.

Hemphill TA. 2009. The U.S. research & experimentation tax credit: The case for an effective R&D investment policy incentive. *Innovation: Management, Policy & Practice* 11(3):341–56.

Internal Revenue Service (IRS). 2008. The Credit for Increasing Research Activities: Statistics from Tax Years 2004-2005. SOI Bulletin. Summer:182–92. http://www.irs.gov/pub/irs-soi/04-05crreac.pdf.

Internal Revenue Service (IRS). 2010. 2007 Statistics of Income—Corporation Income Tax Returns. Washington, DC. http://www.irs.gov/pub/irs-soi/07coccr.pdf. Accessed 25 February 2011.

Jorgenson DW, Ho MS, Stiroh KJ. 2005b. *Productivity, Volume 3: Information Technology and the American Growth Resurgence*. Cambridge, MA: The MIT Press.

Jorgenson DW, Landefeld JS, Nordhaus WD, editors. 2006. *A New Architecture for the U.S. National Accounts*. Chicago: University of Chicago Press.

Jorgenson DW. 2007. Information technology and the G7 economies. In: Berndt ER, Hulten CR, editors. *Hard-to-Measure Goods and Services: Essays in Honor of Zvi Griliches*. Chicago: University of Chicago Press.

Lane J, Bertuzzi S. 2011. Measuring the results of science investments. *Science* 331(6018):678–80.

Lee J, Schmidt AG. 2010. Research and development satellite account update: Estimates for 1959–2007. *Survey of Current Business* 90(12):16–55.

Link AN, Scott JT. 2010. Government as entrepreneur: Evaluating the commercialization success of SBIR projects. *Research Policy* 39:589–601.

Moris F. 2009. R&D exports and imports: New data and methodological issues. In: Reinsdorf M, Slaughter M, editors. *International Flows of Invisibles: Trade in Services and Intangibles in the Era of Globalization*. Studies in Income and Wealth, vol. 69, National Bureau of Economic Research. Chicago: University of Chicago Press.

National Research Council (NRC). 2000. *Improving Access to and Confidentiality of Research Data.* Mackie C, Bradburn N, editors. Washington, DC: National Academies Press.

National Research Council (NRC). 2003. Government-Industry Partnerships for the Development of New Technologies. Washington, DC: National Academies Press.

National Research Council (NRC). 2005. *Measuring Research and Development Expenditures in the U.S. Economy*. Brown LD, Plewes TJ, Gerstein MA, editors. Washington, DC: National Academies Press.

National Research Council (NRC). 2007. *Understanding Business Dynamics: An Integrated Data System for America's Future.* Haltiwanger J, Lynch LM, Mackie C, editors. Washington, DC: National Academies Press.

National Research Council (NRC). 2008. *An Assessment of the SBIR Program*. Wessner CW, editor. Washington, DC: National Academies Press.

National Research Council (NRC). 2009. *Understanding Research, Science and Technology Parks: Global Best Practices*. Wessner CW, editor. Washington, DC: National Academies Press. http://www.nap.edu/catalog.php?record_id=12546.

National Science Board (NSB). 2008. Research and development: National trends and international linkages. Science and Engineering Indicators 2008. NSB 08–01. Arlington, VA: National Science Foundation. http://www.nsf.gov/statistics/seind08/. Accessed 1 November 2011.

National Science Board (NSB). 2010. Research and development: National trends and international linkages. *Science and Engineering Indicators 2010*. NSB 10-01. Arlington, VA: National Science Foundation. http://www.nsf.gov/statistics/seind10/

National Science Foundation (NSF). 2006. *Definitions of research and development: An annotated compilation of official sources.* Arlington, VA. http://www.nsf.gov/statistics/randdef/.

National Science Foundation (NSF). 2008. *NSF announces new U.S. business R&D and innovation survey.* NSF InfoBrief 09-304. Arlington, VA. http://www.nsf.gov/statistics/infbrief/nsf09304. Accessed 10 March 2011.

National Science Foundation (NSF). 2010a. *U.S. businesses report 2008 worldwide R&D expense of $330 billion: Findings from new NSF survey.* NSF InfoBrief 10-322. Arlington, VA. http://www.nsf.gov/statistics/infbrief/nsf10322.

National Science Foundation (NSF). 2010b. *New employment statistics from the 2008 business R&D and innovation survey.* NSF InfoBrief 10-326. Arlington, VA. http://www.nsf.gov/statistics/infbrief/nsf10326/.

National Science Foundation (NSF). 2010c. *NSF releases new statistics on business innovation.* NSF InfoBrief 11-300. Arlington, VA. http://www.nsf.gov/statistics/infbrief/nsf11300. Accessed 10 March 2011.

National Science Foundation (NSF). 2010d. *Federal Funds for Research and Development: Fiscal Years 2007–09*. Detailed statistical tables. NSF 10-305. Arlington, VA. http://www.nsf.gov/statistics/nsf10305/.

Organisation for Economic Co-operation and Development (OECD). 2002. *Proposed Standard Practice for Surveys on Research and Experimental Development* (Frascati Manual). Paris.

Organisation for Economic Co-operation and Development (OECD). 2003. Tax incentives for research and development: Trends and issues. Paris.

Organisation for Economic Co-operation and Development (OECD)/Eurostat. 2005. *Oslo Manual*. Paris.

Organisation for Economic Co-operation and Development (OECD). 2010a. *Handbook on Deriving Capital Measures of Intellectual Property Products*. Paris.

Organisation for Economic Co-operation and Development (OECD). 2010b. *Handbook on Economic Globalisation Indicators*. Paris.

Organisation for Economic Co-operation and Development (OECD). 2010c. *Measuring Innovation—A New Perspective*. Paris.

Organisation for Economic Co-operation and Development (OECD). 2010d. *The OECD Innovation Strategy—Getting a Head Start on Tomorrow*. Paris.

Organisation for Economic Co-operation and Development (OECD). 2011a. Analytical Business Enterprise R&D (ANBERD)-Statistical Analysis Database (STAN)-R&D Expenditure in Industry. Paris. http://www.oecd.org/document/17/0,3746,en_2649_34451_1822033_1_1_1_1,00.html. Accessed 27 July 2011.

Organisation for Economic Co-operation and Development (OECD). 2011b. *R&D Tax Incentives and Government Forgone Tax Revenue: A Cross-Country Comparison*. DSTI/EAS/STP/NESTI(2010)22. Paris.

Saggi K. 2002. Trade, foreign direct investment, and international technology transfer: A survey. *World Bank Research Observer* 17:191–235.

Small Business Administration (SBA), Office of Advocacy. 2010. *The Small Business Economy: A Report to the President*. Washington, DC: U.S. Government Printing Office. http://www.sba.gov/sites/default/files/sb_econ2010.pdf. Accessed 28 February 2010.

Stiglitz JE, Sen A, Fitoussi J-P. 2009. *Report by the Commission on the Measurement of Economic Performance and Social Progress*. Paris. http://www.stiglitz-sen-fitoussi.fr/.

Sveikauskas L. 2007. *R&D and Productivity Growth: A Review of the Literature*. Washington, DC: Bureau of Labor Statistics. Working Paper 408. http://www.bls.gov/ore/pdf/ec070070.pdf. Accessed 1 November 2011.

United States Department of the Treasury, Office of Tax Policy. 2011. *Investing in U.S. Competitiveness: The Benefits of Enhancing the Research and Experimentation (R&E) Tax Credit*. Washington, DC.

Van Ark B, Hulten C. 2007. Innovation, intangibles, and economic growth: towards a comprehensive accounting of the knowledge economy. Paper prepared for "Productivity and Innovation" Statistics Sweden Conference.

Ward M. 1985. *Purchasing Power Parities and Real Expenditures in the OECD*. Paris: OECD.

Wilson D. 2009. Beggar thy neighbor? The in-state, out-of-state, and aggregate effects of R&D tax credits. *Review of Economics and Statistics* 91(2):431–36.

Chapter 5
Academic Research and Development

List of Sidebars

List of Tables

List of Figures

Highlights

Spending and Funding for Academic R&D

In 2009, U.S. academic institutions spent $54.9 billion on science and engineering R&D and an additional $2.4 billion in non-S&E fields.

- In 2009, academic institutions performed nearly half (53%) of the nation's total basic research, a percent that has risen steadily from 47% in the later 1980s.
- Academia performed 36% of all U.S. research (basic plus applied) and 14% of total U.S. R&D.
- Higher education's share of total U.S. research expenditures (basic plus applied) has gradually increased, rising from 24% in 1982 to 36% in 2009.

The federal government provides the bulk of funds for academic R&D; during the past two decades, its share has fluctuated around 60%.

- The federal government provided 59% ($32.6 billion) of the $54.9 billion of academic spending on S&E R&D in FY 2009. The federal share was somewhat higher in the 1970s and early 1980s.
- Six agencies provide almost all (97% in 2009) federal academic R&D support—the National Institutes of Health, National Science Foundation, Department of Defense, National Aeronautics and Space Administration, Department of Energy, and Department of Agriculture.

The bulk of academic R&D funding from nonfederal sources is provided by the universities themselves.

- The share of support provided by institutional funds increased steadily between 1972 (12%) and 1991 (19%) but since then has remained fairly stable at roughly one-fifth of total academic R&D funding.
- Industry's percentage of funding for academic R&D declined steeply after the 1990s, from above 7% in 1999 down to about 5% by 2004, but has seen a 5-year increase to about 6% in 2009.
- Support from other governmental agencies, chiefly state funds, declined from 10% in the late 1970s to about 8% through the 1990s and stood at less than 7% in 2009.

Over the last 20 years, the distribution of academic R&D expenditures across the broad S&E fields shifted in favor of life sciences and away from physical sciences.

- In 2009, the life sciences represented the largest share (60%) of expenditures in academic S&E R&D.
- Over the last 20 years, the life sciences were the only broad field to experience a sizable increase in share—6 percentage points—of total academic R&D. Over the same period, the physical sciences share of total academic R&D dropped 3 percentage points.

Infrastructure for Academic R&D

Research space at academic institutions has continued to grow annually over the last 20 years. Nonetheless, the pace of growth has noticeably slowed in the last few years.

- Total research space at research-performing universities and colleges was 2.2% greater at the end of 2009 than it was in 2007, continuing a two decade long period of expansion.
- The rate of annual increase for all S&E fields combined in the 2001–03 period was 11%, but it has gradually slowed since then. Unlike in other fields, in recent years research space for the biological/biomedical sciences and agricultural sciences has continued to expand at substantial rates.

In 2009, about $2.0 billion in current funds was spent for academic research equipment (i.e., movable items such as computers or microscopes), a 2% increase over 2008, after adjusting for inflation.

- Equipment spending as a share of total R&D expenditures fell from 4.8% in FY 1999 to a three decade low of 3.6% in FY 2009.
- Three S&E fields accounted for 82% of equipment expenditures in 2009: the life sciences (41%), engineering (24%), and the physical sciences (17%).
- In FY 2009, the federal share of support for all academic research equipment funding was 55%. This share has fluctuated between 55% and 63% over the last 20 years.

Cyberinfrastructure

Academic networking infrastructure is rapidly expanding in capability and coverage.

- Research performing institutions had more connections, bandwidth, and campus coverage compared with earlier in the decade.
- Colleges and universities reported external network connections with greater bandwidth, faster internal network distribution speeds, more connections to high-speed networks, and greater on-campus wireless coverage.
- In FY 2003, 66% of institutions had bandwidth of less than 1 gigabit per second and no institutions had speeds faster than 2.5 gigabits per second. By FY 2009, 82% of institutions had bandwidth speeds of 1 gigabit per second or faster and 24% had speeds faster than 2.5 gigabits per second.

Doctoral Scientists and Engineers in Academia

The size of the doctoral academic S&E workforce was an estimated 272,800 in 2008, almost unchanged from 2006. Total academic doctoral employment grew less in this period than in any comparable period since 1973.

Full-time faculty positions, although still the predominant type of employment, increased more slowly than postdoc and other full- and part-time positions.

- The share of all S&E doctorate holders employed in academia dropped from 55% in 1973 to 44% in 2008.
- The percentage of S&E doctorate holders employed in academia who held full-time faculty positions declined from 88% in the early 1970s to 73% in 2008. Over that same period, other full-time positions rose from 6% to 15% of total academic employment, and postdoc and part-time appointments increased from 4% and 2% to 7% and 6%, respectively.

The demographic profile of academic researchers shifted substantially between 1973 and 2008. The increasing proportion of women was a particularly striking change.

- The number of women in academia increased more than eightfold between 1973 and 2008, from 10,700 to about 93,400, raising their share of all academic S&E doctoral employment from 9% to 34%. Women employed as full-time doctoral S&E faculty increased from 7% to 31%.
- In 2008, underrepresented minorities (blacks, Hispanics, and American Indians/Alaska Natives) constituted about 9% of both total academic S&E doctoral employment and full-time faculty positions, up from 2% in 1973.
- The foreign-born share of U.S. S&E doctorate holders in academia increased from 12% in 1973 to nearly 25% in 2008, and nearly half (46%) of postdoc positions in 2008 were held by foreign-born U.S. S&E doctorate holders. No comparable data exist for foreign-born, foreign-degreed doctorate holders.

Between 1973 and 2008, the number of academic researchers with S&E doctorates more than doubled. Among full-time faculty, the balance of emphasis in work activity shifted toward research and away from teaching. Young faculty—those within 3 years of a doctorate award—were less likely than other faculty to report research as a primary work activity.

- About two-thirds of doctoral scientists and engineers employed in academic institutions in 2008 were engaged in research as either a primary or secondary work activity. The proportions of researchers were highest in the life sciences, engineering, and computer sciences.
- The share of full-time S&E faculty identifying research as their primary work activity climbed from 19% in 1973 to 36% in 2008, while the share identifying teaching as their primary activity fell from 68% to 47%.
- In 2008, 33% of recently degreed S&E doctoral faculty identified research as their primary work activity, a smaller share than reported by faculty cohorts who had earned S&E doctorate degrees 4 to 7 years earlier (48%), 8 to 11 years earlier (41%), and 12 or more years earlier (35%).

A substantial pool of academic researchers—including graduate research assistants and doctorate holders employed in postdoc positions—has developed outside the ranks of full-time faculty.

- The number of S&E doctorate holders employed in academic postdoc positions climbed from 4,000 in 1973 to 18,000 in 2008.
- In 2008, 36% of recently degreed S&E doctorate holders in academia were employed in postdoc positions, a figure that approached the share (42%) employed in full-time faculty positions. Among S&E doctorate holders 4 to 7 years beyond their doctorate degrees, 11% held postdoc positions.

For S&E as a whole and for many fields, the share of academic S&E doctorate holders receiving federal support declined since the early 1990s.

- Throughout the 1973–2008 period, fewer than half of full-time S&E faculty received federal support, whereas the share of postdocs who received federal support was more than 70%.
- Among full-time faculty, recent doctorate recipients were less likely to receive federal support than their more established colleagues.

Outputs of Academic S&E Research: Articles and Patents

S&E article output worldwide grew at an average annual rate of 2.6% between 1999 and 2009. The U.S. growth rate was much lower, at 1.0%.

- The United States accounted for 26% of the world's total S&E articles in 2009, down from 31% in 1999. The share for the European Union also declined, from 36% in 1999 to 32% in 2009.
- In Asia, average annual growth rates were high—for example, 16.8% in China and 10.1% in South Korea. In 2009, China, the world's second-largest national producer of S&E articles, accounted for 9% of the world total.
- Very rapid annual growth rates of over 10% between 1999 and 2009 were also experienced by Iran, Thailand, Malaysia, Pakistan, and Tunisia. However, some of these countries had low S&E article production in 1999.

Two-thirds of all S&E articles were coauthored in 2010. Articles with authors from different institutions and different countries have continued to increase, indicating increasing knowledge creation, transfer, and sharing among institutions and across national boundaries.

- Coauthored articles grew from 40% of the world's total S&E articles in 1988 to 67% in 2010. Articles with only domestic coauthors increased from 32% of all articles in 1988 to 43% in 2010. Internationally coauthored articles grew from 8% to 24% over the same period.

- U.S.-based researchers were coauthors of 43% of the world's total internationally coauthored articles in 2010.
- Three other nations—Germany, the United Kingdom, and France—had high, though declining, shares of international coauthorships. Chinese authors increased their share of the world's internationally coauthored S&E articles from 5% to 13% between 2000 and 2010.
- In the United States, because of the predominance of the academic sector in S&E article publishing, academic scientists and engineers have been on the forefront of the integration of S&E research across sectors. In non-academic sectors, cross-sector coauthorship with academic authors ranged from 55% to 76% in 2010.

Like indicators of international coauthorship, cross-national citations provide mixed evidence of changes in the worldwide scope, influence, and quality of U.S. S&E research.

- Between 2000 and 2010, the U.S. share of the world's total citations in S&E articles declined from 45% to 36%, reflecting the broad expansion of the global literature. China's share of these citations increased from 1% to 6%. The EU share remained steady at 33%, and Japan's share fell from 7% to 6%.
- The percentage of U.S.-authored S&E articles receiving the highest number of citations—an indicator of quality and impact on subsequent research—has changed little. In 2010, U.S. articles represented 28% of all articles in the cited period, but 49% of the articles in the top 1% of all cited articles.

Data on citations per publication suggest that the quality of U.S.-authored articles has changed little over the past 10 years.

- In 2010, articles with U.S. authors were highly cited about 76% more often than expected based on the U.S. share of world articles, compared to 85% in 2000. Between 2000 and 2010, EU-authored articles improved on this indicator, from 27% *less* often than expected to 6% *less* often.
- In 2010, China's rate of high citation was nearly equal to its rate of publication in engineering and computer science, but its citation rate did not exceed its publication rate in any field. In most broad fields, China's rate of high citations compared to its publication rate was higher in 2010 than in 2000.

U.S. Patent and Trademark Office (USPTO) data show that annual patent grants to universities and colleges ranged from 2,900 to 4,500 between 1998 and 2010.

- College and university patents have been about 4.2% to 4.7% of U.S. nongovernmental patents for a decade. Biotechnology patents accounted for most U.S. university patents in 2010, at 30%, a percentage that has grown over the past 15 years.
- Data from the Association of University Technology Managers (AUTM) indicate continuing growth in a number of patent-related activities. Invention disclosures grew from 12,600 in 2002 to 18,200 in 2009. New U.S. patent applications filed by AUTM university respondents also increased, from 6,500 in 2001 to 11,300 in 2009. In contrast, the number of issued patents reported by AUTM respondents has remained flat.

Chapter Overview

U.S. universities and colleges occupy a unique position in the nation's overall R&D system. They perform more than half of U.S. basic research and, because they link graduate education and research, prepare the next generation of researchers (see chapter 2).

This chapter discusses the role of the academic sector within the national R&D enterprise. The first section examines trends in spending and funding for academic R&D, identifies key funders of academic R&D, and describes the allocation of funds across academic institutions and S&E fields.

Because the federal government has been the primary source of funding for academic R&D for more than half a century, the importance of federal agency support for overall R&D and for individual fields is explored in some detail. Other significant sources of funding include the institutions themselves, businesses, and state and local government. The first section also traces recent changes in the distribution of funds among academic institutions and the types of academic institutions that receive federal R&D support.

The chapter's second section reviews the status of infrastructure for academic R&D. This discussion provides data on the current trends in academic research facilities, research equipment, and cyberinfrastructure.

The next section discusses trends in the employment of academic doctoral scientists and engineers. Major trends examined include the numbers of academic doctoral scientists and engineers, their changing demographic composition, and the types of positions they hold. This section also examines employment patterns in the segment of the academic workforce that is engaged in research, with particular attention to full-time faculty, postdocs, graduate research assistants, and the academic scientists and engineers receiving research support from the federal government.

The chapter concludes with an analysis of trends in two types of research outputs: S&E articles and patents issued to U.S. universities. (A third major output of academic R&D, educated and trained personnel, is discussed in chapter 2.) This section looks at the volume of research articles for selected countries/regions and focuses (when appropriate) on S&E articles by U.S. academic researchers. Coauthored articles, both across U.S. sectors and internationally, are indicators of increasing collaboration in S&E research. The number of influential articles from U.S. institutions, as measured by the frequency with which they are cited, is examined and compared with citations to S&E articles produced around the globe.

The final section explores academic patenting activities and examines patents, licenses, and income from these as forms of academic R&D output. Patent citations to the S&E literature are also examined, with some attention—new in this edition—to S&E literature citations in patents for clean energy and related technologies.

Expenditures and Funding for Academic R&D

Academic R&D is a key part of the overall U.S. R&D enterprise.[1] Academic scientists and engineers conduct the bulk of the nation's basic research and are especially important as a source of the new knowledge that basic research produces. Indicators tracking the status of the financial resources, the research facilities, and the instrumentation that are used in this work are discussed in this and the next section of the chapter. (For an overview of the sources of data used see the sidebar, "Data on the Financial and Infrastructure Resources for Academic R&D.")

Academic R&D in the National R&D Effort

Expenditures by U.S. colleges and universities on R&D in S&E fields totaled $54.9 billion in 2009.[2] Academic spending in non-S&E fields that year was another $2.4 billion. The corresponding figures for 2008 were $51.9 billion and $2.2 billion. In 2004, these figures were $43.3 billion and $1.6 billion, respectively.

Academic R&D spending is primarily for research (basic and applied)—in 2009, about 96% was spent on research (75% basic, 22% applied) and almost 4% was spent on development.[3] These shares are not appreciably different from the proportions that prevailed 5 and 10 years ago (appendix table 5-1).

Universities and colleges performed about 14% of all U.S. R&D in 2009. Higher education's prominence as a national R&D performer has generally increased over the last 30 years, rising from about 10% of all R&D performed in the United States in the early 1970s to an estimated 14% in 2009 (figure 5-1).

Universities and colleges accounted for just under 36% of all U.S. research in 2009. This was slightly higher than the 35% reported in 2002—and the previously highest share of the U.S. research total over the last 30 years (figure 5-1).

In regard to basic research, the academic sector is by far the country's largest performer. In 2009, it accounted for 53% of all the basic research performed in the United States. Indeed, institutions of higher education have accounted for more than half of all U.S. basic research since 1998 (figure 5-1).

(For a comparison of the academic R&D profiles of other countries, see the section on "International R&D Comparisons" in chapter 4.)

Sources of Support for Academic R&D

Academic R&D relies on funding support from a variety of sources, including the federal government, universities' and colleges' own institutional funds, state and local government, industry, nonprofits, and other organizations. Nevertheless, the federal government has consistently provided the majority of funding.

Data on the Financial and Infrastructure Resources for Academic R&D

Data on the financial and infrastructure resources supporting U.S. academic R&D are drawn from three ongoing National Science Foundation (NSF) surveys:

- Survey of Research and Development Expenditures at Universities and Colleges
- Survey of Science and Engineering Research Facilities
- Survey of Federal Funds for Research and Development.

The data definitions and classifications in these three surveys are similar, but not identical. Furthermore, the respondents differ across the surveys: universities and colleges for the first two, federal agencies for the third.

Some of the data presented in the first part of this section (see "Academic R&D in the National R&D Effort") come from the NSF's *National Patterns of R&D Resources* series, which integrates data from NSF's R&D expenditure surveys to yield a comprehensive account of national R&D spending and funding. These separate data sets are adjusted for internal consistency and to reflect a calendar year. Some of the *National Patterns* figures for 2009 are considered "preliminary."

The data subsequently covered are derived from the Survey of Research and Development Expenditures at Universities and Colleges. These data are not adjusted and represent reporting on an academic year basis (e.g., FY 2009 covers July 2008 through June 2009).

Data on "Top Agency Supporters" and "Agency Support by Character of Work" come from NSF's Survey of Federal Funds for Research and Development, which collects data on the R&D obligations of 30 federal agencies for each federal fiscal year (e.g., FY 2009 covers October 2008 through September 2009). The 2009 federal funds figures remain preliminary.

The federal obligations data for academic R&D (e.g., $26.0 billion in FY 2008) do not match the federally funded expenditures data reported by academic institutions (e.g., $31.3 billion in 2008). Several factors account for this discrepancy: the spans of the academic and federal fiscal years differ slightly, there is a time lag between obligating and spending funds, awards may span multiple years, and federal funds passed to other recipient organizations are sometimes double-counted.

The data on research equipment come from the Survey of Research and Development Expenditures at Universities and Colleges. The data on research facilities and cyberinfrastructure come from the Survey of Science and Engineering Research Facilities. In these surveys, academic R&D expenditures are reported by academic fiscal year.

Research equipment is purchased from operating funds and included in R&D expenditures. Although some large instrument systems may be classified as either facilities or equipment, facilities are generally treated as capital projects for accounting purposes.

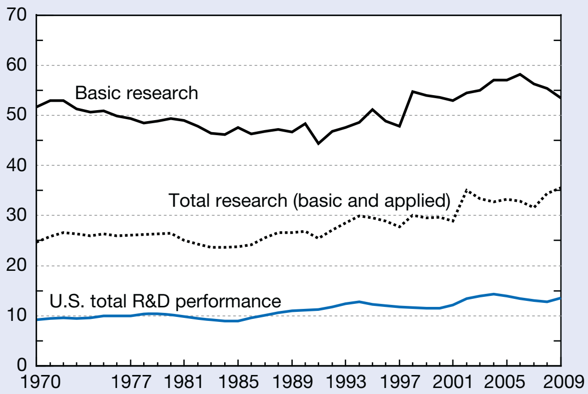
The survey population for the facilities survey includes all universities and colleges in the Academic R&D Expenditures survey with $1 million or more in R&D expenditures. Starting in 2003, the facilities survey included data on computing and networking capacities. Fixed items such as buildings, which often cost millions of dollars, are not included in the reported R&D expenditures.

Redesign of the Survey of R&D Expenditures at Universities and Colleges

NSF's Survey of Research and Development Expenditures at Universities and Colleges has been conducted annually since 1972. In 2007, an effort was started to evaluate and redesign the survey. The goals of the redesign were (1) to update the survey instrument to reflect current accounting principles in order to obtain more valid and reliable measurements of the amount of U.S. academic R&D expenditures and (2) to expand the current survey items to collect some additional detail on topics most often requested by data users. Data from the revised and expanded survey, renamed the "Higher Education R&D (HERD) Survey," is expected to be publicly available in late 2011.

The HERD survey will continue to capture comparable information on R&D expenditures by sources of funding and field, which will allow for continued trend analysis. It will also include a more comprehensive treatment of S&E and non-S&E fields, an expanded population of surveyed institutions, explicit treatment of research training grants and clinical trials, greater detail about the sources of funding for R&D expenditures by field, and headcounts on principal investigators, other research personnel, and postdocs. Britt (2010) provides a more complete list of improvements in the redesigned survey.

Figure 5-1
Academic share of U.S. R&D performance: 1970–2009

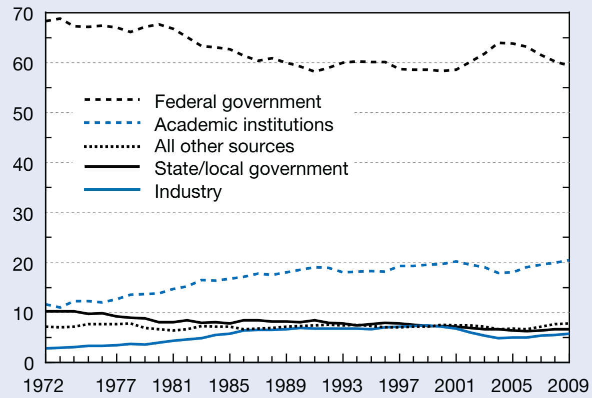


NOTES: Data based on annual reports by performers. Because of changes in survey procedures, character of work data before FY 1998 are not directly comparable with later years.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources (annual series). See appendix table 5-1.

Science and Engineering Indicators 2012

Figure 5-2
Academic R&D expenditures, by source of funding: 1972–2009

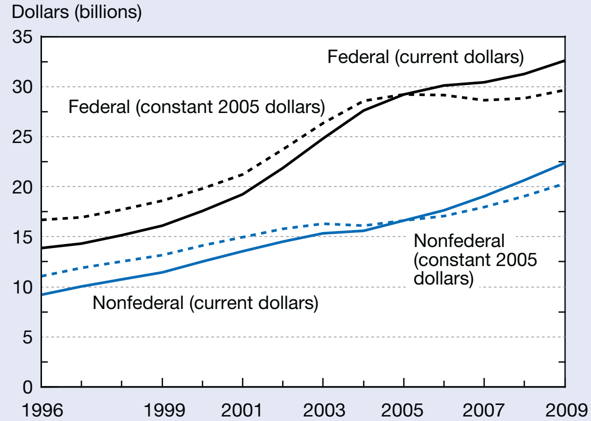


NOTE: Science and engineering R&D; non-S&E R&D not included.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Research and Development Expenditures at Universities and Colleges. See appendix table 5-2.

Science and Engineering Indicators 2012

Figure 5-3
Federal and nonfederal funding of academic R&D expenditures: 1996–2009



NOTES: Science and engineering R&D; non-S&E R&D not included. See appendix table 4-1 for gross domestic product implicit price deflators used to convert current dollars to constant 2005 dollars.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Research and Development Expenditures at Universities and Colleges. See appendix table 5-2.

Science and Engineering Indicators 2012

Federal Funding

The federal government provided $32.6 billion (59%) of the $54.9 billion of academic spending on S&E R&D in FY (academic) 2009.[4] The federal share was somewhat higher in the 1970s and early 1980s, although the federal government has long contributed the majority of funds for academic R&D (figure 5-2 and figure 5-3).

This $32.6 billion of federal funding in FY 2009 was 4.2% above the level of the previous year. The rates of growth in 2008 and 2007 were 2.8% and 1.0%, respectively. Over the previous 10 years, the level of federal funding for academic R&D has been consistently up, averaging 3.3% annually for the 5-year period of 2004–09 and 7.3% annually for the 10-year period of FY 1999–2009. But when adjusted for inflation, the 5-year annual average increase was 0.8% and the 10 year average was 4.8%—FY 2006 and 2007 were years with constant dollar declines in federal funding.

An additional perspective on funding trends is provided by inflation-adjusted obligations for academic S&E R&D reported by the federal agencies (i.e., the funds in constant dollars going to academic institutions in a given federal fiscal year that will be spent on R&D activities in the current and subsequent years). In constant 2005 dollars, federal academic R&D obligations peaked in FY 2004 at $25.0 billion, fell in the three subsequent years, reaching $24.0 billion in FY 2008, and then spiked upward in FY 2009, reaching $28.8 billion (appendix table 5-3).

Federal obligations for S&E R&D grew more than 10% each year on a constant dollar basis between FY 1998 and 2001. This reflected, for the most part, the federal commitment to double the R&D budget of the National Institutes of Health (NIH) over a 5-year period. Between FY (federal) 1998 and 2004, NIH's share of federal academic R&D funding increased from 57% to 63%. Then in FY 2009, the American Recovery and Reinvestment Act (ARRA), which was signed into law on February 17, 2009, provided an additional $18.3 billion in appropriations for federal R&D and R&D facilities and equipment in FY 2009.[5] The significant uptick in obligations observed in FY 2009 reflects the presence of nearly $5 billion of these ARRA funds (appendix table 5-3).

Top Federal Agency Supporters

Six agencies are responsible for the vast majority of annual federal obligations for higher education R&D: the National Institutes of Health (NIH), National Science Foundation (NSF), Department of Defense (DOD), National Aeronautics and Space Administration (NASA), Department of Energy (DOE), and Department of Agriculture (USDA). In federal FY 2009, these six agencies represented about 96% of the estimated $31.6 billion obligated for S&E R&D that year (appendix table 5-3).[6]

NIH is by far the largest funder, providing about 65% of total federal academic R&D obligations in FY 2009. NSF provided 13%; DOD, 9%; NASA, 3%; DOE, 4%; and USDA, 3%.

The federal government's overall support for academic R&D is the combined result of numerous discrete funding decisions made by the R&D-supporting federal agencies, all of which have differing missions and objectives, which in turn affect the priorities for research funding in the academic sector. For the most part, federal R&D funding to the higher education sector is allocated through competitive peer review. Nevertheless, congressional priorities and concerns in the course of the annual federal budget process can influence funding outcomes—see the sidebar, "Congressional Earmarks."

Congressional Earmarks

Broadly defined, academic earmarking is the congressional practice of directing federal funds to educational institutions for facilities or projects that are not required to undergo merit-based peer review. However, this characterization contains enough ambiguity about how to classify individual projects that estimates of the number of earmarked projects or the amount of earmarked funds may reasonably differ.

Detailed assessments of academic earmarks have been prepared by staff of *The Chronicle of Higher Education*. The most recent of these analyses estimated a total of $2.3 billion in academic earmarks in FY 2008 (Brainard and Hermes, 2008). A similar analysis for FY 2003 puts the academic earmark total at $2.0 billion (Brainard and Borrego, 2003). Approximately two-thirds ($1.6 billion) of the FY 2008 funds and $1.4 billion of the FY 2003 funds were for R&D projects, R&D equipment, or construction or renovation of R&D laboratories. A more recent estimate, published in the *Chronicle* but prepared by an outside watchdog group, put the academic earmark total for FY 2010 at $1.5 billion (Kiley, 2010).

Recently, both the Senate and House of Representatives agreed to federal budget rules that aim to eliminate earmarks. There are no earmarks in the final budget appropriations for FY 2011.

Federal Agency Support by Character of Work

Basic research activities represented about 58% of federal obligations for academic R&D in FY 2009 and about 56% in both FY 2007 and 2008 (appendix table 5-4). The two agencies funding the majority of basic research in the academic sector were NIH and NSF.

Applied research represented about 38% of federal obligations for academic R&D in FY 2009, 37% in FY 2008, and 38% in FY 2007. NIH provided the vast majority of funding in this category. Federal obligations for development activities in academia were 4–7% throughout FY 2007–09, with DOD and NASA the principal funders.

Other Sources of Funding

Notwithstanding the continuing dominant federal role in academic R&D funding, funding from nonfederal sources has grown steadily in recent years (figure 5-3). Adjusted for inflation, annual growth in nonfederal funding for academic R&D has averaged 4.8% over the last 5 years, and 4.4% for the last 10 years. The corresponding growth rates for federal funding have been 0.8% and 4.8%.

- **University and college institutional funds**. In FY 2009, institutional funds from universities and colleges comprised the second largest source of funding for academic R&D, accounting for about 20% ($11.2 billion) of the total (appendix table 5-2). Institutional funds encompass institutionally financed research expenditures and unrecovered indirect costs and cost sharing. They exclude departmental research, which is a more informal type of research that is usually coupled with instructional activities in departmental budget accounts and thus does not meet the Office of Management and Budget definition of organized research. The share of support represented by institutional funds increased steadily from 12% in 1972 to 19% in 1991, and it has remained near 20% in the subsequent years. Funds for institutionally financed R&D may derive from general-purpose state or local government appropriations; general-purpose awards from industry, foundations, or other outside sources; endowment income; and gifts. Universities may also use income from patents and licenses or revenue from patient care to support R&D. (See section "Patent-Related Activities and Income" later in this chapter for a discussion of patent and licensing income.)
- **State and local government funds.** State and local governments provided 7% ($3.6 billion) of higher education R&D funding in FY 2009. Although their absolute funding total has continued to rise annually, their funding share has declined from a peak of 10% in the early 1970s to below 7% in recent years. However, these figures are likely to understate the actual contribution of state and local governments to academic R&D, particularly for public institutions, because they only reflect funds that these governments directly target to academic R&D activities.[7] They exclude any general-purpose state or local government appropriations that academic institutions designate and use to

fund separately budgeted research or pay for unrecovered indirect costs—such funds are categorized as institutional funds. (See chapter 8, "State Indicators," for some indicators of academic R&D by state.)

- **Industry funds.** Industrial support accounts for the smallest share of academic R&D funding (just under 6%), and support for academia has never been a major component of industry-funded R&D. After a 3-year decline between 2001 and 2004, industry funding of academic R&D has been steadily increasing, reaching $3.2 billion in FY 2009. (See appendix table 4-5.)
- **Other sources of funds.** In FY 2009, all other sources of support accounted for 8% ($4.3 billion) of academic R&D funding, a level that has stayed about the same since 1972. This category of funds includes, but is not limited to, grants and contracts for R&D from nonprofit organizations and voluntary health agencies.

EPSCoR

The Experimental Program to Stimulate Competitive Research (EPSCoR) is a long standing multi-agency federal program that has the objective of improving the geographical distribution of federal support for academic R&D. An overview of the program and recent statistics on its activities are discussed in the sidebar EPSCoR: The Experimental Program to Stimulate Competitive Research.

Academic R&D Expenditures by Field

Investment in academic R&D has long been concentrated in the life sciences, which have received more than half of all academic R&D expenditures for more than three decades.

Science and Engineering R&D

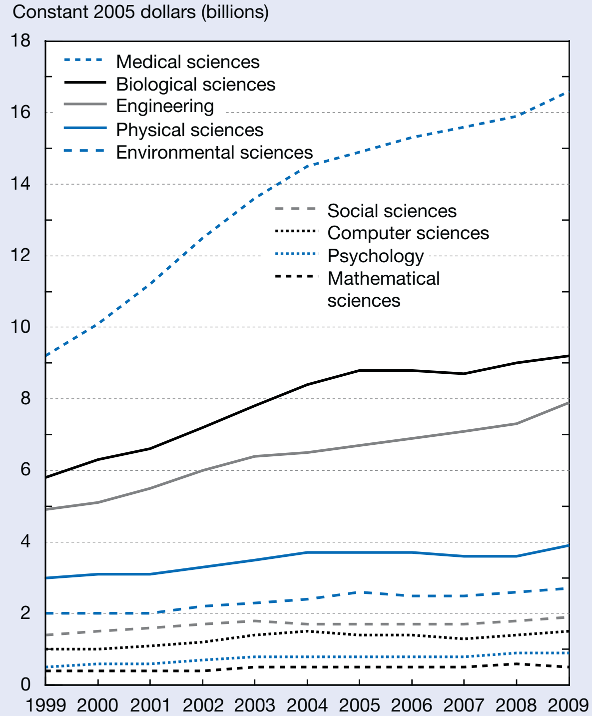
In FY 2009, academic R&D in the life sciences accounted for $32.8 billion (60%) of the $54.9 billion academic S&E R&D total (appendix table 5-5). Within the life sciences, the medical sciences accounted for 33% of the academic total and the biological sciences accounted for another 18%.[8]

Adjusted for inflation, academic R&D expenditures in the medical sciences increased by more than 75% from FY 1990 to FY 2000, and by almost 65% from FY 2000 to FY 2009 (figure 5-4 and appendix table 5-6). This sizable increase shifted the distribution of academic R&D expenditures (figure 5-5). The life sciences gained more than 4 percentage points in financial share over the decade of the 1990s (from 54% to 58%) and nearly another 2 percentage points since 2000 (up to 60%). By contrast, the physical sciences lost 2 percentage points in share over FY 1990–2000 (from 11% to 9%) and an additional percentage point since FY 2000 (down to 8%).

Federal R&D Funds by Field

R&D projects in the life sciences also constitute a majority of federally supported academic S&E R&D. They accounted for $19.3 billion (59%) of the $32.6 billion of federal

Figure 5-4
Academic R&D expenditures, by S&E field: 1999–2009



NOTE: See appendix table 4-1 for gross domestic product implicit price deflators used to convert current dollars to constant 2005 dollars.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Research and Development Expenditures at Universities and Colleges. See appendix table 5-6.

Science and Engineering Indicators 2012

support in FY 2009 (appendix table 5-7). The Department of Health and Human Services (HHS)—of which NIH is a part—supports the vast majority of this life science funding (83%). By contrast, and while their shares of total academic R&D funding are much smaller, DOD, DOE, NASA, and NSF have more diversified funding patterns (figure 5-6). In FY 2009, NSF was the lead federal funding agency for academic research in the physical sciences (30% of federally funded R&D expenditures), mathematics (56%), computer sciences (40%), and environmental sciences (34%). DOD was the lead funding agency in engineering (32%).

Federal funding has played a larger role in overall support for some fields than others (appendix table 5-8). The federal government is the dominant funder in fields such as the atmospheric sciences (78% in FY 2009), physics (73%), and aeronautical/astronautical engineering (70%). But it plays a much smaller role in other fields, such as economics (32% in FY 2009), political science (37%), and agricultural sciences (28%).

The federally financed proportion of R&D spending in *all* of the broad S&E fields has been stable or increased since 1990 (appendix table 5-8). This reverses the trend between 1975 and 1990, when the federal share had declined in all the broad fields.

EPSCoR: The Experimental Program to Stimulate Competitive Research

EPSCoR, the Experimental Program to Stimulate Competitive Research, is based on the premise that universities and their S&E faculty and students are valuable resources that can potentially influence a state's development in the 21st century in much the same way that agricultural, industrial, and natural resources did in the 20th century.

EPSCoR originated as a response to a number of stated federal objectives. Section 3(e) of the National Science Foundation Act of 1950, as amended, states that "it shall be an objective of the Foundation to strengthen research and education in the sciences and engineering, including independent research by individuals, throughout the United States, and to avoid undue concentration of such research and education." Prior to this, in 1947, a Steelman report, titled "Science and Public Policy," in discussing the formation of NSF, stated "it is clear that a portion of the funds expended by the National Science Foundation should be used to strengthen the weaker, but promising, colleges and universities, and thus to increase our total scientific potential."

In 1978, Congress authorized the NSF to conduct EPSCoR in response to broad public concerns about the extent of geographical concentration of federal funding for Research and Development (R&D). Eligibility for EPSCoR participation was limited to those jurisdictions that have historically received lesser amounts of federal R&D funding and have demonstrated a commitment to develop their research bases and improve the quality of S&E research conducted at their universities and colleges.

The success of the NSF EPSCoR program during the 1980s subsequently prompted Congress to authorize the creation of EPSCoR and EPSCoR-like programs in six other federal agencies: the Departments of Energy, Defense, and Agriculture; the National Aeronautics and Space Administration; the National Institutes of Health; and the Environmental Protection Agency. In FY 1992, the EPSCoR Interagency Coordinating Committee (EICC) was established between the federal agencies with EPSCoR or EPSCoR-like programs. The major objectives of the EICC focused on improving coordination among and between the federal agencies in implementing EPSCoR or EPSCoR-like programs consistent with the policies of participating agencies. The participating agencies agreed to the following objectives:

- Coordinate federal EPSCoR and EPSCoR-like programs to maximize the impact of federal support while eliminating duplication in states receiving EPSCoR support from more than one agency.
- Coordinate agency objectives with state and institutional goals, where appropriate, to obtain continued nonfederal support of science and technology (S&T) research and training.
- Coordinate the development of criteria to assess gains in academic research quality and competitiveness and in S&T human resource development.
- Exchange information on pending legislation, agency policies, and relevant programs related to S&T research and training and, when appropriate, to provide responses on issues of common concern.

EPSCoR seeks to increase the R&D competitiveness of an eligible state through the development and utilization of the S&T resources residing in its major research universities. It strives to achieve this objective by (1) stimulating sustainable S&T infrastructure improvements at the state and institutional levels that significantly increase the ability of EPSCoR researchers to compete for federal and private sector R&D funding, and (2) accelerating the movement of EPSCoR researchers and institutions into the mainstream of federal and private sector R&D support.

In FY 2010, five EICC agencies spent a total of $460.1 million on EPSCoR and EPSCoR-like programs, up from $225.3 million in 2001 (table 5-A). The Environmental Protection Agency and the Department of Defense discontinued issuing separate EPSCoR program solicitations in FY 2006 and 2010, respectively.

Table 5-A
EPSCoR and EPSCoR-like program budgets, by agency: FY 2001–10
(Millions of dollars)

Agency	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
All agencies	225.3	288.9	358.0	353.3	367.4	367.1	363.1	418.9	437.2	460.1
DOD	18.7	15.7	15.7	8.4	11.4	11.5	9.5	17.0	14.1	0.0
DOE	7.7	7.7	11.7	7.7	7.6	7.3	7.3	14.7	16.8	21.6
EPA	2.5	2.5	2.5	2.5	2.4	0.0	0.0	0.0	0.0	0.0
NASA	10.0	10.0	10.0	10.0	12.0	12.5	12.8	15.5	20.0	25.0
NIH	100.0	160.0	210.0	214.0	222.0	220.0	218.0	223.6	224.3	228.8
NSF	74.8	79.3	88.8	93.7	93.4	97.8	101.5	120.0	133.0	147.1
USDA	11.6	13.7	19.3	17.0	18.6	18.0	14.0	28.1	29.0	37.6

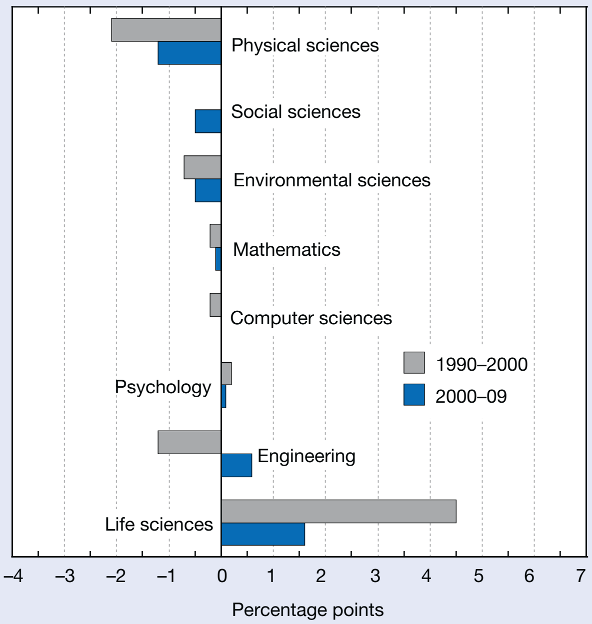
DOD = Department of Defense; DOE = Department of Energy; EPA = Environmental Protection Agency; EPSCoR = Experimental Program to Stimulate Competitive Research; NASA = National Aeronautics and Space Administration; NIH = National Institutes of Health; NSF = National Science Foundation; USDA = U.S. Department of Agriculture

NOTE: EPA discontinued issuing separate EPSCoR program solicitations in FY 2006.

SOURCE: Data provided by agency EPSCoR representatives; collected by NSF Office of Integrative Activities, Office of EPSCoR, April 2011.

Science and Engineering Indicators 2012

Figure 5-5
Changes in share of academic R&D, by selected S&E field: 1990–2000 and 2000–09



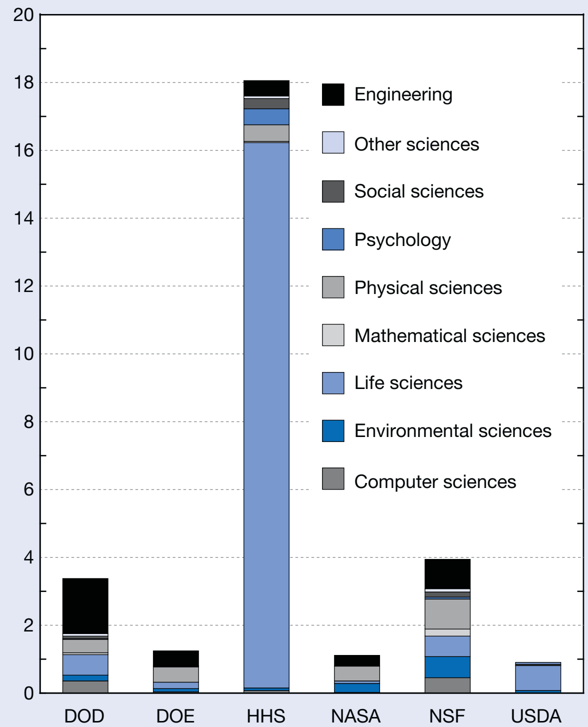
NOTE: Fields ranked by change in share during 2000–09, in ascending order.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Research and Development Expenditures at Universities and Colleges. See appendix table 5-6.

Science and Engineering Indicators 2012

Figure 5-6
Federally financed academic R&D expenditures, by agency and S&E field: FY 2009

Current dollars (billions)



DOD = Department of Defense; DOE = Department of Energy; HHS = Department of Health and Human Services; NASA = National Aeronautics and Space Administration; NSF = National Science Foundation; USDA = U.S. Department of Agriculture

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Research and Development Expenditures at Universities and Colleges (FY 2009). See appendix table 5-7.

Science and Engineering Indicators 2012

Non-S&E R&D

Academic institutions spent a total of $2.4 billion on R&D in non-S&E fields in FY 2009 (table 5-1), an increase of 8% over the $2.2 billion spent in 2008.[9,10] This $2.4 billion is in addition to the $54.9 billion expended on S&E R&D. The federal government funds smaller proportions of R&D in non-S&E than in S&E fields: 36% of the $2.4 billion in non-S&E R&D in FY 2009.

The largest amounts reported for R&D in non-S&E fields were for education ($921 million), business and management ($341 million), and humanities ($253 million). Other areas of non-S&E R&D include law, social work, communication, journalism, library science, and the visual and performing arts.

Academic R&D by Institution

The prior discussion examined R&D for the academic sector as a whole. This section discusses some of the differences that prevail across the types of academic institutions.

R&D Funding for Public and Private Universities and Colleges

In FY 2009, public institutions received $37.5 billion in academic S&E R&D and private institutions received $17.4 billion (appendix table 5-9).

Although public and private universities rely on the same major sources of R&D funding, the importance of the different sources varies substantially (figure 5-7). The federal government provided 71% of the R&D funding for private institutions but only 54% for public institutions. Conversely, public institutions received around 9% of their R&D funding from state and local governments, while private institutions received a little over 2%.

Public academic institutions also supported a larger portion of their R&D from their own sources—24%, compared to 12% at private institutions. This larger proportion of institutional R&D funds in public institutions may reflect the general-purpose state and local government funds that public institutions have directed toward R&D. Private institutions in turn report a larger proportion of unrecovered indirect costs (54% of their institutional total in FY 2009, versus 42% for public institutions). For both types of institutions, these unrecovered indirect costs have declined over the past decade, from 63% to 54% for private institutions and from 44% to 42% for public institutions (figure 5-8).

Both public and private institutions received approximately 6% of their R&D support from industry in FY 2009. The share of total R&D expenditures funded by all other sources was also comparable, at 7% in public and 9% in private institutions.

Distribution of R&D Funds across Academic Institutions

Academic R&D expenditures are concentrated in a relatively small number of institutions. In FY 2009, 711 institutions reported spending at least $150,000 on S&E R&D. Of these, the top-spending 20 institutions accounted for 30% of total academic R&D spending and the top 100 for 80% of this spending (figure 5-9).

Table 5-1
R&D expenditures at academic institutions in non-S&E fields: FY 2007–09
(Millions of current dollars)

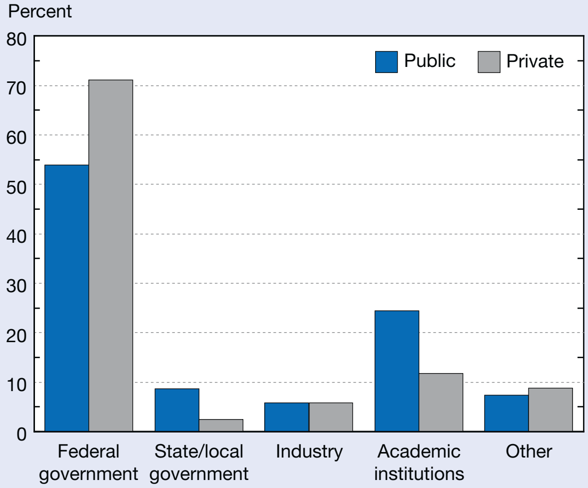
Field	2007 Total expenditures	2007 Federal expenditures	2008 Total expenditures	2008 Federal expenditures	2009 Total expenditures	2009 Federal expenditures
All non-S&E fields	2,058	808	2,206	831	2,386	867
Business and management	275	54	326	66	341	68
Communication, journalism, and library science	90	31	90	29	108	30
Education	902	473	869	450	921	480
Humanities	242	60	246	56	253	60
Law	74	29	89	28	107	23
Social work	93	40	124	59	139	62
Visual and performing arts	46	4	59	4	73	4
Other non-S&E fields	335	116	404	139	445	140

NOTE: Detail may not add to total because some respondents reporting non-S&E R&D expenditures did not break out total and federal funds by non-S&E fields.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Research and Development Expenditures at Universities and Colleges.

Science and Engineering Indicators 2012

Figure 5-7
Sources of R&D funding for public and private academic institutions: FY 2009

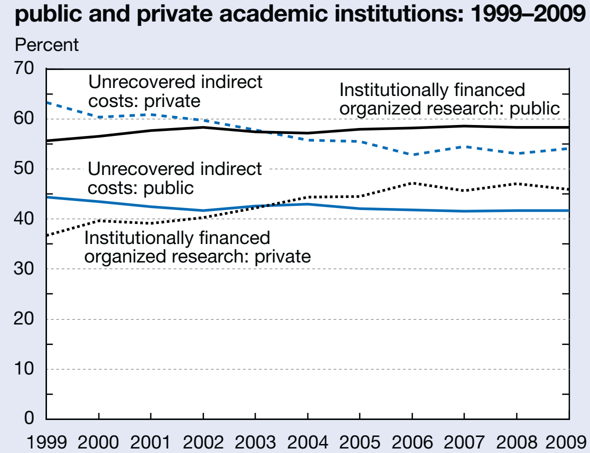


NOTE: Science and engineering R&D; non-S&E R&D not included.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Research and Development Expenditures at Universities and Colleges (FY 2009). See appendix table 5-9.

Science and Engineering Indicators 2012

Figure 5-8
Components of institutional R&D expenditures for public and private academic institutions: 1999–2009

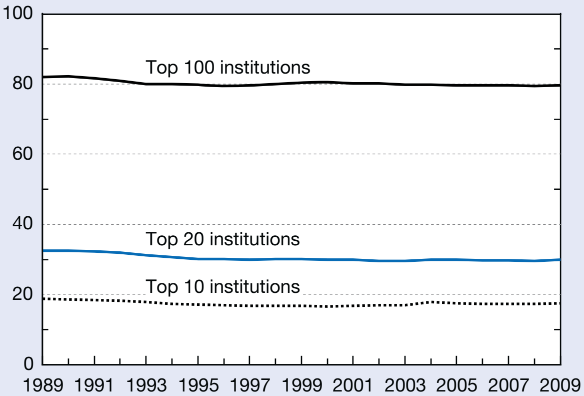


NOTE: Science and engineering R&D; non-S&E R&D not included.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2010) of Survey of Research and Development Expenditures at Universities and Colleges.

Science and Engineering Indicators 2012

Figure 5-9
Share of academic R&D, by institution rank in R&D expenditures: FY 1989–2009

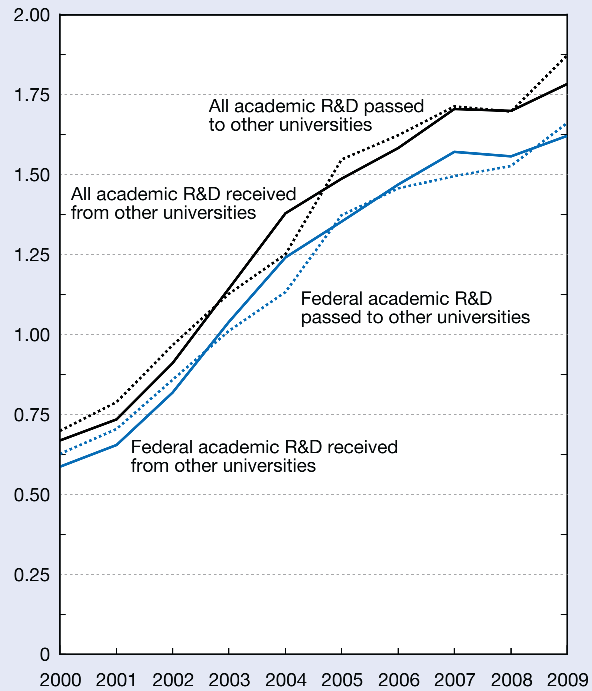


NOTE: Science and engineering R&D; non-S&E R&D not included.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2010) of Survey of Research and Development Expenditures at Universities and Colleges.

Science and Engineering Indicators 2012

Figure 5-10
Total and federally funded academic R&D pass-throughs: FY 2000–09



NOTE: Science and Engineering R&D; non S&E R&D not included.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Research and Development Expenditures at Universities and Colleges. See appendix table 5-12.

Science and Engineering Indicators 2012

The top 100 institutions are listed in appendix table 5-10. The concentration of academic R&D funds among the top 100 institutions has remained largely constant over the past two decades (figure 5-9). Similarly, the shares held by both the top 10 and the top 20 institutions have not changed much over the same period. (Even so, the identities of the universities in each of these groups have varied over time, as universities increase or decrease their R&D activities. For example, 5 of the top 20 institutions in FY 1988 were no longer in the top 20 in FY 2008.)

A similar concentration is found among universities that perform non-S&E R&D. The top 20 performers accounted for 36% of the total non-S&E R&D expenditures in FY 2009 (appendix table 5-11).

R&D Collaboration between Academic Institutions

A persistent trend in academic R&D has been the growth of research collaboration—notably evident in the growth of jointly authored research articles (see later in this chapter for details). This trend is also evident in flows of funds among institutions to support collaborative research activities. One indicator of this collaboration is the amount of total R&D expenditures that is passed through to other academic institutions or received by institutions as subrecipient funding.[11]

On this basis, the R&D funds for joint projects passed through universities to other university subrecipients more than doubled from FY 2000 to 2009, from $699 million to $1.9 billion (figure 5-10 and appendix table 5-12). The FY 2009 value is about 3% of total academic R&D expenditures that year, compared with 2% in 2000. In FY 2009, $1.7 billion (89%) of these pass-through funds came from federal sources.

Overall, $3.8 billion was passed through institutions to all types of subrecipients in FY 2009 (including both academic and nonacademic institutions), and $4.1 billion was received as subrecipient funding from all types of pass-through entities (appendix table 5-12). Again, the majority of these funds (85% of pass-through funds and 90% of subrecipient expenditures) were from federal sources.

Infrastructure for Academic R&D

Physical infrastructure is an essential resource for the conduct of R&D. Not long ago, the capital infrastructure for R&D consisted primarily of research space (such as laboratories and computer rooms) and instrumentation. Accordingly, the square footage of a designated research space and counts of instruments are principal indicators of the status of research infrastructure.

Over the last 20 years, however, advances in information technology have brought significant changes to both the methods of scientific research and the infrastructure needed to conduct R&D. The technologies, human interfaces, and associated processing capabilities resulting from these innovations are often included in the term *cyberinfrastructure.* Cyberinfrastructure may involve mainly one resource, such as a network used to transfer data, or it may involve a complex interaction of many resources resulting in sophisticated capabilities, such as high-performance computation or remote use of scientific instrumentation. No matter how simple or complex these technologies and their human interfaces may be, cyberinfrastructure has become an essential resource for science.

Indicators for research facilities, research equipment, and cyberinfrastructure capacity are discussed in this section. (For an overview of the sources of data used see the sidebar, “Data on the Financial and Infrastructure Resources for Academic R&D,” earlier in this chapter.)

Research Facilities

Research Space

At the close of academic FY 2009, research-performing colleges and universities had 196.1 million net assignable square feet (NASF) of research space available (appendix table 5-13).[12] This was 2.2% above the assignable square footage at the end of FY 2007.

This increase represented continuity in a now two-decade long trend of academic institutions investing to expand their research space. Even so, the pace of growth has slowed in the last few years. The 2.2% expansion over the FY 2007–09 period was the slowest since the 1988–90 period. (The rate of increase peaked in 2001–03 at 11%, and has gradually declined since then.)

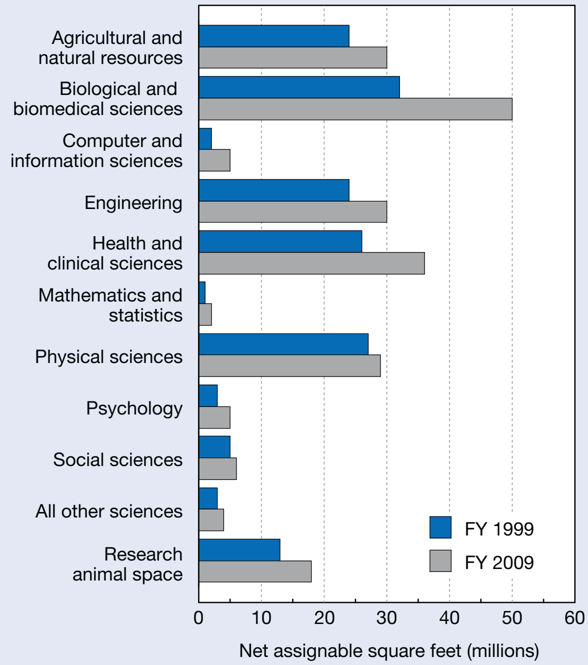
The S&E field of biological/biomedical sciences currently accounts for the largest portion of research space, or 50.3 million NASF in FY 2009 and 26% of the academic total (figure 5-11 and appendix table 5-13).[13] The related field of health/clinical sciences was the second largest, accounting for 36.3 million NASF and 19% of the total. Still sizable are engineering (30.2 million NASF, 15%), agricultural/natural resources (29.5 million NASF, 15%), and physical sciences (28.5 million NASF, 15%). The other fields are substantially smaller: social sciences (5.5 million NASF, 3%), computer/information sciences (5.2 million NASF, 3%), psychology (5.2 million NASF, 3%), mathematics/statistics (1.5 million NASF, 1%), and all other sciences (3.9 million NASF, 2%).

The aforementioned slowing pace of growth in overall academic research space since FY 2005 has played out in a variety of ways across the S&E fields (appendix table 5-13). The large amount of space for biological/biomedical sciences continued to expand at a substantial rate in both the FY 2005–07 and 2007–09 periods. The agricultural/natural resources field also increased its research NASF in both periods. Engineering expanded in FY 2005–07, but had no growth in the 2007–09 period.

Even so, the amount of research space available to a sizable number of S&E fields has experienced no growth or a decline since FY 2005. Health/clinical sciences and physical sciences, both fields with large amounts of research space, experienced declines in each of the FY 2005–07 and 2007–09 periods.[14] The decline in the health/clinical sciences is particularly notable, because this field exhibited some of the largest increases in research space in any S&E field in the first half of the 2000 decade. While much smaller in NASF size, the social sciences exhibited a research space decline in both FY 2005–07 and 2007–09. And, also small, the mathematics/statistics field exhibited a decline in 2007–09.

Compared with other fields, the computer sciences exhibited among the largest rates of increase in research space from FY 2001 to 2007 (appendix table 5-13). Nonetheless, its total research space, currently at 5.2 million NASF, is less than most fields.

Figure 5-11
S&E research space at academic institutions, by field: FY 1999 and 2009



NOTE: S&E fields are those used in the National Center for Educational Statistcs (NCES) Classification of Instructional Programs (CIP). NCES updates the CIP every 10 years. S&E fields here reflect the NCES 2000 CIP update.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Science and Engineering Research Facilities. See appendix table 5-13.

Science and Engineering Indicators 2012

New Construction

Concomitant with the slowing expansion of overall academic research space, new construction also slowed in the second half of the 2000 decade (table 5-2). The 16.2 million NASF of new construction in FY 2002–03 dropped to about 8.8 million in FY 2006–07, even if up somewhat, to 9.9 million in FY 2008–09. Similarly, within the broad decline of total research space, the amount and direction of change in new construction varied significantly across the S&E fields.

The construction starts for new research space in the biological/biomedical sciences was the largest among all the fields in FY 2006–07 and 2008–09, or 2.9 million NASF

Table 5-2
New construction of S&E research space in academic institutions, by field and time of construction: FY 2002–09

Field	Started in FY 2002 or FY 2003	Started in FY 2004 or FY 2005	Started in FY 2006 or FY 2007	Started in FY 2008 or FY 2009
	Net assignable square feet (millions)			
All fields	16.2	10.2	8.8	9.9
Agricultural and natural resources	0.8	0.4	0.5	0.4
Biological and biomedical sciences	4.0	3.2	2.9	3.5
Computer and information sciences	1.0	0.3	0.6	0.3
Engineering	2.2	1.5	1.3	2.1
Health and clinical sciences	5.0	3.3	1.7	1.9
Mathematics and statistics	*	*	*	*
Physical sciences	2.1	0.8	1.0	1.0
Earth, atmospheric, and ocean sciences	0.6	0.3	0.3	0.1
Astronomy, chemistry, and physics	1.5	0.5	0.7	0.9
Psychology	0.2	0.2	0.1	0.3
Social sciences	0.2	0.1	0.1	0.2
Other sciences	0.7	0.3	0.7	0.3
Research animal space	1.4	1.2	1.0	0.8
	Share of total new construction square feet (%)			
All fields	100.0	100.0	100.0	100.0
Agricultural and natural resources	4.9	3.9	5.7	4.0
Biological and biomedical sciences	24.7	31.4	33.0	35.4
Computer and information sciences	6.2	2.9	6.8	3.0
Engineering	13.6	14.7	14.8	21.2
Health and clinical sciences	30.9	32.4	19.3	19.2
Mathematics and statistics	*	*	*	*
Physical sciences	13.0	7.8	11.4	10.1
Earth, atmospheric, and ocean sciences	3.7	2.9	3.4	1.0
Astronomy, chemistry, and physics	9.3	4.9	8.0	9.1
Psychology	1.2	2.0	1.1	3.0
Social sciences	1.2	1.0	1.1	2.0
Other sciences	4.3	2.9	8.0	3.0
Research animal space	8.6	11.8	11.4	8.1

* = >0 but <50,000 net assignable square feet

NOTES: Detail may not add to total because of rounding. Figures for research animal space listed separately and also included in individual field totals. S&E fields are those used in the National Center for Education Statistics (NCES) Classification of Instructional Programs (CIP). NCES updates the CIP every 10 years; S&E fields here reflect the NCES 2000 CIP update. For comparison of subfields in the FY 2005 and FY 2007 surveys, see S&E Research Facilities: FY 2007, detailed statistical tables.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Science and Engineering Research Facilities.

Science and Engineering Indicators 2012

and 3.5 million NASF, respectively. Further back were the health/clinical sciences (1.7 million NASF in FY 2006–07, 1.9 million in 2008–09) and engineering (respectively, 1.3 million and 2.1 million). All the other fields reported some new construction starts in both FY 2006–07 and 2008–09, but at levels well below the top three fields.

Academic institutions draw on various sources to fund their capital projects, including the institutions' own funds, state or local governments, and the federal government. For the construction of new research space initiated in FY 2008–09, about 62% of the funding came from institutions' internal sources, 36% from state/local government, and the remaining 3% from the federal government. This was similar to the new construction initiated in FY 2006–07, where the funding shares were, 62%, 32%, and 6%, respectively. In recent years, the federal portion of funding has been under 10% and declining, with the FY 2009 level the lowest for several decades.

Research Equipment

In FY 2009, about $2.0 billion in current funds was spent for academic research equipment (i.e., moveable items, such as computers or microscopes) necessary for the conduct of organized research projects (appendix table 5-14).[15] The corresponding totals in earlier years were $1.9 billion in FY

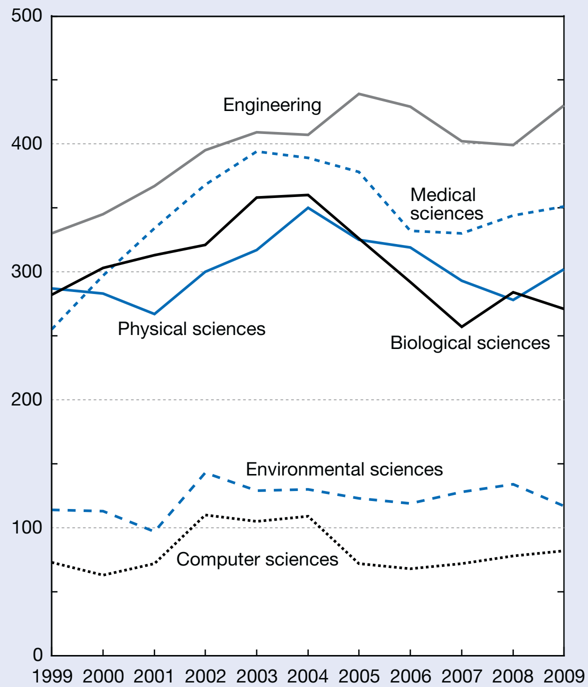
2008, $1.9 billion in FY 2004, and $1.3 billion in FY 1999. Adjusted for inflation, the change in this spending from 2008 to 2009 was a 2% increase, which was an increase of 16% over the 1999 spending level, but a 9% decline from the 2004 level.

The $2.0 billion of equipment spending in FY 2009 was just under 4% of the $54.9 billion of total academic R&D expenditures that year. In FY 2004, the share was somewhat above 4% of the academic R&D total. In FY 1999, the fraction was closer to 5%.

This equipment spending continues to be concentrated in just a few S&E fields. In FY 2009, three fields accounted for 82% of the annual total: life sciences (41%), engineering (24%), and the physical sciences (17%). The shares for these three fields have remained similarly predominant for many years (appendix table 5-14). Even so, when adjusted for inflation, the annual level of equipment spending in all three fields has declined since 2005—reversing a trend of steady growth from FY 2001 to 2004 (figure 5-12).

Some of the funding for academic research equipment comes from the federal government. These federal funds are generally received as part of research grants or as separate equipment grants. In FY 2009, the federal government supported 55% of total academic research equipment funding—a figure that has fluctuated between 55% and 63% over the last 20 years (appendix table 5-15). Nevertheless, the federal share of funding varies significantly by S&E field, ranging from 26% to 77% in 2009. In FY 2009, computer sciences had the largest proportion of federally funded R&D equipment (77%), with atmospheric sciences a close second (76%).

Figure 5-12
Current fund expenditures for S&E research equipment at academic institutions, by field: 1999–2009



NOTE: See appendix table 4-1 for gross domestic product implicit price deflators used to convert current dollars to constant 2005 dollars.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Research and Development Expenditures at Universities and Colleges. See appendix table 5-14.

Science and Engineering Indicators 2012

Cyberinfrastructure

Networking is an essential component of cyberinfrastructure. It facilitates research-related activities such as communication, data transfer, high-performance computation, and remote use of instrumentation.[16] In FY 2009, networking infrastructure on many academic campuses was pervasive and still rapidly expanding in capability and coverage. Research-performing institutions had more connections, bandwidth, and campus coverage than they did earlier in the decade.[17] (Network "bandwidth" is the amount of data that can be transmitted in a given amount of time, typically measured in bits per second.) Colleges and universities reported external network connections with greater bandwidth, faster internal network distribution speeds, more connections to high-speed networks, and greater wireless coverage on campus.

Some academic cyberinfrastructure is dedicated primarily to research activities. For example, universities may have high-performance networks (such as the National LambdaRail or networks to government agencies) available almost exclusively for research activities, and this bandwidth capacity is only for these activities. Nonetheless, universities may have other networks that are available to the entire campus community for both research and non-research activities, and this bandwidth capacity is not an indicator solely of research capacity.

Bandwidth to External Connections

Academic institutions can have multiple networking resources, at varying connection speeds. Internet1—the public multiuse, commodity network often called the "Internet"—is one such component. Many institutions also have direct or indirect connections to high-performance networks that support the development and use of advanced applications and technologies. In the academic community, these high-performance networks are chiefly Internet2 (a high performance backbone network providing leading-edge network services to member colleges, universities, and research laboratories across the country), the National LambdaRail (an advanced optical network for research and education, organized by a consortium of universities, private companies, and federal labs), and connections to federal research networks.

Early in the 2000 decade, some academic institutions reported no Internet1 connections of any kind. By mid-decade, all institutions had Internet1 connections and bandwidth speeds were increasing. Between FY 2005 and FY 2009, the fraction of institutions with total Internet1 and Internet2 bandwidth of more than 100 megabits per second increased from 52% to 80% (table 5-3). Furthermore, the share of institutions with total Internet1 and Internet2 bandwidths of 1 gigabit per second or faster rose from 22% in FY 2005 to 45% in FY 2009. (If current institutional estimates are realized, the percent of institutions with total bandwidths of 1 gigabit or faster will reach 52% in FY 2010.)

Bandwidth has increased broadly across all types of academic institutions. Nevertheless, a greater fraction of doctorate-granting institutions have the faster bandwidths. In FY 2009, 87% of the institutions that granted doctorates had total Internet1 and Internet2 bandwidth of at least 1 gigabit per second, and 32% had bandwidth greater than 2.4 gigabits. In contrast, 71% of nondoctorate granting institutions had total bandwidth at 1 gigabit per second or above and 8% above 2.4 gigabits.

Part of the increase in institutions' bandwidth can be attributed to an increase in the number of connections to high-performance networks (table 5-4). The number of connections to Internet2 has grown gradually over the current decade; by the end of FY 2009, a large majority (75%) of institutions had Internet2 connections. Between FY 2007 and 2009, the percentage of institutions with connections to the National LambdaRail increased, from 25% to 34% of all institutions. The number of institutions anticipating connections to federal government high-performance networks such as the Department of Energy's ESnet or NASA's NREN further increased in FY 2009. Institutions have also begun connecting to more than one high-performance network—for example, in FY 2009, 34% had connections to both Internet2 and the National LambdaRail.

Internal Institutional Networks

The bandwidth speeds of academic institutions' internal networks have also increased considerably. Since early in the present decade, the percentage of institutions with slower bandwidth has rapidly decreased while the percentage with faster bandwidths has rapidly increased. In FY 2003, 66% of institutions had bandwidth less than 1 gigabit per second, but by the end of FY 2009, only 19% did (table 5-5). In FY 2003, no institutions had bandwidth speeds faster than 2.5 gigabits per second, but by FY 2009, 24% of academic institutions did. By FY 2009, 82% of institutions had speeds of 1 gigabit per second or faster.

In FY 2009, all academic institutions had at least some wireless coverage in their campus buildings. In FY 2003, only 14% of these institutions had more than half of their building infrastructure covered by wireless; by FY 2009, the comparable figure was 74%.

The Academic Doctoral S&E Workforce

S&E doctorate holders in academia influence the nation's academic R&D enterprise in two key ways. They work in institutions that conduct academic R&D and produce the bulk of academic articles and patents. Moreover, they teach individuals who then go on to earn S&E doctorates, many of whom

Table 5-3
Bandwidth of commodity internet (Internet1) and Internet2 at academic institutions: FY 2005–10
(Percent distribution)

Bandwidth	FY 2005	FY 2007	FY 2009	FY 2010[a]
All bandwidth	100	100	100	100
No bandwidth	0	0	0	0
≤10 mb	6	3	1	1
11–100 mb	42	33	19	13
101–999 mb	30	31	35	34
1–2.4 gb	15	23	25	25
2.5–9 gb	4	4	5	6
10 gb	*	2	4	7
>10 gb	2	4	11	14
Other	*	0	0	0
Number of institutions	449	448	495	494

* = >0 but <0.5%

mb = megabits per second; gb = gigabits per second

[a]Figures for 2010 are estimated.

NOTES: Details may not add to 100% due to rounding. Internet1, also termed commodity internet, is the general public, multiuse network often called the "Internet." Internet2 is a high-performance backbone network that enables the development of advanced Internet applications and the deployment of leading-edge network services to member colleges, universities, and research laboratories across the country. Total bandwidth for FY 2009 and 2010 includes National LamdaRail bandwidth. The response categories in the FY 2005 survey varied slightly from those in the FY 2007 and 2009 surveys; in the FY 2005 survey, the categories were "1 to 2.5 gb" and "2.6 to 9 gb."

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Science and Engineering Research Facilities.

Science and Engineering Indicators 2012

Table 5-4
Institutions with high-performance network connections, by type of institution: FY 2005–09
(Percent)

Type of institution	Internet2	National LambdaRail	A federal government research network	State or regional high-performance network	Other
FY 2005					
All academic	68	10	11	na	12
Doctorate granting	82	11	13	na	15
Nondoctorate granting	38	7	6	na	6
Public	73	11	12	na	14
Private	58	8	9	na	9
All biomedical	24	2	1	na	3
Research institutions	19	1	1	na	3
Hospitals	35	4	2	na	2
FY 2007					
All academic	70	25	11	55	3
Doctorate granting	81	32	13	59	4
Nondoctorate granting	46	10	4	43	1
Public	75	29	12	61	3
Private	61	17	8	41	3
All biomedical	26	4	0	13	2
Research institutions	20	3	0	10	3
Hospitals	37	6	0	19	2
FY 2009					
All academic	75	34	13	60	8
Doctorate granting	87	43	17	70	9
Nondoctorate granting	51	18	6	39	5
Public	83	41	16	73	7
Private	59	22	8	36	10
All biomedical	29	10	2	15	1
Research institutions	22	11	1	16	1
Hospitals	47	8	4	14	2

na = not applicable; data were not collected in FY 2005.

NOTES: Internet2 is a high-performance hybrid optical packet network. The network was designed to provide next-generation production services as well as a platform for the development of new networking ideas and protocols. National LambdaRail (NLR) is an advanced optical network infrastructure for research and education. NLR enables cutting-edge exploration in the sciences and network research. An institution may have a connection to more than one high-performance network.

SOURCE: National Science Foundation/National Center for Science and Engineering Statistics, Survey of Science and Engineering Research Facilities.

Science and Engineering Indicators 2012

will work in academia and contribute to academic R&D. The focus of this section is on the research aspects of the employment of doctoral scientists and engineers in academia.

This section examines trends in the doctoral S&E academic workforce in terms of its demographic composition and its deployment across institutions, positions, and fields. Particular attention is paid to the component of the academic workforce that is more focused on research, including graduate assistants, those employed in postdoctoral positions, and researchers receiving federal support.

The discussion in this section is limited to individuals, including foreign-born individuals, who received their S&E doctorate at a U.S. institution. (More than two-thirds of foreign-born doctorate holders employed in the United States earned their doctorate degree from a U.S. institution; see chapter 3 for more information on foreign-born doctorate holders working in the United States). Owing to the complex interrelationships among faculty and nonfaculty positions that jointly produce R&D outcomes, much of the discussion addresses the overall academic employment of S&E doctorate holders, including those in nonfaculty positions. At various points the characteristics of full-time faculty are discussed.

Table 5-5
Highest internal network speeds, by highest degree granted: FY 2003–09
(Percent distribution)

Fiscal year and connection speed	All academic institutions	Highest degree granted	
		Doctorate	Nondoctorate
FY 2003	100	100	100
≤10 mb	2	3	2
11–999 mb	64	55	88
1–2.5 gb	33	43	10
2.6–9 gb	0	0	0
10 gb	0	0	0
>10 gb	0	0	0
Other	0	0	0
FY 2005	100	100	100
≤10 mb	0	0	1
11–999 mb	46	38	64
1–2.5 gb	50	56	35
2.6–9 gb	1	1	0
10 gb	3	4	0
>10 gb	*	*	0
Other	0	0	0
FY 2007	100	100	100
≤10 mb	1	1	1
11–999 mb	24	18	39
1–2.4 gb	61	63	55
2.5–9 gb	2	2	1
10 gb	10	13	3
>10 gb	1	2	0
Other	1	1	1
FY 2009	100	100	100
≤10 mb	1	*	1
11–999 mb	18	13	28
1–2.4 gb	58	55	63
2.5–9 gb	2	3	1
10 gb	18	24	5
>10 gb	3	4	1
Other	1	1	1

* = >0 but <0.5%

mb = megabits per second; gb = gigabits per second

NOTE: Details may not add to 100% due to rounding.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Science and Engineering Research Facilities.

Science and Engineering Indicators 2012

Trends in Academic Employment of Doctoral Scientists and Engineers

Academic employment of doctoral scientists and engineers grew over the past three decades and reached a record high of 272,800 in 2008, about the same as the employment numbers in 2006 (appendix table 5-16).[18] However, the change from 2006 was the smallest single-period increase in estimated total academic employment since at least 1973. The long-term growth rate in the number of doctoral scientists and engineers employed in the academic sector was slower than the rate of growth in the business and government sectors (table 5-6). As a result, the share of all S&E doctorate holders employed in academia dropped from 55% to 44% during the 1973–2008 period (table 5-7). In 2008, nearly half of those with recently awarded S&E doctorate degrees (that is, a degree awarded within 3 years of the survey year) were employed in academia, with 18% of recent doctorate holders employed in academic postdoc positions.[19]

Academic Employment of S&E Doctorate Holders

The academic doctoral S&E workforce includes those with a doctorate in an S&E field and employed in the following positions: full and associate professors (referred to as "senior faculty"); assistant professors and instructors (referred to as "junior faculty"); postdoctoral researchers (referred to as "postdocs"); other full-time positions such as lecturers, adjunct faculty, research associates, and administrators; and part-time positions of all kinds. Academic employment is limited to those employed in 2-year or 4-year colleges or universities.

Full-time faculty positions continue to be the norm in academic employment, but S&E doctorate holders are increasingly employed in other full-time positions, postdocs, and part-time positions (figure 5-13). The share of full-time faculty among all academic S&E doctorate holders fell from 88% in the early 1970s to 73% in 2008 (appendix table 5-16). Over the same period, the share of other full-time positions rose from 6% to 15%, the share of postdocs increased from 4% to 7%, and the share of part-time positions increased from 2% to 6% of all academic S&E doctorate holders.

Table 5-6
Average annual growth rate for employment of SEH doctorate holders, by sector: 1973–2008
(Percent)

Sector	1973–2008	1973–83	1983–93	1993–2003	2003–08
All sectors	3.3	5.4	2.5	2.0	1.8
Academia	2.4	4.1	2.0	2.0	1.0
Industry	4.6	7.9	4.1	2.7	2.9
Government	3.2	5.5	2.5	3.1	0.6
Other	2.7	5.3	0.5	–1.6	11.9

SEH = science, engineering, and health

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of 1973–2008 Surveys of Doctorate Recipients.

Science and Engineering Indicators 2012

The proportion of full-time faculty among S&E doctorate holders in higher education fell in all fields during 1973–2008, with the life sciences and psychology experiencing the largest relative declines. Growth in postdoc positions and other full-time positions accounted for the declining share of full-time faculty positions in the life sciences, whereas the growth in part-time and other full-time positions explained the drop in share of faculty positions in psychology (appendix table 5-16).

Over the past three decades, growth in the number of life scientists with academic employment was consistently stronger than for doctorate holders in other S&E fields (figure 5-14). Growth in academic employment slowed in the early 1990s for engineering, social sciences, physical sciences, and mathematics, but has increased since then in social sciences and mathematics (appendix table 5-16).

Table 5-7
SEH doctorate holders employed in academia, by years since doctorate: Selected years, 1973–2008
(Percent)

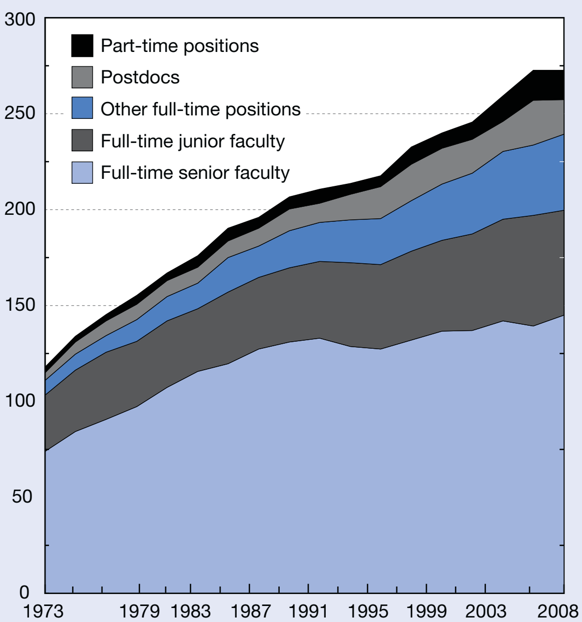
Years since doctorate	1973	1983	1993	2003	2008
All employed doctorate holders	54.8	48.4	45.9	45.6	43.8
≤3	55.2	48.0	50.5	53.7	49.6
4–7	55.8	44.9	47.0	47.7	48.3
≥8	54.2	49.4	45.0	44.2	42.1

SEH = science, engineering, and health

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of 1973, 1983, 1993, 2003, and 2008 Surveys of Doctorate Recipients.

Science and Engineering Indicators 2012

Figure 5-13
SEH doctorate holders employed in academia, by type of position: 1973–2008



SEH = science, engineering, and health

NOTES: Academic employment limited to U.S. doctorate holders employed at 2- or 4-year colleges or universities. Senior faculty includes full and associate professors; junior faculty includes assistant professors and instructors. Other full-time positions include positions such as research associates, adjunct appointments, lecturers, and administrative positions. Part-time positions exclude those held by students or retired persons.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of 1973–2008 Surveys of Doctorate Recipients.

Science and Engineering Indicators 2012

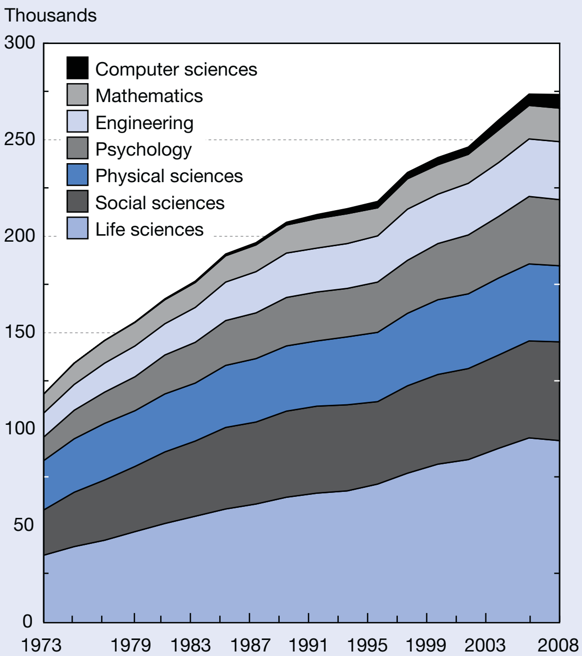
Women in Academic S&E Workforce

The number of women with S&E doctorates employed in academia grew from 10,700 in 1973 to 93,400 in 2008, more than an eightfold increase. In comparison, the number of male S&E doctorate holders increased 67% over the period, from 107,200 in 1973 to 179,400 in 2008 (appendix table 5-17).

These differential rates of increase are reflected in the steadily rising share of women in the academic S&E workforce. Women constituted 34% of all academic S&E doctoral employment and 31% of full-time faculty in 2008, up from 9% and 7%, respectively, in 1973 (table 5-8 and appendix table 5-17). Women's share of academic S&E employment increased markedly over time in all position categories, though to a lesser degree in part-time positions. Women have held a larger share of junior faculty positions (includes assistant professors and instructors) than positions at either the associate or full professor rank. However, as a result of the decades-long trend in the rising proportion of women earning doctoral degrees, coupled with their slightly greater propensity to enter academic employment, the share of women in all three faculty ranks rose significantly between 1973 and 2008. In 2008, women constituted 21% of full professors, 37% of associate professors, and 42% of junior faculty (figure 5-15).

Compared with their male counterparts in the academic doctoral S&E workforce, women were more heavily concentrated in the fields of life sciences, social sciences, and psychology, with correspondingly lower shares in engineering, the physical sciences, mathematics, and computer sciences. Women's share of doctorate holders in each of these fields grew during the 1973–2008 period (appendix table 5-17), with the most pronounced growth in share occurring in engineering, the field in which women were the least well represented.

Figure 5-14
SEH doctorate holders employed in academia, by degree field: 1973–2008



SEH = science, engineering, and health

NOTES: Academic employment limited to U.S. doctorate holders employed at 2- or 4-year colleges or universities, excluding those employed part time who are students or retired. Physical sciences include earth, atmospheric, and ocean sciences; life sciences include biological, agricultural, environmental, and health sciences.

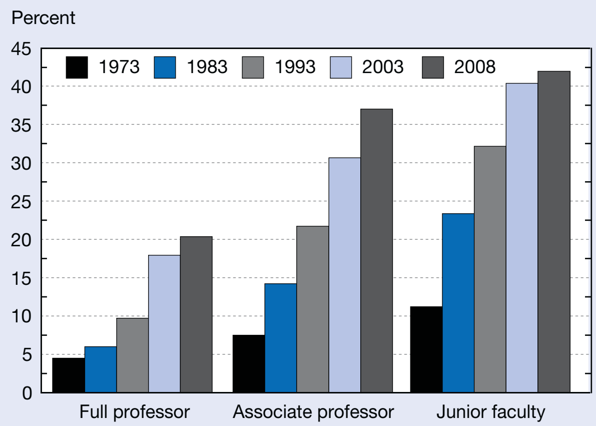
SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of 1973–2008 Surveys of Doctorate Recipients.

Science and Engineering Indicators 2012

Minorities in Academic S&E Workforce

Although the number of academic S&E doctorate holders who are members of underrepresented minority groups (i.e., blacks, Hispanics, and American Indians/Alaska Natives) has increased over time, they remain a small percentage of the total (appendix table 5-18). These groups constituted about 9% of both total academic employment

Figure 5-15
Women as percentage of SEH doctorate holders with full-time employment in academia, by academic rank: Selected years, 1973–2008



SEH = science, engineering, and health

NOTES: Academic employment limited to U.S. doctorate holders employed at 2- or 4-year colleges or universities, excluding those employed part time who are students or retired. Junior faculty includes assistant professors and instructors.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of 1973, 1983, 1993, 2003, and 2008 Surveys of Doctorate Recipients.

Science and Engineering Indicators 2012

Table 5-8
Women as percentage of SEH doctorate holders employed in academia, by position: Selected years, 1973–2008
(Percent)

Position	1973	1983	1993	2003	2008
All positions	9.1	15.0	21.9	30.3	34.2
Full-time senior faculty	5.8	9.3	14.2	22.8	26.8
Full-time junior faculty	11.3	23.5	32.2	40.5	41.9
Other full-time positions	14.5	23.1	30.2	33.1	40.9
Postdocs	14.3	30.1	30.8	38.0	39.4
Part-time positions	48.3	41.7	61.0	54.5	55.2

SEH = science, engineering, and health

NOTES: Academic employment limited to U.S. doctorate holders employed at 2- or 4-year colleges or universities. Senior faculty includes full and associate professors; junior faculty includes assistant professors and instructors. Other full-time positions include positions such as research associates, adjunct appointments, lecturers, and administrative positions. Part-time positions exclude those employed part time who are students or retired.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of 1973, 1983, 1993, 2003, and 2008 Surveys of Doctorate Recipients.

Science and Engineering Indicators 2012

and full-time faculty positions in 2008, up from 2% in 1973. Underrepresented minority groups have a relatively higher share of employment in other positions, which includes part-time positions, than in the full-time faculty and postdoc employment categories (table 5-9).

Underrepresented minorities were concentrated in different degree fields and different types of institutions than whites. Compared with white S&E doctorate holders employed in academia, underrepresented minorities were relatively concentrated in the social sciences and relatively less represented in the physical sciences and the life sciences (appendix table 5-18). Relatively fewer underrepresented minorities were employed at research universities than whites in 2008, and relatively more were employed at master's colleges and universities (table 5-10). (See chapter 2 sidebar, "Carnegie Classification of Academic Institutions," for a brief description of the Carnegie categories.)

The share of Asians/Pacific Islanders employed in the S&E academic doctoral workforce grew dramatically over the past three decades, rising from 4% in 1973 to 14% in 2008. Asians/Pacific Islanders were heavily represented in engineering and computer sciences, where they constituted 27% and 35%, respectively, of the S&E academic doctoral workforce in 2008. Far smaller proportions of Asians/Pacific Islanders were present in social sciences (8%) and psychology (5%) (appendix table 5-18). A larger share of Asians/Pacific Islanders than whites was employed at research universities and medical schools in 2008 (table 5-10).

Table 5-9
Underrepresented minorities as percentage of SEH doctorate holders employed in academia, by position: Selected years, 1973–2008
(Percent)

Position	1973	1983	1993	2003	2008
All positions	2.0	3.7	5.0	7.9	8.9
Full-time faculty	1.9	3.6	5.0	7.8	8.7
Postdocs	2.4	4.8	4.5	7.0	8.3
Other positions	2.9	4.1	5.3	8.4	9.9

SEH = science, engineering, and health

NOTES: Underrepresented minorities include blacks, Hispanics, and American Indians/Alaska Natives. Academic employment limited to U.S. doctorate holders employed at 2- or 4-year colleges or universities. Faculty includes full, associate, and assistant professors plus instructors. Other positions include part-time positions and full-time positions such as research associates, adjunct appointments, lecturers, and administrative positions. Other positions excludes those employed part time who are students or retired.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of 1973, 1983, 1993, 2003, and 2008 Surveys of Doctorate Recipients.

Science and Engineering Indicators 2012

Table 5-10
SEH doctorate holders employed in academia, by Carnegie institution type and race/ethnicity: 2008
(Percent distribution)

Institution type	All S&E doctorate holders	Asian/Pacific Islander	White	Underrepresented minority
All institutions	100.0	100.0	100.0	100.0
Doctorate-granting, very high research	41.7	50.0	40.9	33.6
Other doctorate-granting institutions	17.8	17.1	18.0	17.8
Master's colleges and universities	18.1	13.8	18.4	22.3
Medical schools/medical centers	5.0	6.1	4.7	5.6
Baccalaureate colleges	8.1	3.3	8.9	8.4
Two-year institutions	3.6	1.8	3.8	4.6
Other	5.8	7.8	5.3	7.7

SEH = science, engineering, and health

NOTES: Underrepresented minorities include blacks, Hispanics, and American Indians/Alaska Natives. Academic employment limited to U.S. doctorate holders employed at 2- or 4-year colleges or universities, excluding those employed part time who are students or retired. Institutions designated by 2005 Carnegie classification code. For information on these institutional categories, see *The Carnegie Classification of Institutions of Higher Education,* http://classifications.carnegiefoundation.org/index.php.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of 2008 Survey of Doctorate Recipients.

Science and Engineering Indicators 2012

Foreign-Born U.S. S&E Doctorate Holders

Academia has long relied on foreign-born doctorate holders, many of them with doctorate degrees from U.S. universities, to staff faculty and other academic positions. No current information is available about the number of foreign-born individuals with foreign doctorates who are employed at U.S. universities and colleges. The following discussion is limited to foreign-born individuals with U.S. doctorates.

Academic employment of foreign-born U.S. S&E doctorate holders has increased continuously since the 1970s at a rate that has exceeded the growth in academic employment of U.S.-born S&E doctorate holders (figure 5-16). As a result, the foreign-born share of the total academic employment of U.S. S&E doctorate holders increased from 12% in 1973 to nearly 25% in 2008 (figure 5-16), and reached particularly high proportions in engineering (46%) and computer sciences (51%) (appendix table 5-19). In all fields, foreign-born doctorate holders were a larger share of postdoc employment than of full-time faculty employment. Overall, 46% of postdoc positions were held by foreign-born U.S. S&E doctorate holders, compared with 23% of full-time faculty positions and 23% of other full-time positions.

Of the 39,000 Asian/Pacific Islander doctorate holders employed in academia in 2008, 9% were native-born U.S. citizens, 44% were naturalized U.S. citizens, and 47% were noncitizens. In 2008, Asians/Pacific Islanders represented 50% of the foreign-born faculty employed full-time in the United States and 62% of the foreign-born doctorate holders with postdoc appointments. In contrast, only 1% of native-born full-time faculty and 5% of native-born postdocs were Asians/Pacific Islanders.

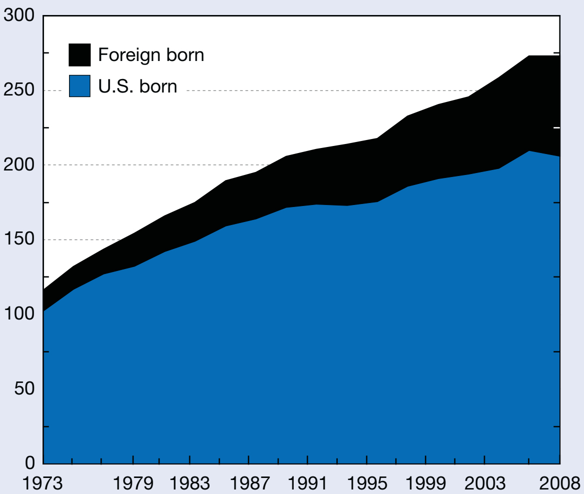
Academic Researchers

The interconnectedness of research, teaching, and public service activities in academia makes it difficult to assess the precise size and characteristics of the academic research workforce by examining the employment trends in academic positions, because individuals employed in the same position may be involved in research activities to differing degrees or not involved in research. Therefore, self-reported research involvement is a better measure than position title for gauging research activity.[20] This section limits the analysis to "academic researchers"—academic S&E doctorate holders who reported that research is either their primary work activity (that is, the activity that occupies the most hours of their work time during a typical work week) or their secondary work activity (the activity that occupies the second most work hours per week).

Doctoral S&E Researchers

From 1973 to 2008, the number of academic researchers grew from 82,300 in 1973 to 184,700 in 2008 (appendix table 5-20). The 2008 total included 137,800 individuals employed in full-time faculty positions. The proportion of academically employed S&E doctorate holders that are researchers declined slightly from 1993 (70%) to 2008 (68%) (figure 5-17). A

Figure 5-16
SEH doctorate holders employed in academia, by birthplace: 1973–2008



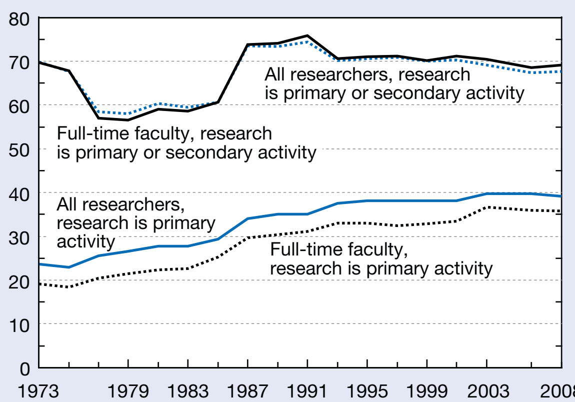
SEH = science, engineering, and health

NOTES: Academic employment limited to U.S. doctorate holders employed at 2- or 4-year colleges or universities, excluding those employed part time who are students or retired.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of 1973–2008 Surveys of Doctorate Recipients.

Science and Engineering Indicators 2012

Figure 5-17
Academic researchers as percentage of SEH doctoral employment, by position and involvement in research: 1973–2008



SEH = science, engineering, and health

NOTES: Academic employment limited to U.S. doctorate holders employed at 2- or 4-year colleges or universities, excluding those employed part time who are students or retired. Full-time faculty includes full, associate, and assistant professors plus instructors. Research includes basic or applied research, development, and design.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of 1973–2008 Surveys of Doctorate Recipients.

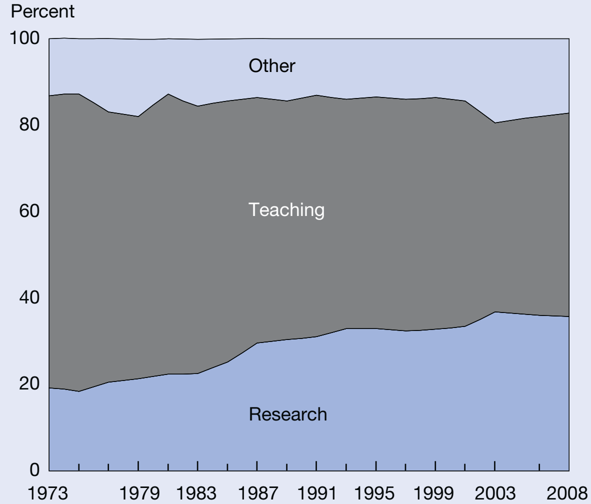
Science and Engineering Indicators 2012

nearly identical pattern of decline was observed for the share of full-time faculty that reported research as a primary or secondary work activity. The proportions of researchers among all academic S&E doctorate holders and all full-time faculty were higher in the life sciences, engineering, and computer sciences than in the social sciences and psychology (appendix table 5-20). In most fields, the share of academic researchers declined between 1993 and 2008.

A different picture emerges when only considering researchers who report research as their primary work activity. In contrast to the declining share of academic employees who reported research as their primary *or* secondary work activity, the share who reported research as their primary work activity steadily increased from 1973 to 2008 (figure 5-17). Taken together, these trends suggest that while research as an important work activity is not becoming more widespread among S&E doctorate holders employed in academia, a growing share of academic S&E positions are becoming research intensive.

Among full-time doctoral S&E faculty, the increased share of doctorate holders reporting research as their primary work activity reflects a shift in priority from teaching to research for many faculty. From 1973 to 2008, the proportion of full-time faculty identifying research as their primary work activity climbed from 19% to 36%, while the share with teaching as their primary activity fell from 68% to 47% (figure 5-18). The balance of emphasis between teaching and research varied across the disciplines, with a higher share of faculty in the life sciences identifying research as their primary work activity, and a higher share of faculty in mathematics and social sciences reporting teaching as their primary activity. Since 1991, the proportion of doctorate holders who list research as a primary work activity declined in physical sciences, computer sciences, and life sciences fields, but grew in mathematics, psychology, engineering, and the social sciences (appendix table 5-20).

Figure 5-18
Primary work activity of full-time doctoral SEH faculty: 1973–2008



SEH = science, engineering, and health

NOTES: Academic employment limited to U.S. doctorate holders employed at 2- or 4-year colleges or universities, excluding those employed part time who are students or retired. Full-time faculty includes full, associate, and assistant professors plus instructors. Research includes basic or applied research, development, or design.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of 1973–2008 Surveys of Doctorate Recipients.

Science and Engineering Indicators 2012

S&E Full-Time Faculty Researchers

Table 5-11 examines the relationship between research and the career stage of S&E full-time faculty. The smallest share of primary researchers occurred among the most recently degreed faculty (33%). The share of faculty who indicated research as their primary work activity increased

Table 5-11
SEH faculty reporting research as primary work activity, by years since doctorate and degree field: 2008
(Percent)

Years since doctorate	All fields	Physical sciences	Mathematics and statistics	Computer and information sciences	Life sciences	Psychology	Social sciences	Engineering
All years since doctorate	35.8	33.4	30.8	37.2	42.7	33.7	27.7	38.8
1–3	33.2	22.8	32.6	44.2	27.5	30.6	29.5	58.7
4–7	48.3	32.3	59.6	56.0	53.1	37.8	41.0	71.0
8–11	40.8	35.1	33.5	38.5	49.3	36.8	31.0	46.8
≥12	34.5	34.3	27.6	35.3	42.5	34.4	25.7	31.6

SEH = science, engineering, and health

NOTES: Academic employment limited to U.S. doctorate holders employed at 2- or 4-year colleges or universities, excluding those employed part time who are students or retired. Faculty includes full, associate, and assistant professors plus instructors. Research includes basic or applied research, development, and design. Physical sciences include earth, atmospheric, and ocean sciences; life sciences include biological, agricultural, environmental, and health sciences.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of 2008 Survey of Doctorate Recipients.

Science and Engineering Indicators 2012

with time since doctorate in the succeeding two cohorts, and then fell in the last reported cohort (12 years or more since doctorate). The higher share (48%) of primary researchers within the second cohort, 4 to 7 years since doctorate, coincides with the period during which many early career faculty would be preparing to apply for tenure at their university, and would have heightened motivation to complete research projects and publish results. In the last cohort reported in the table, 12 years or more beyond the doctorate, the share of full-time faculty reporting research as a primary activity fell to 35%. Other responsibilities—such as mentoring younger faculty, advising doctoral students, and accepting major committee assignments or faculty leadership roles—may become primary work activities for many faculty at this career stage.

A similar pattern prevailed in most degree fields—the share of faculty who indicated that research was their primary work activity increased through the early career cohorts and then fell as faculty approached mid-career. Research was more frequently a primary work activity for early career faculty in engineering and computer sciences than for faculty in other fields (table 5-11).

Collaborative Research

Research in many fields has increasingly involved collaboration. This section describes S&E doctorate holders' self-reports of their collaboration with others using data from the 2006 Survey of Doctorate Recipients.[21] Information on trends in coauthorship can be found later in this chapter under "Coauthorship and Collaboration."

In 2006, roughly 70% of S&E full-time research faculty employed in academic institutions reported working with an immediate work team or with others working elsewhere in the same organization, nearly 60% worked with individuals in other organizations in the United States, and nearly one-third worked with individuals located in other countries. Team work is most common among life scientists, physical scientists, and engineers, and least common among mathematicians and social scientists.

International collaboration was more common among foreign-born S&E full-time research faculty. Communication by e-mail or telephone was, by far, the most commonly used mode of international collaboration, followed by travel to the United States by the foreign collaborator(s), foreign travel by the U.S.-based collaborator, and communication through web-based or virtual technology.

For a more extensive discussion of these topics, see the "Collaborative Research" section in chapter 5 of the 2010 edition of *Indicators* (NSB 2010). For data on international collaborative activity in the S&E workforce more generally, see the "International Engagement by the Domestic S&E Workforce" in chapter 3.

Graduate Research Assistants

The close coupling of advanced training with hands-on research experience is a key strength of U.S. graduate education. Many of the 434,100 full-time S&E graduate students in 2008 (table 5-12) contributed significantly to the conduct of academic research.

The number of research assistants (RAs)—full-time graduate students whose primary mechanism of financial support is a research assistantship—has grown faster than graduate enrollment, both overall and in most fields. Graduate research assistantships were the primary means of support for 27% of graduate students in 2008, up from 22% in 1973. In the field distribution of RAs, there was a shift away from the physical sciences and social sciences and into the life sciences, computer sciences, and engineering. In engineering and the physical sciences in 2008, the proportion of RAs was high relative to graduate enrollment; 42% of graduate students in the physical sciences and 40% of engineering graduate students were supported in their graduate study primarily by research assistantships. In the life sciences, the proportion of RAs relative to graduate enrollment was similar to the overall proportion across all fields (27%), possibly reflecting the heavier reliance on postdoctoral researchers rather than RAs in the life sciences fields (table 5-12).

The majority of the academic research workforce remains employed in the intensive and very intensive research universities, although the research universities' shares of both academic researchers and of RAs have declined since 1973. (See chapter 2 sidebar, "Carnegie Classification of Academic Institutions," for a brief description of the Carnegie categories.) During the 2003–2008 period, the research universities employed 48% of all S&E doctorate holders in academic positions, 57% of those reporting research as their primary or secondary activity, and 79% of S&E graduate students for whom an RA was their primary means of support (table 5-13). Trends indicate a growing research presence by full-time academic researchers at institutions not classified as research universities, although RAs remain highly concentrated in the research universities.

Academic Employment in Postdoc Positions

The number of S&E doctorate holders employed in academic postdoc positions climbed from 4,000 in 1973 to 18,000 in 2008 (appendix table 5-16).[22] (See sidebar, "Postdoctoral Researchers.") During that time period, the share of postdocs increased from 4% to 7% of all academically employed S&E doctorate holders. Postdocs were much more prevalent in the life sciences, engineering, and the physical sciences than in social sciences, although the proportion of postdoc positions in physical sciences has declined since the mid-1990s (figure 5-19 and appendix table 5-16).

The demographic profile of individuals employed in academic postdoc positions has changed dramatically over time. The proportions of postdocs held by women, racial/ethnic minorities, and foreign-born individuals has climbed since 1973 (table 5-14).

Table 5-12
Full-time SEH graduate students and graduate research assistants at universities and colleges, by degree field: Selected years, 1973–2008

	1973		1983		1993		2003		2008	
Group and degree field	Thousands	Percent	Thousands	Percent	Thousands	Percent	Thousands	Percent	Thousands	Percent
Graduate students	161.6	100	252.0	100	329.6	100	398.0	100	434.1	100
Physical sciences	28.9	18	37.2	15	41.9	13	41.9	11	44.5	10
Mathematics	10.3	6	11.0	4	14.5	4	14.6	4	16.2	4
Computer sciences	2.9	2	10.6	4	17.4	5	30.9	8	31.3	7
Life sciences	40.6	25	69.2	28	91.6	28	123.2	31	138.8	32
Psychology	15.2	9	26.6	11	34.8	11	35.8	9	42.1	10
Social sciences	32.4	20	43.5	17	55.6	17	61.3	15	68.2	16
Engineering	31.3	19	53.9	21	73.8	22	90.4	23	93.0	21
Graduate research assistants	35.9	100	54.9	100	90.2	100	114.3	100	118.3	100
Physical sciences	8.9	25	12.6	23	17	19	18.1	16	18.7	16
Mathematics	0.7	2	0.8	2	1.4	2	1.8	2	1.9	2
Computer sciences	0.7	2	1.4	3	3.8	4	7.5	7	7.3	6
Life sciences	9.4	26	16.5	30	28.0	31	35.5	31	37.4	32
Psychology	1.9	5	3.0	5	4.6	5	5.6	5	6.1	5
Social sciences	4.0	11	5.0	9	7.4	8	8.4	7	8.1	7
Engineering	10.4	29	15.6	28	28.0	31	37.4	33	37.0	31

SEH = science, engineering, and health

NOTES: Detail may not add to total because of rounding. Graduate research assistants are full-time graduate students with research assistantships as primary mechanism of support. Physical sciences include earth, atmospheric, and ocean sciences; life sciences include biological, agricultural, environmental, and health sciences.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of 1973, 1983, 1993, 2003, and 2008 Surveys of Graduate Students and Postdoctorates in Science and Engineering.

Science and Engineering Indicators 2012

Early Career Postdocs

A temporary postdoc appointment is a common stop along the career path of S&E doctorate holders, particularly during their early career stages. In 2008, 36% of recently degreed S&E doctorate holders in academia were employed in postdoc positions, a figure that approached the share (42%) employed in full-time faculty positions (appendix table 5-21). With the exception of 2003, the share of recently degreed S&E doctorate holders in academic postdoc positions has exceeded the share holding full-time tenured or tenure-track faculty positions since 1995 (figure 5-20). S&E doctorate holders 4 to 7 years beyond the doctorate degree were far less likely than their recently degreed counterparts to be employed in academic postdoc positions; in 2008, only 11% of these doctorate holders held postdoc positions.

The vast majority of academic postdocs are employed at very high research activity universities. In 2008, the share of all academic postdocs employed at these institutions reached 75% (table 5-15). At the research universities, 70% of S&E postdoc appointments in 2008 were held by recently degreed individuals, and 5% by doctorate holders who were 8 or more years past their degree. The postdoc populations employed at medical schools and other universities and colleges included a larger pool of doctorate holders who had not recently earned the doctorate degree.

In comparison to 1995, a larger share of S&E doctorate holders employed in academia in 2006, 45% versus 41%, had held a postdoc appointment at some point in their career, and a slightly larger share than in 1995 had been employed in postdoc positions two or more times (table 5-16). Postdocs and multiple postdocs are relatively more prevalent among early career S&E doctorate holders than among the total pool of S&E doctorate holders. Early career postdoc employment and multiple instances of postdoc employment are typical for academic careers in the life sciences and the physical sciences (table 5-16), the two fields of study that have had the highest incidence of postdocs over the years (figure 5-19).

Government Support of Academic Doctoral Researchers

The federal government provides academic researchers with a substantial portion of overall research support. This section presents data from S&E doctorate holders in academia who reported on the presence or absence (but not magnitude) of federal support for their work.[23]

Academic Scientists and Engineers Who Receive Federal Support

In 2008, 45% of all S&E doctorate holders in academia and 56% of those for whom research was a primary or secondary activity reported federal government support for their work (appendix table 5-22). For S&E as a whole and for many fields, the share of S&E doctorate holders and researchers receiving federal support has declined since the early 1990s.

Faculty and other full-time S&E doctoral employees were less likely than postdocs to receive federal support. Throughout the 1973–2008 period, fewer than half of full-time S&E faculty received federal support, whereas the share of postdocs receiving federal support was above 70%.

Table 5-13
SEH doctorate holders and graduate research assistants employed in academia, by Carnegie institution type: 1973–2008
(Percent distribution)

Group and institution type	1973–83	1983–93	1993–2003	2003–08
All employed S&E doctorate holders	100.0	100.0	100.0	100.0
Research universities	53.7	53.4	50.0	48.4
Doctorate-granting institutions	11.5	11.4	11.0	10.5
Comprehensive institutions	18.0	18.5	18.3	18.6
Other institutions	16.8	16.8	20.7	22.6
Researchers	100.0	100.0	100.0	100.0
Research universities	64.8	62.2	57.8	56.8
Doctorate-granting institutions	10.9	11.2	11.3	10.8
Comprehensive institutions	12.4	13.9	14.5	15.1
Other institutions	11.9	12.8	16.4	17.3
Graduate research assistants	100.0	100.0	100.0	100.0
Research universities	87.5	84.0	80.4	79.3
Doctorate-granting institutions	9.3	10.1	11.8	11.8
Comprehensive institutions	2.2	3.5	4.9	5.4
Other institutions	1.0	2.4	2.9	4.5

SEH = science, engineering, and health

NOTES: Detail may not add to total because of rounding. Academic employment of S&E doctorate holders limited to those employed at 2- or 4-year colleges or universities, excluding those employed part time who are students or retired. Researchers are S&E doctorate holders employed in academia reporting research as a primary or secondary work activity; research includes basic or applied research, development, and design. Graduate research assistants are full-time graduate students with research assistantships as primary mechanism of support. Institutions designated by 1994 Carnegie classification code. Freestanding schools of engineering and technology included under comprehensive institutions. Other institiitions includes freestanding medical schools, 4-year colleges, specialized institutions, and institutions without Carnegie code. For information on these institutional categories, see *The Carnegie Classification of Institutions of Higher Education*, http://classifications.carnegiefoundation.org/index.php.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of 1973–2008 Surveys of Doctorate Recipients and Survey of Graduate Students and Postdoctorates in Science and Engineering.

Science and Engineering Indicators 2012

Postdoctoral Researchers

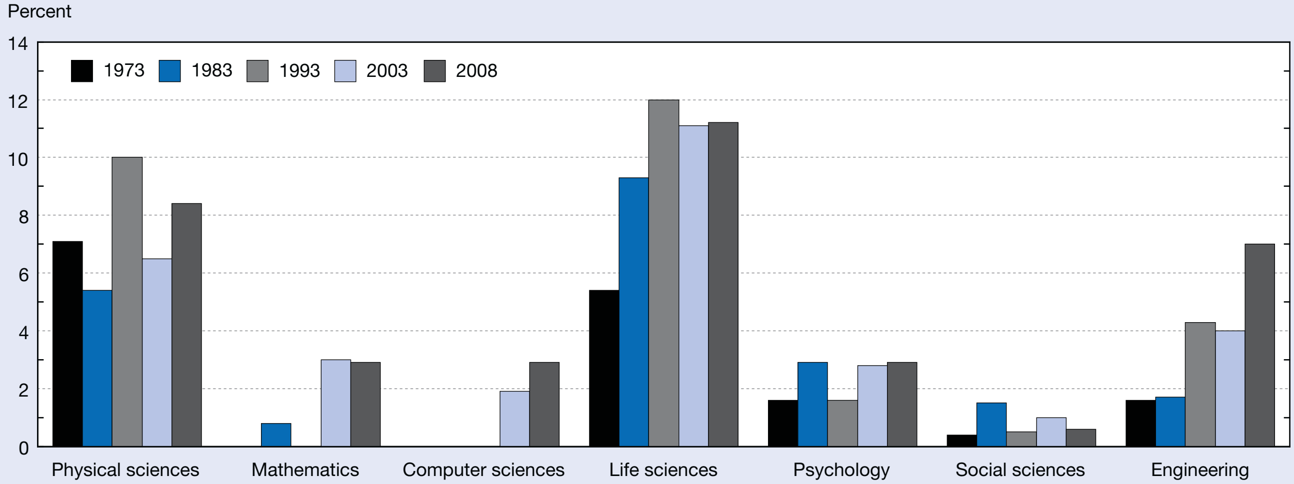
A postdoc is a temporary position in academia, industry, a nonprofit organization, or government, taken after the completion of a doctorate. It serves as a period of apprenticeship for the purpose of gaining scientific, technical, and professional skills. Ideally, the individual employed in a postdoc position gains these skills under the guidance of an advisor, and with the administrative and infrastructural support of a host institution and the financial support of a funding organization. However, the conditions of postdoc employment vary widely between academic and non-academic settings, across disciplines, and even within institutions, and formal job titles are an unreliable guide to actual work roles.

Postdoctoral researchers have become indispensable to the science and engineering enterprise and perform a substantial portion of the nation's research. Most have recently earned the doctorate degree, and so they bring a new set of techniques and perspectives that broadens their research teams' experience and makes them more competitive for additional research funding. In addition to conducting research, postdoctoral researchers also educate, train, and supervise junior members, help write grant proposals and papers, and present research results at professional society meetings (COSEPUP 2000).

Since 1991, the share of academic S&E doctorate holders receiving federal support has declined in all position categories (appendix table 5-22).

Federal support is more prevalent in very high research activity universities and medical schools. More than 60% of S&E doctorate holders and full-time faculty employed in research universities and medical schools received federal support in 2008 (appendix table 5-23). The percentage with federal support was less than 30% among those employed in doctoral/research universities, master's-granting universities, and baccalaureate colleges.

Figure 5-19
SEH doctorate holders with academic employment in postdoc position, by degree field: Selected years, 1973–2008



SEH = science, engineering, and health

NOTES: Data on computer sciences not available for 1973. Academic employment limited to U.S. doctorate holders employed at 2- or 4-year colleges or universities, excluding those employed part time who are students or retired. Physical sciences include earth, atmospheric, and ocean sciences; life sciences include biological, agricultural, environmental, and health sciences.
SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of 1973, 1983, 1993, 2003, and 2008 Surveys of Doctorate Recipients.

Science and Engineering Indicators 2012

Table 5-14
SEH doctorate holders with academic employment in postdoc position, by demographic group: Selected years, 1973–2008
(Percent distribution)

Demographic group	1973	1983	1993	2003	2008
Sex					
Female	16.7	30.1	30.8	37.6	39.4
Male	83.3	69.9	69.2	62.4	60.6
Race/ethnicity					
White	85.7	81.9	68.4	63.1	57.8
Asian/Pacific Islander	11.9	13.3	27.1	30.6	33.9
Underrepresented minority	2.4	4.8	4.5	7.0	8.3
Place of birth					
United States	82.5	81.7	60.9	57.0	53.9
Foreign	17.5	18.3	39.1	43.0	46.1

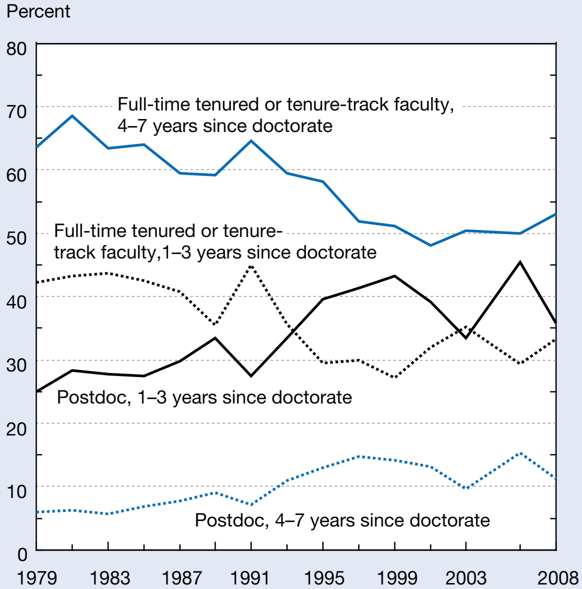
SEH = science, engineering, and health

NOTES: Academic employment limited to U.S. doctorate holders employed at 2- or 4-year colleges or universities, excluding those employed part time who are students or retired. Underrepresented minorities include blacks, Hispanics, and American Indians/Alaska Natives. Asian/Pacific Islander includes Pacific Islanders through 1999 but excludes them in 2001–08.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of 1973, 1983, 1993, 2003, and 2008 Surveys of Doctorate Recipients.

Science and Engineering Indicators 2012

Figure 5-20
Recent SEH doctorate holders employed in academia, by position and years since doctorate: 1979–2008



SEH = science, engineering, and health

NOTES: Academic employment limited to U.S. doctorate holders employed at 2- or 4-year colleges or universities, excluding those employed part time who are students or retired. Full-time tenured or tenure-track faculty includes full, associate, and assistant professors plus instructors.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of 1973–2008 Surveys of Doctorate Recipients.

Science and Engineering Indicators 2012

Federal Support of Early Career S&E Doctorate Holders

Federal support has been less available to early career S&E doctoral faculty than to more established faculty, and the percentage of early career S&E faculty with federal support has declined. From 1973–2008, S&E doctorate holders with recently earned doctorates (i.e., doctorates earned within 3 years of the survey) employed in full-time faculty positions were far less likely to receive federal support than those in postdoc positions (figure 5-21). In 2008, 27% of recent doctorate recipients in full-time faculty positions received federal support, down from 38% in 1991. Of recent S&E doctorate recipients employed in postdoc positions in 2008, 71% received federal support, which was a substantial decline from 1991 (84%).

S&E doctorate holders employed as full-time faculty who had received their doctorate 4–7 years earlier were more likely to receive federal support than those with more recently earned doctorates, and the same was true of those employed in postdoc positions (figure 5-21). As with recent doctorate recipients, the share of full-time faculty and postdocs 4–7 years beyond the doctorate who received federal support also declined from 1991. The shares of early career full-time faculty and postdocs with federal support were higher in some fields (life sciences, physical sciences, and engineering) than in others (mathematics and social sciences) (appendix table 5-24).

Table 5-15
SEH doctorate holders with academic employment in postdoc position, by Carnegie institution type and years since doctorate: 2008
(Percent distribution)

Institution type	Number of postdocs (thousands)	Total	Years since doctorate 1–3	4–7	≥8
All institutions	18.0	100.0	68.6	25.6	5.8
Doctorate-granting, very high research	13.5	100.0	69.7	25.2	5.1
Other doctorate-granting institutions	1.4	100.0	75.1	24.7	S
Medical schools/medical centers	1.6	100.0	60.4	29.0	10.7
Other universities and colleges	1.5	100.0	61.5	26.3	12.2

S = data suppressed for reasons of confidentiality and/or reliability

SEH = science, engineering, and health

NOTES: Academic employment limited to U.S. doctorate holders employed at 2- or 4-year colleges or universities, excluding those employed part time who are students or retired. Institutions designated by 2005 Carnegie classification code. For information on these institutional categories, see *The Carnegie Classification of Institutions of Higher Education,* http://classifications.carnegiefoundation.org/index.php.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of 2008 Survey of Doctorate Recipients.

Science and Engineering Indicators 2012

Table 5-16
SEH doctorate holders employed in academia, by years since doctorate, number of postdoc positions held during career, and degree field: 1995 and 2006
(Percent distribution)

	All fields		Life sciences		Physical sciences	
Years since doctorate and postdocs *(n)*	1995	2006	1995	2006	1995	2006
All years since doctorate	100.0	100.0	100.0	100.0	100.0	100.0
0	59.3	54.7	36.1	36.6	37.5	35.7
1	29.2	33.2	45.9	43.6	43.7	47.2
≥2	11.4	12.1	15.5	19.9	18.9	17.1
1–3 years since doctorate	100.0	100.0	100.0	100.0	100.0	100.0
0	47.1	42.7	33.7	31.9	21.0	24.2
1	44.0	49.8	54.3	57.2	63.9	69.5
≥2	8.9	7.5	12.0	10.8	15.1	6.2
4–7 years since doctorate	100.0	100.0	100.0	100.0	100.0	100.0
0	54.5	52.6	20.5	26.1	22.6	32.5
1	30.9	35.6	46.0	52.5	50.0	47.3
≥2	14.6	11.8	17.5	31.3	27.5	20.1

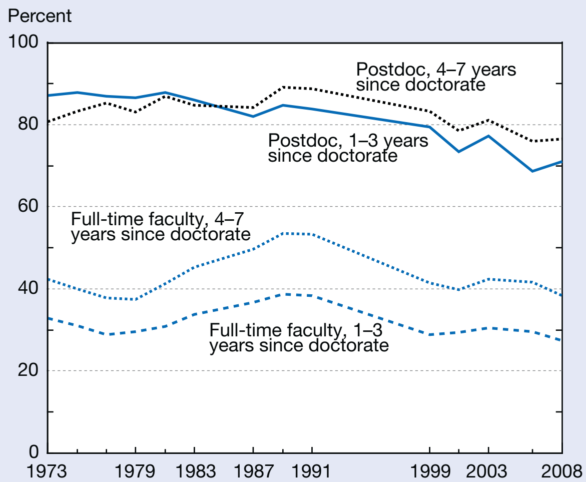
SEH = science, engineering, and health

NOTES: Academic employment limited to U.S. doctorate holders employed at 2- or 4-year colleges or universities, excluding those employed part time who are students or retired. Physical sciences include earth, atmospheric, and ocean sciences; life sciences include biological, agricultural, environmental, and health sciences. The number of postdoc positions held during career includes postdoc appointments outside academia.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of 1995 and 2006 Surveys of Doctorate Recipients.

Science and Engineering Indicators 2012

Figure 5-21
SEH doctorate holders employed in academia with federal support, by position and years since doctorate: 1973–2008



SEH = science, engineering, and health

NOTES: 1985 and 1993–97 data not comparable with other years and understate degree of federal support. In 1985 and 1993–97, federal support question asks whether work performed during week of April 15 was supported by government; in other years, question pertains to work conducted over course of entire year. Academic employment limited to U.S. doctorate holders employed at 2- or 4-year colleges or universities, excluding those employed part time who are students or retired. Faculty includes full, associate, and assistant professors plus instructors.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of 1973–2008 Surveys of Doctorate Recipients.

Science and Engineering Indicators 2012

Outputs of S&E Research: Articles and Patents

Chapter 2 of this volume discusses the human capital outputs of higher education in S&E. This section continues that theme by examining the intellectual output of academic S&E research using indicators derived from published research articles and U.S. patent and related data.

Researchers have traditionally published the results of their work in the world's peer-reviewed S&E journals.[24] Article-level data from these journals are indicators of S&E research output by countries and—within the United States—by academia and other sectors of the economy.[25] (See sidebar "Bibliometric Data and Terminology.") These *bibliometric* data can also be used to track trends in S&E research collaboration, using measures of coauthorship between and among departments, institutions, sectors, and countries. Finally, citations in more current research articles to previous research, and in patents to published research articles, offer insight into the importance and impact of previous research and its connection to inventions.

S&E Article Output

Between 1999 and 2009, the total world S&E article output in the SCI/SSCI database grew at an average annual rate of 2.6% (table 5-17). Leading this growth was China at 16.8% per year, which propelled it from ninth largest S&E article producer[26] in 1999 to second largest in 2009 behind the United States. Very rapid growth of over 10% per year

Bibliometric Data and Terminology

The article counts, coauthorships, and citations discussed in this section are derived from S&E articles, notes, and reviews published in a set of scientific and technical journals tracked by Thomson Scientific in the Science Citation Index and Social Sciences Citation Index (http://www.thomsonreuters.com/business_units/scientific/). Journal items excluded are letters to the editor, news stories, editorials, and other material whose purpose is not the presentation or discussion of scientific data, theory, methods, apparatus, or experiments.

Journal selection. This section uses a changing set of journals that reflects the current mix of journals and articles in the world. Thomson Reuters selects journals each year as described at http://www.thomsonreuters.com/products_services/science/free/essays/journal_selection_process/, and the selected journals become part of the SCI and SSCI. The journals selected are notable for their relatively high citation rank within their corresponding S&E subfields; journals of only regional interest are excluded.

The number of journals analyzed by NSF from SCI/SSCI was 4,093 in 1988 and 5,085 in 2010, an annual growth rate of about 1.0%. These journals give good coverage of a core set of internationally recognized peer-reviewed scientific journals. The coverage extends to electronic-only journals and print journals with electronic versions. In the period 1988–2010, the database contained 14.6 million S&E articles, notes, and reviews. Over the same period, the average number of articles, notes, and reviews per journal per year increased from about 115 to 154, an annual growth rate of about 1.3%.

Article data. Except where noted, *author* means *departmental or institutional author.* Articles are attributed to countries or sectors by the country or sector of the institutional address(es) given in the articles, *not by the national origins or the citizenship of the authoring scientists or engineers.* If no institutional affiliation is listed, the article is excluded from the counts in this chapter.

Likewise, *coauthorship* refers to *institutional* coauthorship. An article is considered coauthored only if it shows different institutional affiliations or different departments of the same institution; multiple listings of the same department of an institution are considered one institutional author. The same logic applies to cross-sector and international collaboration.

Two methods of counting articles are used: fractional and whole counts. *Fractional counting* is used for article and citation counts. In fractional counting, credit for co-authored articles is divided among the collaborating institutions or countries based on the proportion of their participating departments or institutions. *Whole counting* is used for coauthorship data. In whole counting, each institution or country receives one credit for its participation in the article. (If authors list more than one departmental or institutional affiliation, these are fractionalized for article and citation counts; whole counts are used for each affiliation in coauthorship data.)

Data in the first section *only* ("S&E Article Output") are reported by publication year through 2009 as reported in the data files through late January, 2011. These data are noted as "by year of publication." Publication data in the remaining bibliometrics sections ("Coauthorship and Collaboration," "Trends in Output and Collaboration Among U.S. Sectors," and "Trends in Citation of S&E Articles") are reported through 2010. These data are noted as "by data file year."

The country/economy breakouts are reported in appendix table 5-25. Data reported in this section are grouped into 13 broad S&E fields and 125 subfields (appendix table 5-26).

was also experienced by South Korea and, from low bases, by Iran, Tunisia, Thailand, Pakistan, and Malaysia.

Viewed regionally, growth in S&E article output over the decade has been uneven. Mature economies had modest growth or decline: the United States averaged 1.0%, EU member countries 1.4%, while Japan declined by –1.1% per year and Russia by –2.0%. Developing economies, mainly in Asia, far outpaced this growth in S&E articles, where China (16.8%) and South Korea (10.1%) were joined by Taiwan at 7.7%, Singapore at 8.2%, and India at 6.9% (table 5-17 and appendix table 5-27).

The research portfolios of the U.S., EU, and Asian economies differ in important ways (NSB 2010; and appendix tables 5-27 through 5-40):

- China and Japan emphasize the physical sciences more than the United States and European Union;
- The United States, European Union, and Japan produce relatively more articles in the life sciences than China or other Asian nations; and
- S&E research publications with authors in Asian countries are more heavily concentrated in engineering than those with authors in the United States or European Union.

Countries in Central and South America together increased their S&E article output between 1999 and 2009 at an annual rate of 5.6%. Brazil had the highest growth rate in the region, at 7.7% (table 5-17 and appendix table 5-27).

The countries or other entities with indexed S&E articles are always evolving.[27] In the current volume, 199 receive credit for publishing S&E articles (appendix table 5-25). Of these, a small number account for most of the publications.[28] Table 5-17 shows that five countries (the United States, China, Japan, the United Kingdom, and Germany)

Table 5-17
S&E articles in all fields, by country/economy: 1999 and 2009

Rank	Country	1999	2009	Average annual change (%)	2009 world total (%)	2009 cumulative world total (%)
–	World	610,203	788,347	2.6	na	na
1	United States	188,004	208,601	1.0	26.5	26.5
2	China	15,715	74,019	16.8	9.4	35.8
3	Japan	55,274	49,627	-1.1	6.3	42.1
4	United Kingdom	46,788	45,649	-0.2	5.8	47.9
5	Germany	42,963	45,003	0.5	5.7	53.6
6	France	31,345	31,748	0.1	4.0	57.7
7	Canada	22,125	29,017	2.7	3.7	61.4
8	Italy	20,327	26,755	2.8	3.4	64.7
9	South Korea	8,478	22,271	10.1	2.8	67.6
10	Spain	14,514	21,543	4.0	2.7	70.3
11	India	10,190	19,917	6.9	2.5	72.8
12	Australia	14,341	18,923	2.8	2.4	75.2
13	Netherlands	12,168	14,866	2.0	1.9	77.1
14	Russia	17,145	14,016	-2.0	1.8	78.9
15	Taiwan	6,643	14,000	7.7	1.8	80.7
16	Brazil	5,859	12,306	7.7	1.6	82.2
17	Sweden	9,890	9,478	-0.4	1.2	83.4
18	Switzerland	8,195	9,469	1.5	1.2	84.6
19	Turkey	3,223	8,301	9.9	1.1	85.7
20	Poland	5,100	7,355	3.7	0.9	86.6
21	Belgium	5,713	7,218	2.4	0.9	87.5
22	Iran	665	6,313	25.2	0.8	88.3
23	Israel	5,929	6,304	0.6	0.8	89.1
24	Denmark	4,783	5,306	1.0	0.7	89.8
25	Finland	4,719	4,949	0.5	0.6	90.4
26	Greece	2,626	4,881	6.4	0.6	91.1
27	Austria	4,158	4,832	1.5	0.6	91.7
28	Norway	3,043	4,440	3.9	0.6	92.2
29	Singapore	1,897	4,187	8.2	0.5	92.8
30	Portugal	1,711	4,157	9.3	0.5	93.3
31	Mexico	2,884	4,128	3.7	0.5	93.8
32	Czech Republic	2,360	3,946	5.3	0.5	94.3
33	Argentina	2,636	3,655	3.3	0.5	94.8
34	New Zealand	2,915	3,188	0.9	0.4	95.2
35	South Africa	2,303	2,864	2.2	0.4	95.5
36	Ireland	1,459	2,798	6.7	0.4	95.9
37	Hungary	2,200	2,397	0.9	0.3	96.2
38	Egypt	1,293	2,247	5.7	0.3	96.5
39	Thailand	549	2,033	14.0	0.3	96.7
40	Chile	1,059	1,868	5.8	0.2	97.0
41	Ukraine	2,355	1,639	-3.6	0.2	97.2
42	Romania	917	1,367	4.1	0.2	97.4
43	Malaysia	471	1,351	11.1	0.2	97.5
44	Slovenia	708	1,234	5.7	0.2	97.7
45	Serbia	NA	1,173	NA	0.1	97.8
46	Croatia	647	1,164	6.0	0.1	98.0
47	Pakistan	296	1,043	13.4	0.1	98.1
48	Tunisia	257	1,022	14.8	0.1	98.3
49	Slovakia	979	1,000	0.2	0.1	98.4

na = not applicable; NA = not available

NOTES: Countries/economies shown produced 1,000 articles or more in 2009. Countries/economies ranked on 2009 total. Article counts from set of journals covered by Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). Articles classified by year of publication and assigned to country/economy on basis of institutional address(es) listed on article. Articles on fractional-count basis, i.e., for articles with collaborating institutions from multiple countries/economies, each country/economy receives fractional credit on basis of proportion of its participating institutions. Detail does not add to total because of countries/economies not shown.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board™, special tabulations (2011) from Thomson Reuters, SCI and SSCI, http://thomsonreuters.com/products_services/science/. See appendix table 5-27.

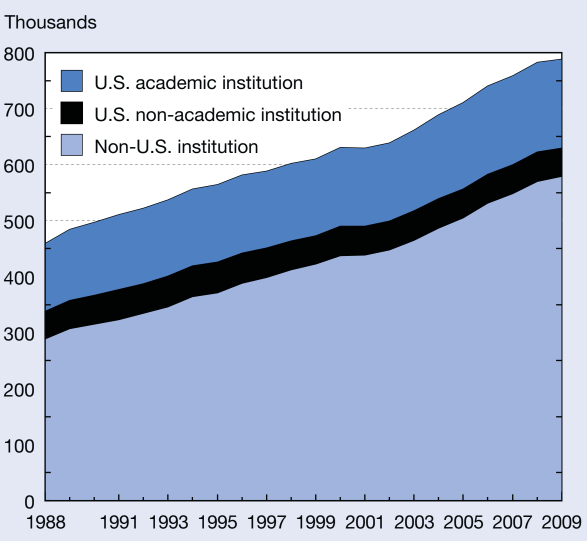
Science and Engineering Indicators 2012

accounted for more than 50% of the total world S&E article output in 2009. The 49 countries in table 5-17—one quarter of the countries in the data—produced 98% of the world total of S&E articles.

The number of journals covered by SCI/SSCI has expanded to accommodate the rising number of research articles. Most of the increase reflects activity in new S&T centers. Figure 5-22 shows how the number of published articles has grown over the past 20 years, from 485,000 articles in 1989 to 788,000 in 2009. Non-U.S. articles have increasingly dominated world S&E article output, growing from 63% to 74% of the total. The expansion of non-U.S. S&E articles signals the return on decades of increased investments in higher education and the more recent conviction that R&D is essential to economic growth and competitiveness. It also reflects a slowdown in the growth of U.S. S&E article output to around 1% or less in recent years.

In Figure 5-22, co-authored articles are pro-rated to U.S. sectors and foreign countries, depending on their fraction of the institutional addresses. These fractions were then re-summed to produce the shares shown in the figure. But that method of allocating credit for S&E article authorship does not show the relationships among the authors, author sectors, and country authors that together illuminate the extent to which S&E research is an increasingly global, collaborative undertaking. The following sections explore these growing collaborative and international dimensions of world S&E research as indicated by data on S&E publications. Together these indicators will describe a growing globalization of the social system of scientific knowledge production and the global use of its outputs.

Figure 5-22
World S&E articles, by author characteristic: 1988–2009



NOTES: Article counts from set of journals covered by Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). Articles classified by year of publication and assigned to country and sector on basis of institutional address(es) listed on article. Articles on fractional-count basis, i.e., for articles with collaborating institutions from multiple countries/sectors, each country/sector receives fractional credit on basis of proportion of its participating institutions. Sector not available for non-U.S. articles.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board™, special tabulations (2011) from Thomson Reuters, SCI and SSCI, http://thomsonreuters.com/products_services/science/.

Science and Engineering Indicators 2012

Coauthorship and Collaboration

Article output trends since about the mid-1990s have two defining features: the rapid growth of articles with authors from the developing world, and a rise in the percentage of global article output that is the result of collaboration among researchers internationally. Articles with authors from different institutions in the United States and from different countries have continued to increase, indicating rising knowledge creation, transfer, and sharing among institutions and across national boundaries.[29, 30] This section covers broad trends in coauthorship for the world as a whole and continues with an examination of country-level trends, including selected country-to-country coauthorship patterns and indexes of international collaboration.[31] Indicators of cross-sector coauthorship, which are available only for the United States, are examined below in the section "Trends in Output and Collaboration Among U.S. Sectors."

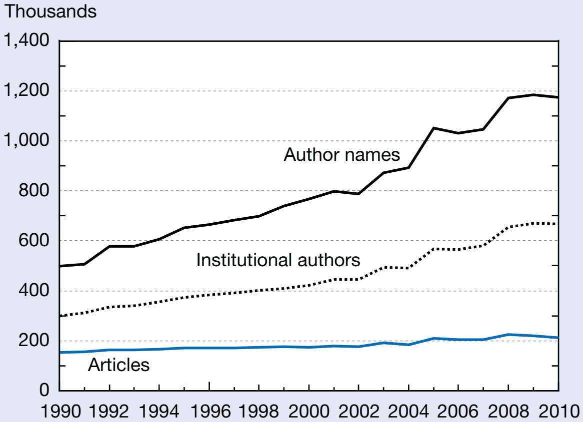
Article Author Names and Institutions

Earlier volumes of this report have noted the imbalance between the growth in number of S&E articles and the growth in the number of authorship credits to institutions and individuals that produced those articles (NSB 2008, 08-01, figure 5-29; NSB 2010, 10-01, table 5-16). The much faster growth in authorship credits to institutions and individuals—in all broad fields—has been used as an indicator of a steady rise in the collaborative nature of S&E research, both domestically and internationally.

Figure 5-23 shows the same trend, but here data are restricted to articles with at least one U.S. *academic* author. Over the period 1990–2010, the number of such articles in the data analyzed in this section increased by an average of 1.6% annually. In contrast, the number of institutions listed on these articles grew over twice as fast at 4.1% annually, and the number of author names grew even faster, at 4.4% annually.

Figure 5-24 focuses on the authors per paper for S&E articles by field with an author from the U.S. academic sector over the same 20-year period. In two decades, the average number of author names per paper in all S&E fields grew from 3.2 to 5.6. The average number of authors per paper more than quadrupled in astronomy (3.1 to 13.8) and doubled in physics (4.5 to 10.1). Growth in the average number of coauthors was slowest in the social sciences (from 1.6 authors per paper in 1990 to 2.1 in 2010) and in mathematics (from 1.7 to 2.2). In short, papers authored by a single U.S. academic scientist or engineering are becoming an increasingly small minority of the published literature. NSF analysis shows that in 2010,

Figure 5-23
U.S. academic S&E articles, institutional authors, and author names: 1990–2010



NOTES: Article counts from set of journals covered by Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). Articles classified by year they entered database. Articles counted on a whole-count basis. All articles have at least one U.S. academic author and may have authors from other sectors and from outside the U.S. Author name counted each time it appears in data set. Authors assigned to institution on basis of institutional address listed on article; authors from separate departments each counted as individual institutional author; multiple authors from same department of institution considered as one institutional author.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board™, special tabulations (2011) from Thomson Reuters, SCI and SSCI, http://thomsonreuters.com/ products_services/science/.

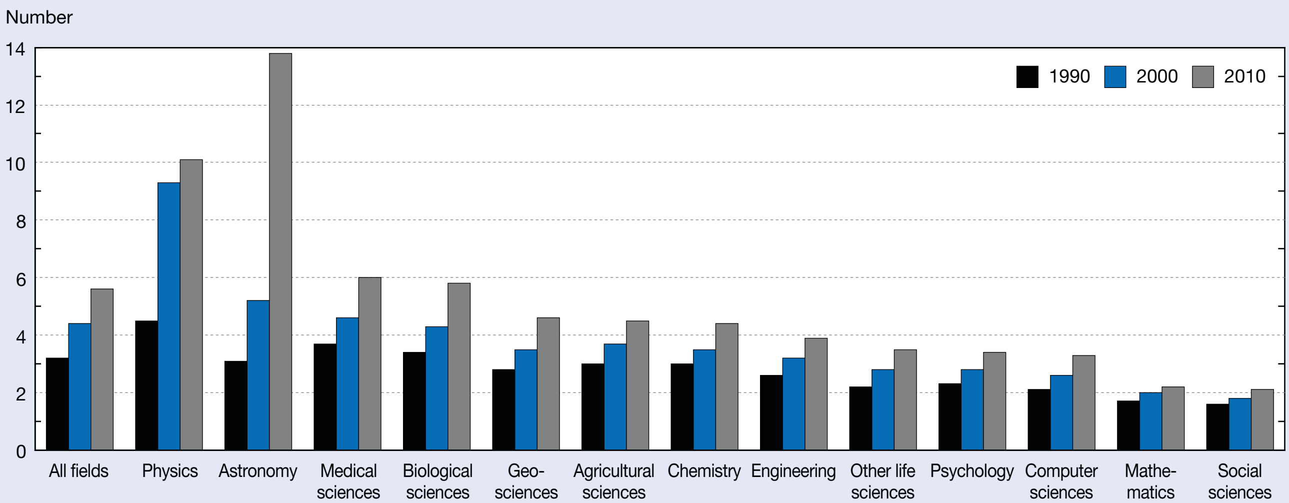
Science and Engineering Indicators 2012

92.4% of all S&E articles with at least one U.S. academic author had two or more author names.

A closely related indicator, coauthored articles (i.e., articles with authors in different institutions or departments or in more than one country) has also increased steadily. Figure 5-25 contrasts these trends for the world as a whole with those for articles with at least one U.S. academic author. Coauthored articles grew from 42% of the world's total S&E articles in 1990 to 67% in 2010. This growth has two parts. Coauthored articles that list only domestic institutions grew from 33% of all articles in 1990 to 43% in 2010. Articles that list institutions from more than one country, that is, internationally coauthored articles (which also may have multiple domestic institutional authors), grew more dramatically—from 10% to 24% over the same period.

The percent of S&E articles with a U.S. *academic* author that is internationally coauthored is higher than the percent of total world international coauthorships (figure 5-25). Purely domestic coauthorship in this sector has been relatively flat in the United States, at about 43% of total U.S. academic articles from 1990 to 2010. Over the same period U.S. academic articles with a non-U.S. coauthor have grown strongly, from 12% to 32%. (These coauthorships may also include multiple domestic U.S. coauthors.) The remainder of this section takes a closer look at patterns within this broad increase in international coauthorship around the world.

Figure 5-24
Number of authors per U.S. academic S&E article, by S&E field: Selected years, 1990–2010

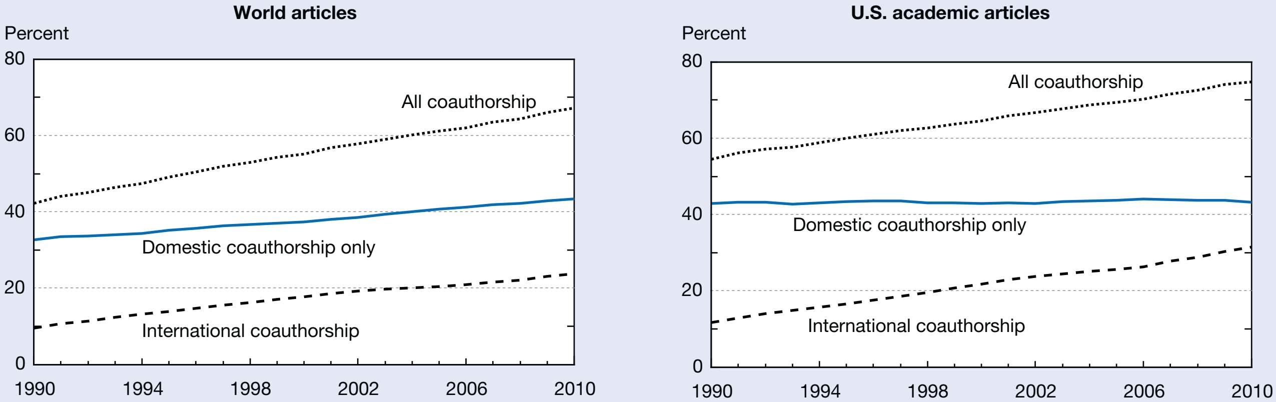


NOTES: Data from set of journals covered by Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). Articles classified by year they entered database. All articles have at least one U.S. academic author and may have authors from other sectors and from outside United States.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board™, special tabulations (2011) from Thomson Reuters, SCI and SSCI, http://thomsonreuters.com/products_services/science/.

Science and Engineering Indicators 2012

Figure 5-25
World and U.S. academic S&E articles coauthored domestically and internationally: 1990–2010



NOTES: Article counts from set of journals covered by Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). Articles classified by year they entered database, rather than year of publication, and assigned to country/economy on basis of institutional address(es) listed on article. Articles on whole-count basis, i.e., each collaborating institution or country credited one count. Internationally coauthored articles may also have multiple domestic coauthors.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board™, special tabulations (2011) from Thomson Reuters, SCI and SSCI, http://thomsonreuters.com/products_services/ science/.

Science and Engineering Indicators 2012

International Coauthorship Patterns From a Country Perspective

International coauthorship can be considered from two perspectives: (1) a country's level of participation in the world's total S&E coauthorships, and (2) a country's international coauthorship vis-à-vis the country's total S&E authorship.

World total S&E coauthorship. Table 5-18 shows the world's countries/economies that account for 1% or more of internationally coauthored S&E articles, and how their relative standing, or rank, has changed over the past 10 years. U.S.-based researchers were coauthors of 43% of the world's total internationally coauthored articles in 2010, well above the global percentage of U.S. article output. Germany, the United Kingdom, and France were also leading contributors to the world's internationally coauthored articles. The most notable trend in this indicator, however, was the rise of authors from China, who increased their share of world internationally coauthored S&E articles from 5% to 13% over the last 10 years.

Individual region/country coauthorship. Table 5-19 compares a region/country's share of total world international coauthorship with the region/country's internal or domestic rate of international coauthorship. The table is restricted to countries that had institutional authors on at least 5% or more of the world's internationally coauthored S&E articles in 2010 (see also appendix table 5-41).

The sheer volume of U.S. internationally coauthored articles dominates these measures: 32% of U.S. articles in 2010 were internationally coauthored, up from 23% in 2000. Even higher rates of international coauthorship are evident among the countries of the European Union, where large Framework Research Programs have strongly encouraged it, and in Switzerland. Both Japan's and Asia-8's international coauthorship rates have increased over the past 10 years, and more countries passed the 50% mark over the decade.

Table 5-19 also shows China's idiosyncratic position on this indicator. Table 5-17 shows that China's S&E article output grew sufficiently over the decade to place it as the world's second largest S&E article-producing nation. At the same time, China's internationally coauthored articles as a share of its total article output remained almost flat and, at 27%, was the lowest percentage of all countries/regions shown on Table 5-19. This atypical measure shows that China's very rapid S&E article growth has been driven by articles with solely domestic authors (see discussion below of China's rates of internal and international citations).

What accounts for specific coauthorship relationships? Linguistic and historical factors (Narin et al. 1991), geography, and cultural relations (Glänzel and Schubert 2005) play a role. In recent years, coauthorships in Europe have risen in response to EU policies and incentives that actively encouraged intra-European cross-border collaboration. However, strong ties among science establishments in the Asian region, without the formal framework that characterizes Europe, indicate that regional dynamics can play a strong role in the development of collaborative ties. The discussion below in the section "International Collaboration in S&E" identifies strong coauthorship relationships in specific country pairs across the world, based on the strength of their coauthorship rates.

Table 5-18
Share of internationally coauthored S&E articles worldwide, by region/country: 2000 and 2010
(Percent)

Country/economy	2000	2010
United States	43.8	42.9
Germany	20.0	18.8
United Kingdom	19.0	18.7
France	15.3	13.8
China	5.0	13.0
Canada	9.3	10.1
Italy	9.3	9.4
Japan	10.4	8.2
Spain	6.1	8.1
Australia	5.3	7.1
Netherlands	6.7	6.9
Switzerland	5.8	6.1
Sweden	5.4	4.8
South Korea	2.3	4.4
Belgium	4.0	4.3
Russia	6.9	3.7
India	2.1	3.3
Brazil	2.8	3.0
Austria	2.6	2.9
Denmark	3.1	2.9
Poland	3.2	2.6
Israel	3.0	2.3
Finland	2.6	2.2
Taiwan	1.4	2.2
Norway	1.7	2.1
Portugal	1.2	1.9
Singapore	0.8	1.8
Czech Republic	1.5	1.8
Greece	1.4	1.6
Mexico	1.7	1.6
New Zealand	1.3	1.5
Ireland	0.9	1.4
South Africa	1.0	1.4
Argentina	1.3	1.3
Turkey	0.8	1.2
Hungary	1.7	1.2
Chile	0.8	1.1
Iran	0.2	1.0

NOTES: Internationally coauthored articles have at least one collaborating institution from indicated country/economy and an institution from outside that country/economy. Article counts from set of journals covered by Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). Articles classified by year they entered database, rather than year of publication, and assigned to country/economy on basis of institutional address(es) listed on article. Articles on whole-count basis, i.e., each collaborating country/economy credited one count. Countries/economies with less than 1% of world's 2010 international articles omitted.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board™, special tabulations (2011) from Thomson Reuters, SCI and SSCI, http://thomsonreuters.com/products_services/science/. See appendix table 5-41.

Science and Engineering Indicators 2012

International Coauthorship With the United States

Table 5-20 lists the 31 countries whose institutions appeared on at least 1% of U.S. internationally coauthored articles in 2010. U.S. authors are most likely to coauthor articles with colleagues from the United Kingdom (14.1%), China (13.7%), Germany (13.3%), and Canada (11.8%).

Table 5-19 shows that the rate at which U.S. researchers participate in international collaboration is below that of many countries with smaller science establishments. The large size of the U.S. S&E establishment results in a share

Table 5-19
International collaboration on S&E articles, by selected region/country: 2000 and 2010
(Percent distribution)

	Share of region/country total article output		Share of world's internationally coauthored articles	
Region/country	2000	2010	2000	2010
United States	23	32	44	43
EU				
France	42	56	15	14
Germany	39	54	20	19
Italy	39	48	9	9
Netherlands	45	56	7	7
Spain	36	50	6	8
United Kingdom	35	53	19	19
Other Western Europe				
Switzerland	52	68	6	6
Asia				
China	26	27	5	13
Japan	19	28	10	8
Asia-8	24	30	8	13
Other				
Australia	33	49	5	7
Canada	36	48	9	10

EU = European Union

NOTES: Internationally coauthored articles have at least one collaborating institution from indicated country/economy and an institution from outside that country/economy. Article counts from set of journals covered by Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). Articles classified by year they entered database, rather than year of publication, and assigned to country/economy on basis of institutional address(es) listed on article. Articles on whole-count basis, i.e., each collaborating country/economy credited one count. Countries/economies with less than 5% of 2010 international total omitted. See appendix table 5-25 for countries/economies included in Asia-8, which in this table is treated as a single country. Detail adds to more than 100% because articles may have authors from more than two countries/economies.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board™, special tabulations (2011) from Thomson Reuters, SCI and SSCI, http://thomsonreuters.com/products_services/science/.

Science and Engineering Indicators 2012

Table 5-20
International coauthorship of S&E articles with the United States, by selected country/economy: 2000 and 2010
(Percent)

Country/economy	2000 U.S. share of country/economy international articles	2000 Country/economy share of U.S. international articles	2010 U.S. share of country/economy international articles	2010 Country/economy share of U.S. international articles
World	43.8	na	42.9	na
United Kingdom	30.9	13.4	32.3	14.1
China	35.2	4.0	45.2	13.7
Germany	29.7	13.6	30.4	13.3
Canada	52.1	11.0	49.9	11.8
France	25.6	8.9	27.5	8.8
Italy	32.0	6.8	33.4	7.3
Japan	42.3	10.0	36.9	7.0
South Korea	59.8	3.2	53.8	5.5
Australia	35.4	4.3	32.0	5.3
Spain	27.0	3.8	27.9	5.3
Netherlands	29.7	4.5	31.1	5.0
Switzerland	31.2	4.1	31.1	4.4
Sweden	27.6	3.4	29.2	3.3
Israel	51.8	3.5	53.9	2.8
Brazil	38.9	2.5	39.7	2.8
Taiwan	61.2	1.9	51.2	2.6
India	38.1	1.8	33.5	2.5
Belgium	23.3	2.1	24.7	2.5
Russia	24.8	3.9	27.1	2.3
Denmark	29.6	2.1	30.8	2.0
Austria	26.7	1.6	25.9	1.8
Poland	26.3	1.9	27.4	1.7
Mexico	42.3	1.6	44.4	1.6
Finland	30.8	1.8	28.8	1.5
Norway	28.0	1.1	28.9	1.4
Greece	27.2	0.9	35.0	1.3
Singapore	27.0	0.5	31.0	1.3
New Zealand	33.1	1.0	34.4	1.2
South Africa	33.2	0.8	36.5	1.2
Turkey	39.7	0.7	40.6	1.1
Argentina	34.6	1.0	35.0	1.1

na = not applicable

NOTES: Internationally coauthored articles have at least one collaborating institution from indicated country/economy and an institution from outside that country/economy. Article counts from set of journals covered by Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). Articles classified by year they entered database, rather than year of publication, and assigned to country/economy on basis of institutional address(es) listed on article. Articles on whole-count basis, i.e., each collaborating country/economy credited one count. Countries/economies ranked on percentage of their share of U.S.'s international articles in 2010; countries/economies with less than 1% of U.S.'s 2010 international articles omitted.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board™, special tabulations (2011) from Thomson Reuters, SCI and SSCI, http://thomsonreuters.com/products_services/science/. See appendix table 5-41.

Science and Engineering Indicators 2012

of U.S. internationally coauthored articles that is lower than those of most other countries. Scientists and engineers in countries with smaller S&E establishments, in order to find an appropriate coauthor, must more frequently turn to coauthors abroad, resulting in relatively larger shares of those countries' S&E articles that are coauthored with U.S. scientists and engineers. These relationships are summarized in table 5-20.

For example, 2.8% of U.S. internationally coauthored articles in 2010 had an Israeli coauthor. The corresponding figure for Israel, with its much smaller scientific infrastructure, is 53.9%. Also, 49.9% of Canada's internationally coauthored articles had a U.S. coauthor, but only 11.8% of U.S. international coauthorship was with a colleague at a Canadian institution.[32] Linguistic, geographic, and other ties underlie these collaborations.

Notable changes in these patterns of U.S. international coauthorship parallel changes in other indicators discussed in this section. As China's total S&E article output grew rapidly, so did its coauthorship with U.S. authors: the U.S. share of China's internationally coauthored articles increased about 10 percentage points to 45.2% over the past decade, and China's share of U.S. internationally coauthored articles increased 9.7 percentage points to 13.7% (table 5-20). In contrast, U.S. scientists and engineers lost relative share of international coauthorship elsewhere (e.g. Japan, Australia, Taiwan, and South Korea) as their counterparts broadened the geographic scope of their collaborations with foreign scientists and engineers.

An Index of International Collaboration in S&E

The size of countries' S&E systems conditions the scope and reach of their international collaborations (Glänzel and Schubert 2004). An index of international collaboration addresses this issue. This index is a ratio of country A's percentage of country B's international coauthorships to country A's percentage of total international coauthorship (Narin et al. 1991) (see sidebar, "Calculating the Index of International Collaboration"). An index value substantially greater than 1 indicates strong collaborative ties, and a value substantially below 1 signals relatively infrequent collaboration. The 1995 and 2010 indexes for country pairs that produced more than 1% of all internationally coauthored articles in 2010 are shown in appendix table 5-42.

Table 5-21 lists the international collaboration index for selected pairs of countries. In North America, the Canada-United States index shows a rate of collaboration that is slightly greater than would be expected based solely on the number of internationally coauthored articles produced by these two countries, and the index has changed little over the past 15 years. The United States-Mexico index is just about as would be expected and is also stable.

Mexico-Argentina scientific collaboration networks are strong at 3.5, well above expected levels. In South America, the collaboration index of Argentina-Brazil, at 5.1, is one of the highest in the world.

Collaboration indexes between pairs of countries on opposite sides of the North Atlantic are all low and have changed little over the past 15 years. In Europe, collaboration patterns are mixed but most have increased, indicating growing integration across the European Union for S&E article publishing. Among the large publishing countries (Germany, the United Kingdom, and France) collaboration was less than expected, but grew in all three countries over 15 years. A particularly strong collaboration network has developed between scientists in Poland and the Czech Republic.

The Scandinavian countries[33] increased their collaboration indexes with many countries elsewhere in Europe (appendix table 5-42). Within Scandinavia, the indexes are among the highest in the world (table 5-21).

Cross-Pacific collaboration patterns are mixed. Japan-United States collaboration fell below the expected value over the 15 years, while the United States-China index rose to 1. U.S. collaboration with South Korea and Taiwan weakened but remained higher than expected in both cases. The international collaboration indexes between Canada and countries in Asia are lower than the U.S.-Asia indexes.

Collaboration indexes within Asia and across the South Pacific between the large article producers are generally higher than expected, but have experienced some weakening. Australia's coauthorships are strongly linked to New Zealand. Two strongly collaborating pairs are South Korea-Japan and Australia-Singapore, but each of these networks has declined in strength. India's collaborations with both South Korea and Japan grew stronger between 1995 and 2010.

Calculating the Index of International Collaboration

Appendix table 5-41 contains the raw data for calculating the 2010 indexes of international collaboration contained in appendix table 5-42. Using the data for the world, China, and the United States, the 2010 U.S.-China index is computed as follows:

- China-U.S coauthorships as a proportion of U.S. international coauthorship = 10,917 / 79,581 = 0.1372
- China's percentage of total international coauthorship = 24,164 / 185,303 = 0.1304
- U.S.-China coauthorships as a percentage of China's international coauthorship = 10,917 / 24,164 = 0.4518
- U.S. percentage of total international coauthorship = 79,581 / 185,303 = 0.4295

The indexes for any country pair are always symmetrical. The China-U.S. and U.S.-China index are the same, as follows:

- China-U.S. index: 0.1372 / 0.1304 = 1.05 and
- U.S.-China index: 0.4518 / 0.4295 = 1.05

The 2010 China-U.S. index value is essentially 1, the "expected" index value when two countries coauthor with each other at the same rate as they coauthor with all countries. This is an increase since 1995, when the index was 0.83.

Trends in Output and Collaboration Among U.S. Sectors

In the U.S. innovation system, ties between and among universities, industry, and government can be beneficial for all sides. These ties include the flows of knowledge among these sectors, for which research article outputs and collaboratively produced articles are proxy indicators. S&E articles authored at academic institutions have for decades

Table 5-21
Index of international collaboration on S&E articles, by selected country/economy pair: 1995 and 2010

Country/economy pair	International collaboration index 1995	2010
North/South America		
Canada–United States	1.16	1.16
Mexico–United States	0.97	1.03
United States–Brazil	0.89	0.92
Argentina–Brazil	3.93	5.12
Mexico–Argentina	2.48	3.46
North Atlantic		
UK–United States	0.68	0.75
Germany–United States	0.66	0.71
France–United States	0.59	0.64
Canada–France	0.60	0.78
Europe		
France–Germany	0.74	0.98
France–UK	0.71	0.93
Germany–UK	0.64	0.93
Belgium–Netherlands	2.41	2.85
Italy–Switzerland	1.48	1.53
Poland–Czech Republic	1.96	3.93
Hungary–Germany	1.22	1.42
Germany–Czech Republic	1.23	1.40
Scandinavia		
Finland–Sweden	3.45	3.97
Norway–Sweden	4.30	4.16
Sweden–Denmark	3.29	3.54
Finland–Denmark	2.73	3.02
Pacific Rim		
Japan–United States	1.04	0.86
China–United States	0.83	1.05
South Korea–United States	1.39	1.25
Taiwan–United States	1.59	1.19
China–Canada	0.75	0.74
Japan–Canada	0.64	0.56
Asia/South Pacific		
China–Japan	1.49	1.26
South Korea–Japan	2.49	1.94
Australia–Singapore	2.01	1.66
Australia–China	1.11	1.06
Australia–New Zealand	4.49	3.92
India–Japan	0.72	1.13
India–South Korea	1.25	2.12

UK = United Kingdom

NOTES: International collaboration index shows first country's rate of collaboration with second country divided by second country's rate of international coauthorship. Article counts from set of journals covered by Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). Articles classified by year they entered database, rather than year of publication, and assigned to country/economy on basis of institutional address(es) listed on article. Articles on whole-count basis, i.e., each collaborating country/economy credited one count.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board™, special tabulations (2011) from Thomson Reuters, SCI and SSCI, http://thomsonreuters.com/products_services/science/. See appendix table 5-42.

Science and Engineering Indicators 2012

accounted for more than 70% of all U.S. articles, and this percentage has been slowly rising—to 76% in 2010 (table 5-22), primarily as a result of declines in articles with authors from industry (for a discussion of this shift, see NSB 2008). This section contrasts U.S. academic authorship with nonacademic authorship, including output trends by sector and trends in coauthorship, both between U.S. sectors and between U.S. sectors and authors abroad.

Article Output by Sector

Total annual S&E articles by authors in U.S. nonacademic sectors changed little over the past decade, ranging from 48,000 to 55,000 articles[34] per year between 1995 and 2010 (appendix table 5-43). The number of articles produced by scientists and engineers in the federal government and in industry was more than 15,000 in each sector in 1995 but slowly declined through 2010, and each sector lost share over that period (table 5-22). State and local government authorship, dominated by articles in the medical and biological sciences, has remained constant. Scientists and engineers in the private nonprofit sector increased their output to about 18,000 in 2008 and then declined to near 17,000 in 2010 (appendix table 5-43).

Federally funded research and development centers (FFRDCs) are research institutions that are sponsored by federal agencies and administered by universities, industry, or other nonprofit institutions. FFRDCs have specialized research agendas closely related to the mission of the sponsoring agency and may house large and unique research instruments not otherwise available in other research venues.

Table 5-22
U.S. S&E articles, by sector: Selected years, 1995–2010
(Percent)

Sector	1995	2000	2005	2010
Federal government	7.9	7.2	6.6	6.1
Industry	8.1	7.3	6.4	5.8
Academic	71.6	72.8	74.6	76.1
FFRDCs	2.8	2.7	2.8	2.4
Private nonprofit	8.0	8.5	8.2	8.6
State/local government	1.0	0.9	0.9	0.9

FFRDCs = federally funded research and development centers

NOTES: Detail does not add to 100% because joint and unknown sectors omitted. Article counts from set of journals covered by Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). Articles classified by year they entered database, rather than year of publication, and assigned to sector on basis of institutional address(es) listed on article. Articles on fractional-count basis, i.e., for articles with collaborating institutions from multiple sectors, each sector receives fractional credit on basis of proportion of its participating institutions.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board™, special tabulations (2011) from Thomson Reuters, SCI and SSCI, http://thomsonreuters.com/products_services/science/. See appendix table 5-43.

Science and Engineering Indicators 2012

Although authors at FFRDCs published articles in all of the broad S&E fields considered in this chapter, articles in physics, chemistry, and engineering together represented 71% of publication by this sector in 2010, reflecting the more specialized research programs in FFRDCs (appendix table 5-43).[35]

In contrast, articles published by authors in the private nonprofit sector are primarily in the medical sciences (54% of the sector's articles in 2010) and biological sciences (25%) (appendix table 5-43). Federal government authors show a similar pattern, with 30% in the biological sciences and 28% in the medical sciences.

Trends in Sector Coauthorship

Coauthorship data are indicators of collaboration at the sectoral level between U.S. institutional authors and between U.S. sectors and foreign institutions.[36] These data show that the growing integration of R&D activities, as measured by coauthorship, is occurring across R&D-performing U.S. institutions in all sectors.

Overall, the largest increases in this integration have been driven by increased coauthorship between U.S. academic authors and non-U.S. authors (in all sectors; NSF data do not identify the sectors of non-U.S. authors) (table 5-23). Co-authorship between non-U.S. authors and U.S. academic authors increased over the decade by 9.9 percentage points.

Between 2000 and 2010, coauthorship within sectors increased for all U.S. sectors.[37] Coauthorship within academia rose from 39% in 2000 to 47% in 2010. FFRDC to FFRDC coauthorship increased 6 percentage points (table 5-23). Because most publishing scientists and engineers are in the academic sector, non-academic scientists and engineers turn to academia for collaborators, so the resulting rates of cross-sector coauthorship with academic authors are quite high and continue to increase. Because of the predominance of the academic sector in S&E article publishing in the United States, academic scientists and engineers have been on the forefront of integrating S&E research across institutions, both nationally and internationally.

Table 5-23
U.S. S&E article coauthorship, by sector, foreign coauthorship, and U.S. coauthor sector: 2000 and 2010
(Percent)

Sector	Foreign coauthor	U.S. coauthor sector: Federal government	Industry	Academic	FFRDCs	Private nonprofit	State/local government
2000							
Federal government	21.2	18.1	9.2	55.0	3.1	9.6	2.5
Industry	22.5	9.6	14.5	45.6	3.1	10.3	1.5
Academic	21.7	7.8	6.2	38.6	2.8	9.2	1.5
FFRDCs	35.0	8.0	7.6	51.2	13.4	4.2	0.2
Private nonprofit	20.4	8.4	8.6	57.0	1.4	25.1	2.4
State/local government	11.7	16.2	9.4	68.2	0.6	18.2	13.8
2010							
Federal government	29.6	21.8	10.6	64.8	4.6	14.9	3.1
Industry	31.5	11.8	19.3	55.4	3.8	16.0	2.1
Academic	31.6	8.3	6.4	46.9	3.4	11.7	1.6
FFRDCs	46.4	10.9	8.0	62.2	19.4	8.0	0.3
Private nonprofit	31.6	10.8	10.5	66.5	2.5	30.3	2.8
State/local government	18.8	18.8	11.5	75.6	0.7	23.1	15.6
2000–10 change (percentage points)							
Federal government	8.4	3.7	1.4	9.8	1.5	5.2	0.6
Industry	9.1	2.2	4.8	9.8	0.7	5.7	0.6
Academic	9.9	0.5	0.2	8.3	0.6	2.4	0.1
FFRDCs	11.3	2.9	0.4	11.0	6.0	3.7	*
Private nonprofit	11.2	2.5	1.9	9.5	1.0	5.2	0.3
State/local government	7.1	2.6	2.1	7.4	0.1	4.9	1.8

* = rounds to zero

FFRDCs = federally funded research and development centers

NOTES: Article counts from set of journals covered by Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). Articles classified by year they entered the database, rather than year of publication, and assigned to sector on basis of institutional address(es) listed on article. Articles on whole-count basis, i.e., each collaborating country or sector credited one count. Articles from joint or unknown sectors omitted. Articles may have authors from more than two sectors. Articles with authors from a single sector omitted from table.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board™, special tabulations (2011) from Thomson Reuters, SCI and SSCI, http://thomsonreuters.com/products_services/science/.

Science and Engineering Indicators 2012

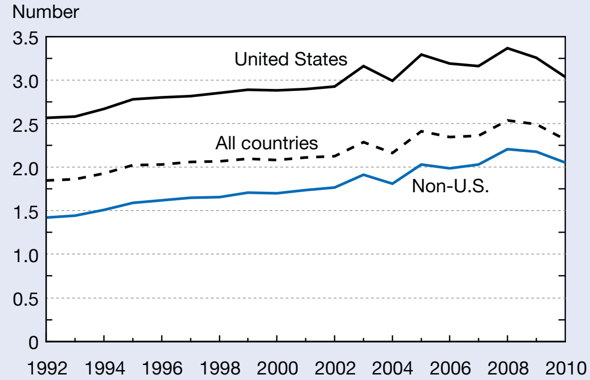
As discussed earlier in this chapter, international collaboration has increased rapidly in the United States. International coauthorship across the U.S. sectors rose by 7–11 percentage points between 2000 and 2010 (table 5-23). Articles from FFRDCs reached the highest rate of collaboration with foreign authors, at 46%, followed by those from academia, private nonprofit institutions, industry, and the federal government, at roughly 30% each.

Trends in Citation of S&E Articles[38]

Citations indicate influence, and they are increasingly international in scope. When scientists and engineers cite the published papers resulting from prior S&E research, they are formally crediting the influence of that research on their own work.[39] Citations are generally increasing in volume relative to S&E articles. In 1992, an S&E article received, on average, 1.85 citations. In contrast, an S&E article in 2010 received on average 2.32 citations (Figure 5-26). Articles with U.S. authors tended to receive more citations than others, but the gap narrowed over the period as the total share of U.S.-authored articles declined.[40]

Like the indicators of international coauthorship discussed above, cross-national citations are evidence that S&E research is increasingly international in scope. Two other trends accompanied the steady growth of international citations in the world's S&E literature: changing shares of total citations across countries and changing shares of highly cited S&E literature. These are discussed in the following sections.

Figure 5-26
Average citations per S&E article, by country of author: 1992–2010



NOTES: Article/citation counts from set of journals covered by Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). Articles classified by year they entered database, rather than year of publication, and assigned to country/economy on basis of institutional address(es) listed on article. Articles on fractional-count basis, i.e., for articles with collaborating institutions from multiple countries/economies, each country/economy receives fractional credit on basis of proportion of its participating institutions. Citation counts based on 3-year period with 2-year lag, e.g., citations for 2008 are references made in articles in 2008 data tape to articles in 2004–06 data tapes.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board™, special tabulations (2011) from Thomson Reuters, SCI and SSCI, http://thomsonreuters.com/products_services/ science/.

Science and Engineering Indicators 2012

Citation Trends in a Global Context

Shares of the world total of citations to S&E research articles have changed concurrently with shares of the world total of these articles. Table 5-24 shows, for example, that between the periods 1996–98 and 2006–08, the U.S. share of world S&E articles declined from 32% to 28% across all fields.[41] The U.S. share declined in every broad field, although the decline varied in size. Table 5-24 shows parallel trends for the U.S. share of citations and indicates an even larger decline, from 45% to 36%.

China's share of total world S&E articles and citations increased over the same period. However, in contrast to the global trend of increasing international citations, China's pattern has been different. Unlike the United States and other large article-producing countries/regions, the share of China's citations that are international citations *decreased* between 2000 and 2010, from 60% to 51% (figure 5-27), suggesting that much of the use of China's expanding S&E article output—as indicated by citations to those articles—is occurring *within* China.[42]

Trends in Highly Cited S&E Literature

Another indicator of performance of a national or regional S&E system is the share of its articles that are highly cited. High citation rates can indicate that an article has a greater impact on subsequent research than articles with lower citation rates.

Appendix table 5-44 shows citation percentiles for 2000 and 2010 by field for the top five S&E article-producing countries/regions.[43] In that table, a country whose global research influence was high would have higher proportions of articles in higher citation percentiles, whereas a country whose influence was low would have greater proportions of articles in lower citation percentiles. In other words, a country whose research is highly influential would have higher shares of its articles in higher citation percentiles.

World citations to U.S. research articles show that U.S. articles continue to have the highest citation rates across all broad fields of S&E. In both 2000 and 2010, as displayed in appendix table 5-44, the U.S. share of articles in the 99th percentile was higher than its share in the 95th percentile, and these were higher than its share in the 90th percentile, and so forth, even while U.S. shares of all articles and all citations were decreasing. In 2010, U.S. articles represented 28% of the world's total of 2.3 million articles in the cited period shown; the U.S. authored 49% of the rare 21,900 articles in the 99th percentile and 24% of the 1.3 million articles in the 50th percentile.

Only U.S. publications display the preferred relationship of strongly higher proportions of articles in the higher percentiles of article citations. When cited, articles with authors

Table 5-24
S&E articles, citations, and international citations, by selected region/country: 2000 and 2010
(Percent)

Region/country	Share of world articles (cited years) 1996–98	Share of world articles (cited years) 2006–08	Share of world citations (citing year) 2000	Share of world citations (citing year) 2010	Share of region/country citations that are international (citing year) 2000	Share of region/country citations that are international (citing year) 2010
United States	32.4	27.8	44.8	36.4	48.1	53.7
EU	35.4	32.4	33.3	32.8	44.8	49.7
China	2.0	7.5	0.9	6.0	60.3	50.8
Japan	8.8	7.0	7.1	5.7	62.3	70.2
Asia-8	4.1	7.4	1.8	5.3	62.9	65.0

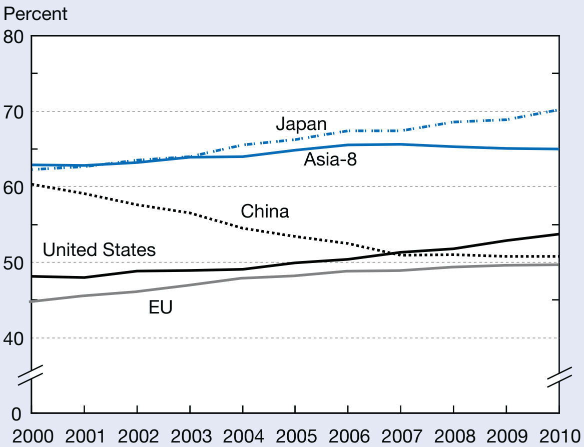
EU = European Union

NOTES: Article/citation counts from set of journals covered by Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). Articles classified by year they entered database, rather than year of publication, and assigned to country/economy on basis of institutional address(es) listed on article. Articles on fractional-count basis, i.e., for articles with collaborating institutions from multiple countries/economies, each country/economy receives fractional credit on basis of proportion of its participating institutions. See appendix table 5-25 for countries/economies included in EU and Asia-8, which in this table are treated as single countries. Citation counts based on 3-year period with 2-year lag (e.g., citations for 2000 are references made in articles in 2000 data tape to articles in 1996–98 data tapes); data shown are for the 3 years in cited year window.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board™, special tabulations (2011) from Thomson Reuters, SCI and SSCI, http://thomsonreuters.com/products_services/science/.

Science and Engineering Indicators 2012

Figure 5-27
Share of selected country/region citations that are international: 2000–10



EU = European Union

NOTES: Article/citation counts from set of journals covered by Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). Articles classified by year they entered database, rather than year of publication, and assigned to country/region on basis of institutional address(es) listed on article. Articles on fractional-count basis, i.e., for articles with collaborating institutions from multiple countries/regions, each country/region receives fractional credit on basis of proportion of its participating institutions. See appendix table 5-25 for countries included in EU and Asia-8, which in this table are treated as single countries. Citation counts based on 3-year period with 2-year lag, e.g., citations for 2009 are references made in articles in 2009 data tape to articles in 2005–07 data tapes.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board™, special tabulations (2011) from Thomson Reuters, SCI and SSCI, http://thomsonreuters.com/products_services/science/.

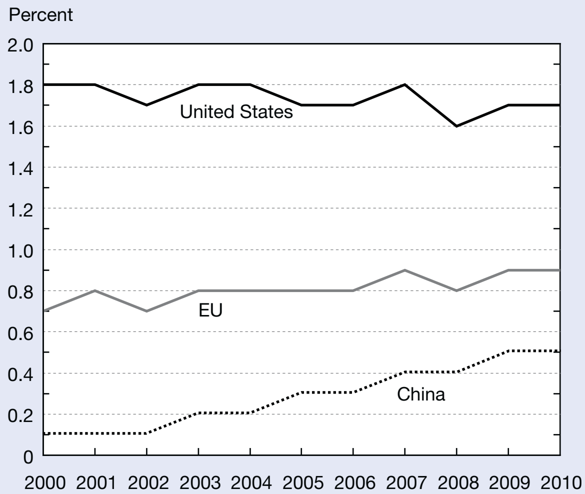
Science and Engineering Indicators 2012

from the European Union, China, Japan, and the Asia-8 are more often found in the lower citation percentiles. (These data are summarized in appendix table 5-45.) Nevertheless, as the U.S. share of all articles produced declined between 2000 and 2010, its share of articles in the 99th percentile (i.e., the top 1%) of cited articles also declined, particularly in some fields. Shares in the top percentile increased for the European Union, China, Japan, and the Asia-8.

To control for changing shares of the world's S&E articles, Figure 5-28 shows the percentage of total articles for each of the United States, European Union, and China that appears in the world's top 1% of cited articles. Across the decade, 1.6%–1.8% of U.S.-authored S&E articles have appeared in the world's top 1% of cited articles, compared with 0.7%–0.9% of articles from the EU. China's articles in the top 1% of cited articles remained behind the United States and European Union but increased from 0.1% to 0.5% over the period.

When citation rates are normalized by the share of world articles during the citation period to produce an index of highly cited articles, the influence of U.S. articles has changed little over the past 10 years. Between 2000 and 2010, the U.S. index of highly cited articles barely changed (from 1.85 to 1.76) (figure 5-29 and appendix table 5-45) and remained well above the expected index value of 1. During the same period, the EU increased its index from 0.73 to 0.93, and China, Japan, and the Asia-8 increased their index values but remained below their expected values. In other words, the United States had 76% more articles than expected in the 99th percentile of cited articles in 2010, and the EU had 7% fewer than expected. China had 51% fewer articles in the 99th percentile than expected in 2010, and Japan 39% fewer.

Figure 5-28
Share of U.S., EU, and China S&E articles that are in the world's top 1% of cited articles: 2000–10



EU = European Union

NOTES: Article/citation counts from set of journals covered by Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). Articles classified by year they entered database, rather than year of publication, and assigned to country/economy on basis of institutional address(es) listed on article. Articles on fractional-count basis, i.e., for articles with collaborating institutions from multiple countries/regions, each country/region receives fractional credit on basis of proportion of its participating institutions. See appendix table 5-25 for countries included in EU, which in this figure is treated as a single country. Citation counts based on 3-year period with 2-year lag, e.g., citations for 2009 are references made in articles in 2009 data tape to articles in 2005–07 data tapes.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board™, special tabulations (2011) from Thomson Reuters, SCI and SSCI, http://thomsonreuters.com/products_services/science/.

Science and Engineering Indicators 2012

The United States experienced gains on the index of highly cited articles in engineering, astronomy, other life sciences, and psychology and declines in chemistry, geosciences, and mathematics, although all remained well above expectation (appendix table 5-45). The EU reached its expected value in engineering, chemistry, physics, and the agricultural sciences. Japan and the Asia-8 countries did not achieve the expected value of 1 in any broad field.

Notably, China achieved an index value of near 1 in engineering and computer sciences (figure 5-30). In most broad fields, China's indexes of highly cited articles were higher in 2010 than in 2000. In a few fields—the biological, medical, and social sciences—the Chinese index remained low, and these fields kept the index for all fields below 0.5 in 2010 (appendix table 5-45).

Academic Patents, Licenses, Royalties, and Startups

Other indicators of academic R&D outputs reflect universities' efforts to develop their intellectual property for possible commercial use in the form of patents and associated activities. The majority of U.S. universities did not become actively involved in managing their own intellectual property until late in the 20th century, although some were granted patents much earlier.[44] The Bayh-Dole Act of 1980 gave colleges and universities a common legal framework for claiming ownership of income streams from patented discoveries that resulted from their federally funded research. To facilitate the conversion of new knowledge produced in their laboratories to patent-protected public knowledge that can be potentially licensed by others or form the basis for a startup firm, more and more research institutions established technology management/transfer offices (Association of University Technology Managers 2009).

The following sections discuss overall trends in university patenting and related indicators through 2009–10.

University Patenting Trends

U.S. Patent and Trademark Office (USPTO) data show that annual patent grants to universities and colleges ranged from 2,900 to 4,500 between 1998 and 2010 (appendix table 5-46).[45]

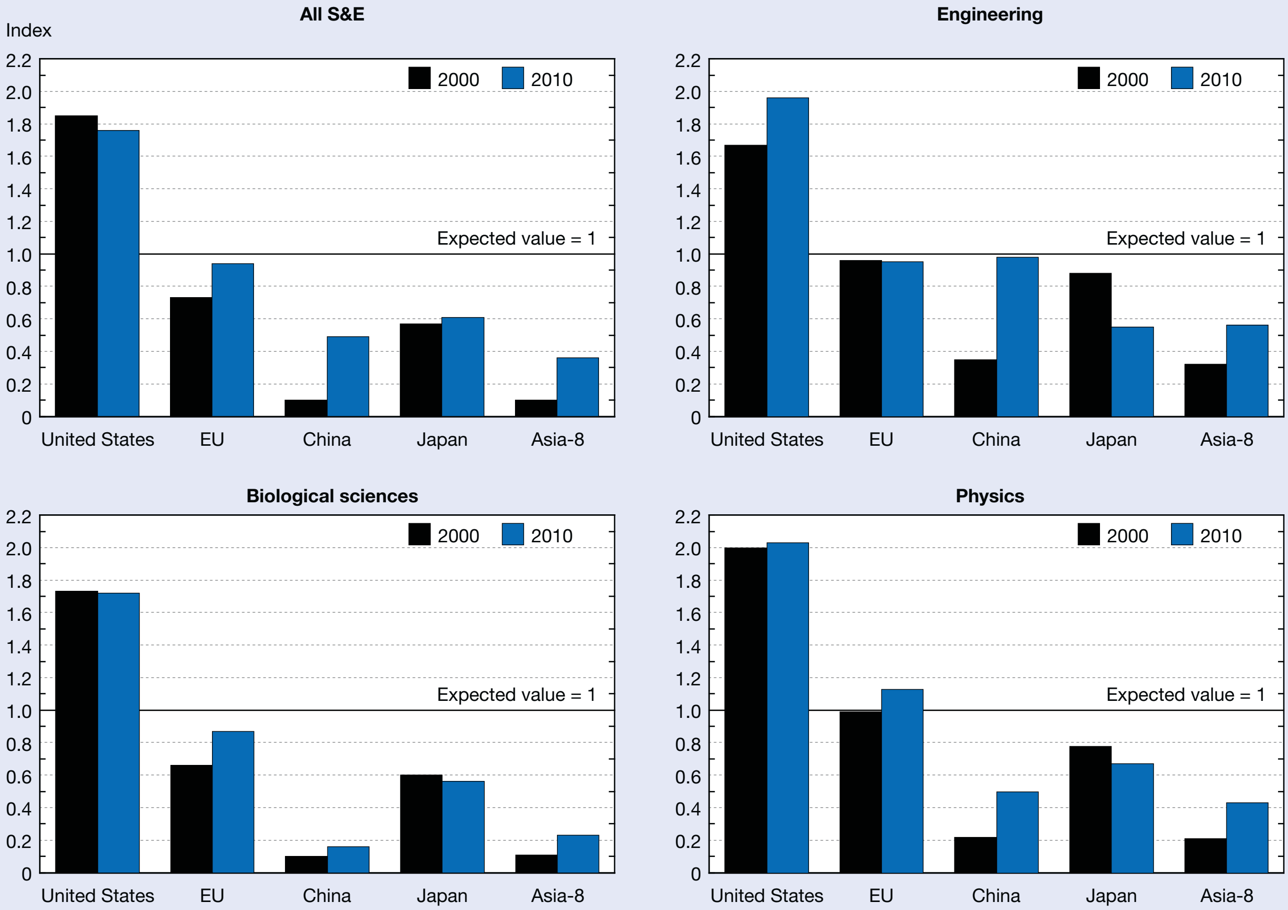
The top 200 R&D-performing institutions, with 97% of the total patents granted to U.S. universities during the 1998–2010 period, dominate among universities and university systems receiving patent protection.[46] College and university patents have been about 4.2–4.7% of U.S. nongovernmental patents for a decade. Among the top R&D-performing institutions that received patents between 1998 and 2010, 19 accounted for more than 50% of all patents granted to these institutions (although these included a few multicampus systems, including the Universities of California and Texas). The University of California system received 11.9% of all U.S. patents granted to U.S. universities over the period, followed by the Massachusetts Institute of Technology with 4.2% of all U.S. patents granted to U.S. universities.

Biotechnology patents account for the largest percent (30%) of U.S. university patents in 2010 (appendix table 5-47), and have grown over the past 15 years (figure 5-31). Pharmaceutical patents, the next largest technology area, have more recently begun to decline, from nearly 450 a year in the late 1990s to about 300 in more recent years. Patents for measuring devices, semiconductors, and optics have all increased gradually over the past two decades.

Patent-Related Activities and Income

Data from the Association of University Technology Managers (AUTM) indicate continuing growth in a number of patent-related activities. Invention disclosures filed with university technology management offices describe prospective inventions and are submitted before a patent application is filed. These grew from 12,600 in 2002, to 18,200 in

Figure 5-29
Index of highly cited articles, by selected S&E field and region/country: 2000 and 2010



EU = European Union

NOTES: Article/citation counts from set of journals covered by Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). Articles/citations classified by year they entered database, rather than year of publication, and assigned to country/region on basis of institutional address(es) listed on article. See appendix table 5-25 for countries included in EU and Asia-8. Citation counts based on 3-year period with 2-year lag, e.g., citations for 2010 are references made in articles in 2010 data tape to articles in 2006–08 data tapes. Index of highly cited articles is country's share of world's top 1% cited articles divided by its share of world articles for the cited year window.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board™, special tabulations (2011) from Thomson Reuters, SCI and SSCI, http://thomsonreuters.com/products_services/science/. See appendix table 5-45.

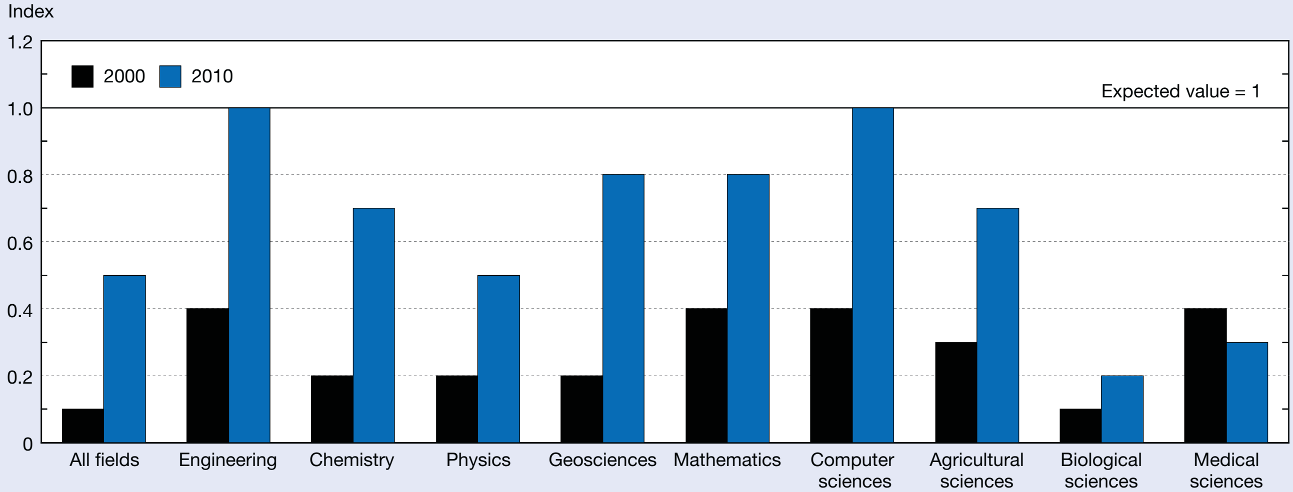
Science and Engineering Indicators 2012

2009 (notwithstanding small shifts in the number of institutions responding to the AUTM survey over the same period) (figure 5-32). Likewise, new U.S. patent applications filed by AUTM university respondents also increased, from 6,500 in 2001, to 11,300 in 2009. U.S. patents awarded to AUTM respondents stayed flat over the period, at about 3,000 per year with some fluctuation.[47]

The AUTM survey respondents reported 348 startup companies formed in 2003 and 555 in 2009, with a total of extant startup companies in 2009 of 3,175 (appendix table 5-48). Licenses and options that generated revenues also increased over the period. However, active licenses, while increasing steadily from 1999 to 2008, declined slightly in 2009; this decline may reflect the downturn in the U.S. economy in that period.

Most royalties from licensing agreements accrue for relatively few patents and the universities that own them, and many of the AUTM respondent offices report no income. (Thursby and colleagues [2001] report that the objectives of university technology management offices include more than royalty income.) At the same time, large one-time payments to a university can affect the overall trend in university licensing income. In 2009, the 153 institutions that responded to the AUTM survey reported a total of $1.5 billion in net royalties from their patent holdings, down sharply from the previous 2 years, perhaps as a result of the nation's economic downturn in 2008–09 (appendix table 5-48).

Figure 5-30
Chinese index of highly cited articles, by selected S&E field: 2000 and 2010

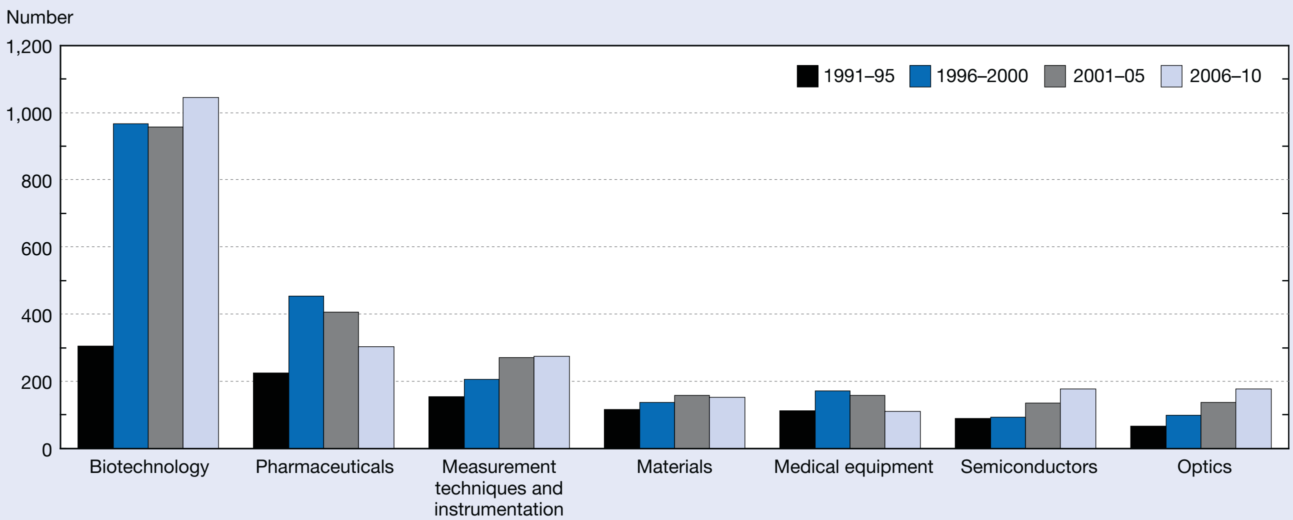


NOTES: Article/citation counts from set of journals covered by Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). Articles/citations classified by year they entered database, rather than year of publication, and assigned to country on basis of institutional address(es) listed on article. Citation counts based on 3-year period with 2-year lag, e.g., citations for 2010 are references made in articles in 2010 data tape to articles in 2006–08 data tapes. Index of highly cited articles is country's share of world's top 1% cited articles divided by its share of world articles for the cited year window.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board™, special tabulations (2011) from Thomson Reuters, SCI and SSCI, http://thomsonreuters.com/products_services/science/. See appendix table 5-45.

Science and Engineering Indicators 2012

Figure 5-31
U.S. academic patents, by technology area: Selected 5-year averages, 1991–2010

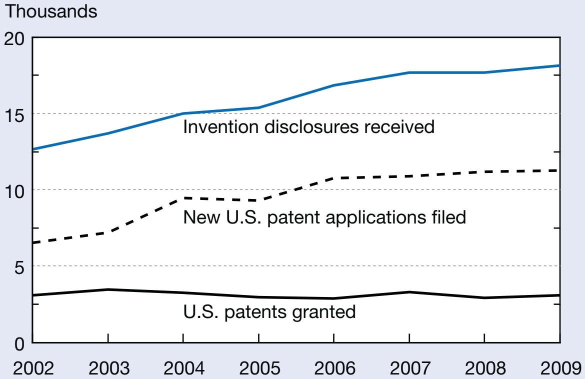


NOTES: Data include institutions affiliated with academic institutions, such as university and alumni organizations, foundations, and university associations. Universities vary in how patents assigned, e.g., to boards of regents, individual campuses, or entities with or without affiliation with university. The Patent Board™ technology areas constitute an application-oriented classification system that maps the thousands of International Patent Classes (IPCs) at main group level into 1 of 35 technology areas. If patent has more than one IPC, only primary IPC is considered in mapping. Data in figure not comparable to previous versions of the figure due to changes in classification system.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board™, special tabulations (2011) from U.S. Patent and Trademark Office (USPTO), Patent Grant Bibliographic Data.

Science and Engineering Indicators 2012

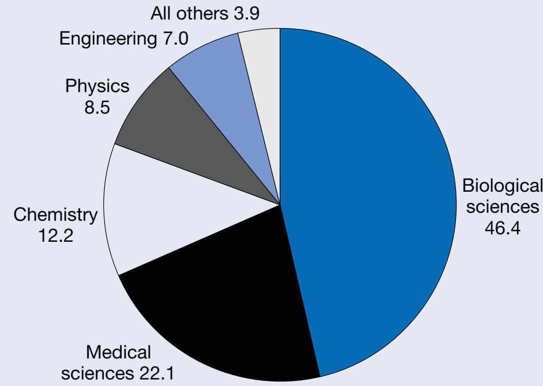
Figure 5-32
U.S. university patenting activities: 2002–2009



SOURCE: Association of University Technology Managers (AUTM), AUTM Licensing Surveys: 2002–2009. See appendix table 5-48.

Science and Engineering Indicators 2012

Figure 5-33
Citations of U.S. S&E articles in U.S. patents, by selected S&E article field: 2010



NOTES: Citations are references to S&E articles in journals covered by Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). Citation counts based on a 6-year window with 5-year lag, e.g., citations for 2010 are references in U.S. patents issued in 2010 to articles published in 2000–05.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board™, special tabulations (2011) from U.S. Patent and Trademark Office (USPTO), Patent Grant Bibliographic Data, and Thomson Reuters, SCI and SSCI, http://www.thomsonreuters.com/products_services/ science/. See appendix table 5-50.

Science and Engineering Indicators 2012

Patent-to-Literature Citations

Citations to the S&E literature on the cover pages of issued patents are one indicator of the contribution of research to the development of practical innovations.[48] This indicator of how science links to invention increased sharply in the late 1980's and early 1990's (Narin, Hamilton, and Olivastro 1997), due in part to developments in U.S. policy, industry growth and maturation, and court interpretation. At the same time, patenting activity by academic institutions was increasing rapidly, as were patent citations to S&E literature produced across all sectors (NSB 2008, pp. 5-49 to 5-54).

Between 1998 and 2010, growth for this indicator was much slower. Of utility patents awarded to both U.S. and foreign assignees, 11% cited the S&E articles analyzed in this chapter in 2010 (appendix table 5-49). Concomitant with a growth in the percentage of U.S. utility patents awarded to foreign assignees, nearly 50% of the citations to the S&E literature in 2010 cited non-U.S. S&E articles.

In 2010, five broad S&E fields (biological sciences, medical sciences, chemistry, physics, and engineering) accounted for 96% of the citations to U.S. articles in USPTO patents (figure 5-33 and appendix table 5-50). These citations are dominated by articles in the biological sciences, at 46% of the total (compare with patents awarded by technology area, figure 5-31).

Considering only citations to U.S. articles, growth in citations has been uneven across the sectors and thus sector shares have changed somewhat (appendix table 5-49). Citations to articles authored in the industry, nonprofit, and government sectors have lost share, largely to articles from academia, which grew from 58% to 64% of the total citations to U.S. articles between 1998 and 2010. Appendix table 5-50 summarizes the increasing role of citations to U.S. academic articles in the science linkage to U.S. patents. Of the five broad fields of S&E that accounted for virtually all patent citations to U.S. academic articles, increased shares of academic citations were notable in engineering (from 46% to 63%) and physics (from 43% to 66%).

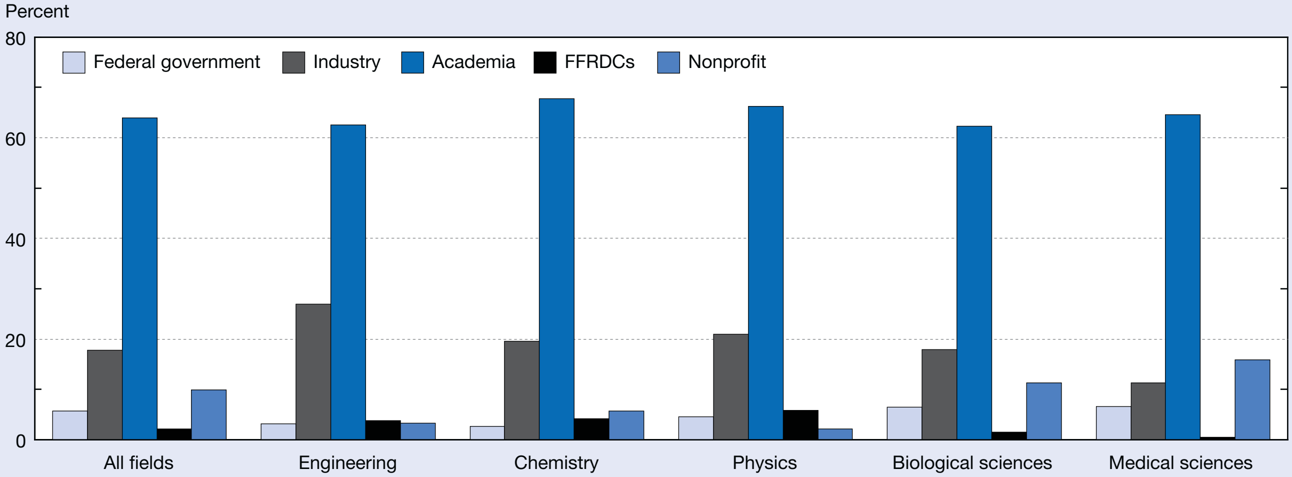
Figure 5-34 shows, within the most cited S&E fields, the distribution by U.S. sector of citations to articles in U.S. patents in 2010. As noted above, academic articles dominate across all of the fields shown, from 62% in the biological sciences to 68% in chemistry. U.S. government-authored articles received 7% of the 2010 patent citations in both the biological and medical sciences. S&E articles from industry accounted for 27% of the engineering citations and about one-fifth of the articles cited in chemistry and physics. FFRDC-authored articles accounted for 6% of the physics citations.

Energy and Environment-Related Patent Citations

NSF developed a set of four filters for identifying patents with potential application in pollution mitigation and in alternative means of energy production, storage, and management. (See sidebar "Identifying Clean Energy and Pollution Control Patents" for details on the filters.) These include patents slated by the federal government for fast-track review at USPTO.[49]

Chapter 6 of this volume presents extensive data on the patents in these four technology areas, including the nationality of their assignees. (See chapter 6, "Patenting of clean energy and pollution control technologies.") This section reports on the citations in those patents to the S&E literature, using those citations to indicate the linkages between S&E

Figure 5-34
Citations of U.S. S&E articles in U.S. patents, by selected S&E field and article author sector: 2010



FFRDC = federally funded research and development center

NOTES: Citations are references to U.S. S&E articles in journals covered by Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). Citations on fractional-count basis, i.e., for cited articles with collaborating institutions from more than one sector, each sector receives fractional credit on basis of proportion of its participating institutions. Citation counts based on a 6-year window with 5-year lag, e.g., citations for 2010 are references in U.S. patents issued in 2010 to articles published in 2000–05. Detail may not add to total because of rounding.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board™, special tabulations (2011) from U.S. Patent and Trademark Office (USPTO), Patent Grant Bibliographic Data, and Thomson Reuters, SCI and SSCI, http://www.thomsonreuters.com/products_services/science/.

Science and Engineering Indicators 2012

Identifying Clean Energy and Pollution Control Patents

Using a combination of U.S. Patent Classification and International Patent Classification codes and text strings, NSF developed algorithms to identify USPTO-issued patents with potential application in four broad "green" technology areas. The four technology areas and their main sub-categories are listed below. The search codes used to locate relevant patents will be available in D'Amato et al. (2012 forthcoming), which documents the process used in developing these patent filters.

Alternative energy production	Energy storage	Energy management (smart grid)	Pollution mitigation
Bioenergy	Batteries	Advanced components	Recycling
Geothermal	Flywheels	Sensing and measurement	Air
Hydropower	Superconducting magnetic energy systems	Advanced control methods	Solid waste
Nuclear	Ultracapacitors	Improved interfaces and decision support	Water
Solar	Hydrogen production and storage	Integrated communication	Environmental remediation
Wave/tidal/ocean	Thermal energy storage		Cleaner coal
Wind	Compressed air		Carbon and greenhouse gas capture and storage
Electric/hybrid vehicles			
Fuel cells			

R&D[50] and the potential for practical use of the results of those R&D projects in new inventions and technologies.

Five broad S&E fields dominate the citations to S&E literature in these four patent areas: chemistry, physics, engineering, the biological sciences, and geosciences (which in this taxonomy includes the environmental sciences). The range of S&E fields cited indicates that these developing technologies rely on a wide base of S&E knowledge.[51]

The S&E fields cited by these patents are shown in table 5-25. Thirty-five percent of the citations in alternative energy patents that cite S&E articles were to chemistry articles, followed by articles from physics (28%), engineering (20%), and the biological sciences (15%).

Chemistry also dominates the citations in patents for energy storage systems, at 54%., followed by citations to articles in engineering (20%), physics (16%), and the biological sciences (9%).

Patents with potential for application in pollution mitigation processes cite S&E articles most often in chemistry, at 31%. The biological sciences, geosciences, and engineering each receive about one-fifth of the citations in these patents.

Smart grid is a set of patents related to efficient use and distribution of energy. Two fields dominate the S&E article citations in these patents: physics (52%) and engineering (40%).

Table 5-25
Patent citations to S&E articles, by selected patent technology area and article field: 1998–2010

Technology/field	Citations (*n*)	Percent
Alternative energy	7,852	100.0
Chemistry	2,770	35.3
Physics	2,171	27.6
Engineering	1,532	19.5
Biological sciences	1,179	15.0
Geosciences	116	1.5
All others	84	1.1
Energy storage	3,909	100.0
Chemistry	2,106	53.9
Engineering	783	20.0
Physics	637	16.3
Biological sciences	338	8.6
All others	45	1.2
Smart grid	1,433	100.0
Physics	750	52.3
Engineering	572	39.9
Computer sciences	33	2.3
Biological sciences	31	2.2
Geosciences	20	1.4
Chemistry	19	1.3
All others	8	0.6
Pollution mitigation	5,390	100.0
Chemistry	1,643	30.5
Biological sciences	1,162	21.6
Geosciences	1,088	20.2
Engineering	1,068	19.8
Physics	211	3.9
Agricultural sciences	136	2.5
All others	82	1.5

NOTES: Citations are references to S&E articles in journals covered by Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). Citation counts based on a 6-year window with 5-year lag, e.g., citations for 2002 are references in U.S. patents issued in 2002 to articles published in 1992–97. Patents may appear in more than one technology area and thus citation counts may overlap slightly. See sidebar "Identifying clean energy and pollution control patents" for details on these technology areas.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board™, special tabulations (2011) from U.S. Patent and Trademark Office (USPTO), Patent Grant Bibliographic Data, and Thomson Reuters, SCI and SSCI, http://www.thomsonreuters.com/products_services/science/.

Science and Engineering Indicators 2012

Conclusion

U.S. universities and colleges continue to be key performers of U.S. R&D, particularly for basic research. Academic spending on R&D has continued to increase yearly over the last 10 years, both in current dollar and inflation-adjusted terms. Academic R&D spending primarily supports basic research—it accounted for 75% in 2009, with another 21% supporting applied research and 4% for development—proportions that have been stable over the decade. The federal government has long provided the majority of funding for academic R&D, at 59% in FY 2009. This federal support has grown yearly over the last 10 years—although when adjusted for inflation, FYs 2006 and 2007 were years of real dollar declines. Academic R&D has also long been concentrated in just a few S&E fields. For decades, more than half of all academic R&D spending has been in the life sciences.

The structure and organization of academic R&D have also changed. Research-performing colleges and universities continued to expand their research space, particularly in the biological and medical sciences, which are the fields with the bulk of R&D expenditures.

Both the overall academic S&E doctoral workforce and the academic research workforce have continued to increase, although the change since 2006 was the smallest single-period increase on record. The life sciences accounted for much of the growth in the academic S&E doctoral workforce, and life scientists represented more than a third of academic S&E doctoral researchers in 2008. The growth in the number of new PhDs has outpaced the growth in the number of full-time faculty positions since the late 1980s, particularly among life scientists. The following long-term academic workforce trends continue: a relative shift of S&E doctorate holders away from full-time faculty positions toward other full-time positions, part-time positions, and (in some years) postdocs; a relative shift toward greater employment of women and minorities; a steadily increasing proportion of foreign-born faculty and postdocs; and a decline in share of academic researchers receiving federal support. Federal support has been less available to early career S&E doctoral faculty than to more established faculty, and the percentage of early career S&E faculty with federal support has declined since 1991.

The intimate links between research and U.S. graduate education, regarded as a model by other countries, helps to bring large numbers of foreign students to the United States, many of whom stay in the country after graduation. Academia has also been able to attract many talented foreign-born scientists and engineers into its workforce. In research institutions, foreign-born faculty who received their degrees in the United States approach half the total of all U.S. degrees granted in engineering and computer science.

Data on S&E research articles suggest that research is increasingly done in team settings: the number of authors per article has steadily increased over the past 20 years. Academic R&D is also becoming more international, and this trend is reflected in the data on S&E articles. U.S. academic scientists and engineers are collaborating extensively with colleagues in other countries—in 2010, nearly one-third of S&E articles with a U.S. author also had at least one coauthor from abroad, and U.S. authors appeared on more than 40% of all internationally coauthored articles.

Citation data indicate that U.S. scientific publications remain highly influential relative to publications from other countries. However, the relative volume of U.S. article output has not kept up with the increasing outputs of the European Union and several countries in Asia. In recent years, China has become the second-largest national producer of S&E articles.

Notes

1. For this discussion, the terms *universities and colleges, higher education,* and *academic institutions* are used interchangeably and include only those schools that grant a bachelor's or higher degree in science or engineering and spend at least $150,000 for separately budgeted R&D in S&E.

2. The academic R&D totals presented here exclude expenditures at the federally funded research and development centers (FFRDCs) associated with universities. Those expenditures are tallied separately and discussed in chapter 4. Nevertheless, the FFRDCs and other national laboratories (including federal intramural laboratories) play an important role in academic research and education, providing research opportunities for students and faculty at academic institutions and highly specialized, shared research facilities.

3. For the definitions used in National Science Foundation (NSF) surveys and a more complete discussion of these concepts, see the chapter 4 sidebar, "Definitions of R&D."

4. The academic R&D reported here includes separately budgeted R&D and related recovered indirect costs, as well as institutional estimates of unrecovered indirect costs associated with externally funded R&D projects, including mandatory and voluntary cost sharing.

5. Under the act the funding was to be obligated by the end of FY 2009. However, the expenditures for these projects could span several years.

6. Statistics on R&D performance can differ depending on whether the reporting is by R&D performers or R&D funders. There are a number of reasons for this difference; for a discussion see the chapter 4 sidebar, "Tracking R&D: Gap Between Performer- and Source-Reported Expenditures."

7. Federal grants, contracts, and awards from other sources that are passed through state and local governments to academic institutions are credited to the original provider of the funds.

8. The medical sciences include subfields such as pharmacy, neuroscience, oncology, and pediatrics. The biological sciences include subfields such as microbiology, genetics, epidemiology, and pathology. These distinctions may blur at times because the boundaries between fields often are not well defined.

9. Data reported on non-S&E R&D expenditures are lower-bound estimates (slightly) for the national totals because NSF did not attempt to adjust for the 2.7% nonresponse rate on this survey item. Also, only institutions that conducted at least $150,000 of S&E R&D were surveyed. The activities of institutions that do not perform S&E R&D (but may conduct substantial amounts of non-S&E R&D) are not reflected here.

10. Data on non-S&E R&D expenditures have been collected by NSF since FY 2003. However, the response rates on these items for the years prior to 2006 make trend analysis unreliable.

11. This financial pass through is far from a complete indicator, as it provides little indication of the nature of the collaborative relationships involved.

12. Research space here is defined as the space used for sponsored R&D activities at academic institutions that is separately budgeted and accounted for. Research space is measured in net assignable square feet (NASF). This is the sum of all areas on all floors of a building assigned to, or available to be assigned to, an occupant for a specific use, such as research or instruction. NASF is measured from the inside faces of walls. Multipurpose space that is partially used for research is prorated to reflect the proportion of time and use devoted to research.

13. The S&E fields used in the NSF Survey of Science and Engineering Research Facilities are based on the National Center for Education Statistics (NCES) Classification of Instructional Programs (CIP)—which is updated every 10 years (the current version is dated 2000). The S&E fields used in both the FY 2007 and FY 2009 Survey of Science and Engineering Research Facilities reflect the 2000 CIP update. For a comparison of the subfields in the FY 2005 and FY 2007 surveys, see the detailed statistical tables for S&E Research Facilities: FY 2007.

14. The S&T field and subfield definitions were updated to the 2000 CIP starting with the FY 2007 facilities survey. Therefore, some of the observed declines in research space for health/clinical sciences and physical sciences between FY 2005 and FY 2007 could reflect definition changes.

15. Because of rising capitalization thresholds, the dollar threshold for inclusion in the equipment category has changed over time. Generally, university equipment that costs less than $5,000 would be classified under the cost category of "supplies."

16. The "bricks and mortar" section of the Survey of Science and Engineering Research Facilities asks institutions to report their research space only. Therefore, the reported figures do not include space used for other purposes such as instruction or administration. In the cyberinfrastructure section of the survey, however, respondents are asked to identify all of their cyberinfrastructure resources, regardless of whether these resources were used for research or other functions.

17. Research-performing academic institutions are defined as colleges and universities that grant degrees in S&E and expend at least $1 million in R&D funds. Each institution's R&D expenditures are determined through the NSF Survey of Research and Development Expenditures at Universities and Colleges.

18. Unless specifically noted, data on S&E doctorate holders in this section come from the Survey of Doctorate Recipients, a biennial NSF survey. All numbers are rounded to the nearest 100. Small estimates may be unreliable.

19. The United States is unlike many other countries in the fraction of doctorate holders who are employed in academia. A comparison of 1990–2006 doctorate recipients in 14 countries for which data are available found that in most of these countries, more than half of doctorate holders were employed in academia, compared with 47% for the United States. Only the United States, Austria, and Belgium had substantial fractions of doctorate holders employed in the business sector, and the United States had one of the smallest fractions employed in government (Organisation for Economic Co-operation and Development 2009).

20. Respondents were presented with a list of work activities and asked to identify the activities which occupied the most and second most hours during the typical work week. This measure was constructed slightly differently prior to 1993, and the data are not strictly comparable across the two periods. Prior to 1993, the survey question asked the respondent to select the primary and secondary work activity from a list of activities. Beginning in 1993, respondents were asked on which activity they spent the most hours and on which they spent the second most hours. Therefore, the crossing over of the two trends between 1991 and 1993 could partly reflect a difference in methodology. However, the faster growth rate for researchers in both the 1973–91 and 1993–2008 periods means that changes in question wording cannot fully explain the observed trend. Because individuals may select both a primary and a secondary work activity, they can be counted in both groups.

21. On the 2006 Survey of Doctorate Recipients, respondents were asked to indicate whether they "Work with an immediate work group or team?"; "Work with others in the same organization (company, university, agency, etc.), but not the same group or team?"; "Work with individuals in other organizations in the U.S.?"; and "Work with individuals located in other countries?" For respondents who indicated that they had collaborated with individuals located in other countries, subsequent questionnaire items inquired about the nature of the collaboration (for example, sharing information, sharing facilities, preparing a joint publication) and the mode of collaboration (for example, collaboration via telephone or e-mail, travel to foreign country).

22. These data include only U.S.-trained postdocs employed in U.S. academic institutions. A 2003 survey conducted by the Sigma Xi honor society, which was nonrepresentative and likely to undercount foreign-degreed postdocs, found that 46% of responding postdocs had received their doctorate from a non-U.S. institution.

23. Interpretation of the data on federal support of academic researchers is complicated by a technical difficulty. Between 1993 and 1997, respondents to the Survey of Doctorate Recipients were asked whether work performed during the week of April 15 was supported by the federal government. In most other survey years, the reference was to the entire preceding year, and in 1985, it was to the month of April. However, the volume of academic research activity is not uniform over the entire academic year. A 1-week (or 1-month) reference period seriously understates the number of researchers supported at some time during an entire year. Thus, the numbers for 1985 and 1993–97 cannot be compared with results for the earlier years or with those from the 1999 through 2008 surveys, which also used an entire reference year.

The discussion in this edition of *Indicators* generally compares data for 2008 with data for 1991. All calculations express the proportion of researchers with federal support relative to the number responding to this question. The reader is cautioned that, given the nature of these data, the trends discussed are broadly suggestive rather than definitive. The reader also is reminded that trends in the proportion of all academic researchers supported by federal funds occurred against a background of rising overall numbers of academic researchers.

24. Publication traditions in broad S&E fields differ somewhat. For example, computer scientists often publish their findings in conference proceedings, and social scientists often write books as well as publish in journals. Proceedings and books are poorly covered in the data currently used in this chapter.

25. The U.S. sector identification in this chapter is quite precise; to date, sector identification has not been possible for other countries.

26. Statements that a country "authors" a certain number of articles are somewhat imprecise, especially given the growing rates of international collaboration discussed later in this chapter. This chapter follows the convention of counting a country's articles in fractions (i.e., articles with more than one country's participation are fractionalized according to the number of different institutional authors listed on the article). These fractions are then allocated to the respective

country and totaled to produce a national article count. This chapter uses the more straightforward if less precise terminology "country X produces some *number* of the world's S&E articles." It also refers to the percentage of the world's total S&E articles accounted for by certain countries.

27. For example, Vatican City is not strictly a country; the Union of Soviet Socialist Republics (USSR) and Hong Kong are contained in the data in earlier years, but the USSR no longer exists and Hong Kong data are now reported as part of China. See appendix table 5-25 for a list of the locations represented in the data.

28. Distributions of data in which a small percentage of cases account for a significant amount of the total value across all cases belong to a group of statistical distributions collectively referred to as *power law distributions* (Adamic, 2000). Examples of other phenomena with such distributions include earthquakes (only a few among a large number of earthquakes have great power) and Internet traffic (visits to a relatively small number of sites account for a very large proportion of visits to all sites).

29. Coauthorship is a broad, though limited, indicator of collaboration among scientists. Previous editions of *Indicators* discussed possible underlying drivers for increased collaboration, including scientific advantages of knowledge- and instrument-sharing, decreased costs of travel and communication, and national policies (NSB 2006). Katz and Martin (1997), Bordons and Gómez (2000), and Laudel (2002) analyze limitations of coauthorship as an indicator of research collaboration. Despite these limitations, other authors have continued to use coauthorship as a collaboration indicator (Adams et al. 2005; Gómez, Fernández, and Sebastián 1999; Lundberg et al. 2006; Wuchty, Jones, and Uzzi 2007; Zitt, Bassecoulard, and Okubo 2000).

30. The reader is reminded that the data on which these indicators are based give the nationality of the institutional addresses listed on the article. Authors themselves are not associated with a particular institution and may be of any nationality. Therefore the discussion in this section is based on the nationality of institutions, not authors, and makes no distinction between nationality of institutions and nationality of authors.

31. For a consideration of current limitations in identifying interdisciplinary S&E research using bibliometrics techniques, see Wagner et al. (2011) and the sidebar "Can Bibliometric Data Provide Indicators of Interdisciplinary Research?" in NSB 2010.

32. Readers are reminded that the *number* of coauthored articles between any pair of countries is the same; each country is counted once per article in these data. However, countries other than the pairs discussed here may also appear on the article.

33. Finland is included here as one of the Scandinavian countries. Iceland is not.

34. Article counts in this section are based on the year in which the article appeared in the database, not on the year of publication, and therefore are not the same counts as in the earlier discussion of total world article output.

35. The 16 FFRDCs sponsored by the Department of Energy dominated S&E publishing by this sector. Across all fields of S&E, DOE-sponsored labs accounted for 83% of the total for the sector in 2005 (NSB 2008). Scientists and engineers at DOE-sponsored FFRDCs published 96% of the sector's articles in chemistry, 95% in physics, and 90% in engineering (see "S&E Articles From Federally Funded Research and Development Centers," NSB 2008, p. 5–47). Nine other federal agencies, including the Departments of Defense, Energy, Health and Human Services, Homeland Security, Transportation, and Treasury; the National Aeronautics and Space Administration; the Nuclear Regulatory Commission; and National Science Foundation also sponsor another 23 FFRDCs (NSF/SRS 2009).

36. Identification of the sector of the non-U.S. institution is not possible with the current data set.

37. Readers are reminded that coauthors from different departments in an institution are coded as different institutions.

38. This chapter uses the convention of a 3-year citation window with a 2-year lag. For example, 2008 citation rates are from references in articles in the 2008 data file to articles contained in the 2004, 2005, and 2006 data files of the Thomson Reuters Science Citation Index and Social Sciences Citation Index databases. Analysis of the citation data shows that, in general, the 2-year citing lag captures the 3 peak citation years for most fields, with the following exceptions: in astronomy and physics, the peak citation years are generally captured with a 1-year lag, and in computer sciences, psychology, and the social sciences with a 3-year lag.

39. "Influence" is used here broadly; even citations that criticize or correct previous research indicate the influence of that previous research on the citing article.

40. Because different S&E fields have different citation behaviors, these indicators should be used with caution. For example, articles in the life sciences tend to list more references than, for example, articles in engineering or mathematics. Thus, a country's research portfolio that is heavily weighted toward the life sciences (e.g., the U.S.) may receive proportionately more citations than a country whose portfolio is more heavily weighted toward engineering or mathematics.

41. The reader is reminded that articles in this section are counted by the year they entered the database, not by year of publication. Therefore article counts, and percentages based on them, are different from the data presented earlier in this section.

42. Some part of this percentage decrease may reflect the *increase* in Chinese journals in the SCI and SSCI databases used in this chapter. Since more Chinese authors in these journals are available to cite their Chinese coauthors, international citations to Chinese-authored articles is declining as a share of total citations. However, accounting for the "nationality" of a journal is not straightforward, and the data file used by NSF excludes journals that are primarily of regional interest. NSF's count of "Chinese" journals shows

an increase of 75% over the past decade, compared to an increase of 334% for Chinese-authored articles.

43. Percentiles are specified percentages below which the remainder of the articles falls. For example, the 99th percentile identifies the number of citations 99% of the articles failed to receive. For example, across all fields of science, 99% of articles from 2005 to 2007 failed to receive at least 21 citations in 2009. Matching numbers of citations with a citation percentile is not precise because all articles with a specified number of citations must be counted the same. Therefore, the citation percentiles discussed in this section and used in appendix tables 5-44 and 5-45 have all been counted conservatively, and the identified percentile is in every case higher than specified, (i.e., the 99th percentile is always greater than 99%, the 95th percentile is always greater than 95%, and so forth). Actual citations/percentiles per field vary widely because counts were cut off to remain within the identified percentile. For example, using this method of counting, the 75th percentile for engineering contained articles with three to four citations in 2005 through 2007, whereas the 75th percentile for astronomy contained articles with 6 to 10 citations.

44. For an overview of these developments in the 20th century, see Mowery (2002).

45. Sharp changes in the number of patents granted are related to the speed of processing at United States Patent and Trademark Office.

46. The institutions listed in appendix table 5-46 are slightly different from those listed in past volumes, and data for individual institutions may be different. In appendix table 5-46, an institution is credited with a patent even if it is not the first assignee, and therefore some patents may be double counted. Several university systems are counted as one institution, and medical schools may be counted with their home institution. Universities also vary in how they assign patents (e.g., to boards of regents, individual campuses, or entities with or without affiliation with the university).

47. The patent counts reported by Association of University Technology Managers respondents in figure 5-32 and appendix table 5-48 cannot be compared with the patent counts developed from USPTO data as in appendix tables 5-46 and 5-47.

48. Patent-based data must be interpreted with caution. Year-to-year changes in the data may reflect changes in USPTO processing times (so-called “patent pendency” rates). Likewise, industries and companies have different tactics and strategies for pursuing patents, and these may also change over time.

Patent citations to S&E research discussed in this section are limited to the citations found on the cover pages of successful patent applications. These citations are entered by the patent examiner, and may or may not reflect citations given by the applicant in the body of the application. Patent cover pages also contain references to scientific and technical materials not contained in the article data used in this chapter (e.g., other patents, conference proceedings, industry standards, etc.). Analyses of the data referred to in this section found that nonjournal references on patent cover pages accounted for 19% of total references in 2008. The journals/articles in the SCI/SSCI database used in this chapter—a set of relatively high-impact journals—accounted for 83% of the journal references, or 67% of the total science references, on the patent covers.

49. Pilot Program for Green Technologies Including Greenhouse Gas Reduction, 74 Fed. Reg. 64,666 (USPTO, December 8, 2009).

50. Due to data limitations, this discussion is limited to the following: patent data are patent awards made by the USPTO to all assignees, not just U.S. assignees. S&E publication data are for all publications in all U.S. sectors and all country authors.

51. Compare with Organisation for Economic Co-operation and Development, 2010, p.36.

Glossary

Academic doctoral S&E workforce: Includes those with a U.S. doctorate in an S&E field employed in 2- or 4-year colleges or universities in the following positions: full and associate professors (referred to as *senior faculty*); assistant professors and instructors (referred to as *junior faculty*); postdocs; other full-time positions such as lecturers, adjunct faculty, research associates, and administrators; and part-time positions of all kinds.

Academic institution: In the Expenditures and Funding for Academic R&D section of this chapter, an academic institution is generally defined as an institution that grants a bachelors’ or higher degree in science or engineering and that has spent at least $150,000 for separately budgeted R&D in S&E within the fiscal year being measured. Elsewhere in the chapter, this term encompasses any accredited institution of higher education.

Underrepresented minority: Demographic category including blacks, Hispanics, and American Indians/Alaska Natives; groups considered to be underrepresented in academic institutions.

References

Adamic L. 2000. Zipf, Power-laws, and Pareto—A Ranking Tutorial. Palo Alto: Information Dynamics Lab, HP Labs. http://www.hpl.hp.com/research/idl/papers/ranking/ranking.html. Accessed 19 June 2009.

Adams J, Black G, Clemmons R, Stephan P. 2005. Scientific teams and institutional collaborations: Evidence from U.S. universities, 1981–1999. *Research Policy* 34:259–85.

Association of University Technology Managers (AUTM). 2009. *AUTM Licensing Activity Survey Full Report, FY 2007.* Tieckelmann R, Kordal R, Flanigan S, Glavicic-Théberge T, Bostrom D, editors. http://www.autm.net/AM/Template.cfm?Section=Licensing_Surveys_AUTM. Accessed 18 May 2009.

Bordons M, Gómez I. 2000. Collaboration networks in science. In: Cronin B, Atkins HB, editors. *The Web of Knowledge: A Festschrift in Honor of Eugene Garfield.* Medford, NJ: Information Today, Inc. p 197–213.

Brainard J, Borrego A. 2003. Academic pork barrel tops $2-billion for the first time. *The Chronicle of Higher Education* 50(5):A18. http://chronicle.com/weekly/v50/i05/05a01801.htm. Accessed February 2009.

Brainard J, and Hermes JJ. 2008. College's earmarks grow, amid criticism. *The Chronicle of Higher Education* 54(29):A1. http://chronicle.com/free/v54/i29/29a00101.htm. Accessed February 2009.

Britt, R. 2010. *Universities Report $55 Billion in Science and Engineering R&D Spending for FY 2009; Redesigned Survey to Launch in 2010*. InfoBrief NSF 10-329. Arlington , VA: National Science Foundation, Division of Science Resources Statistics. Available at http://www.nsf.gov/statistics/infbrief/nsf10329/.

Committee on Science, Engineering, and Public Policy (COSEPUP). 2000. *Enhancing the Postdoctoral Experience for Scientists and Engineers.* Washington, DC: National Academies Press. http://books.nap.edu/catalog.php?record.id=9831#toc. Accessed 15 May 2011.

Glänzel W, Schubert A. 2004. Analyzing scientific networks through co-authorship. In: Moed HFM, Glänzel W, Schmoch U, editors. *Handbook of Quantitative Science and Technology Research: The Use of Publication and Patent Statistics in Studies on S&T Systems*. Dordrecht, The Netherlands: Kluwer Academic Publishers. p 257–76.

Glänzel W, Schubert A. 2005. Domesticity and internationality in co-authorship, references and citations. *Scientometrics* 65(3):323–42.

Gómez I, Fernández MT, Sebastián J. 1999. Analysis of the structure of international scientific cooperation networks through bibliometric indicators. *Scientometrics* 44(3):441–57.

Katz J, Martin B. 1997. What is research collaboration? *Research Policy* 26:1–18.

Kiley K, 2010. Banning Congressional Earmarks Would Cost Colleges Billions. *The Chronicle of Higher Education,* December 12.

Laudel G. 2002. Collaboration and reward. What do we measure by co-authorships? *Research Evaluation* 11(1):3–15.

Lundberg J, Tomson G, Lundkvist I, Skår J, Brommels M. 2006. Collaboration uncovered: Exploring the adequacy of measuring university-industry collaboration through co-authorship and funding. *Scientometrics* 69(3):575–89.

Mowery D. 2002. The changing role of universities in the 21st century U.S. R&D system. In: Teich A, Nelson D, Lita S, editors. *AAAS Science and Technology Policy Yearbook 2002.* Washington, DC: American Association for the Advancement of Science. p 253–71.

Narin F, Stevens K, Whitlow E. 1991. Scientific co-operation in Europe and the citation of multinationally authored papers. *Scientometrics* 21(3):313–23.

Narin F, Hamilton K, Olivastro D. 1997. The increasing linkage between U.S. technology and public science. *Research Policy* 26:317–30.

National Science Board (NSB). 2010. *Science and Engineering Indicators 2010*. Arlington, VA: National Science Foundation (NSB 10-01). Available at http://nsf.gov/statistics/seind10/.

National Science Board (NSB). 2008. *Science and Engineering Indicators 2008*. Two volumes. Arlington, VA: National Science Foundation (volume 1, NSB 08-01; volume 2, NSB 08-01A). Available at http://www.nsf.gov/statistics/seind08/.

National Science Foundation, Division of Science Resources Statistics (NSF/SRS). 2009a. Federally funded R&D centers. Master government list. http://www.nsf.gov/statistics/ffrdc. Accessed 14 August 2009.

Organisation for Economic Co-operation and Development (OECD). 2010. Measuring Innovation: A New Perspective. http://www.oecd.org/document/22/0,3746,en_41462537_41454856_44979734_1_ 1_1_1,00.html. Accessed 16 June 2011.

Organisation for Economic Co-operation and Development (OECD). 2010. Careers of Doctorate Holders: Employment and Mobility Patterns. STI Working Paper 2010/4, Laureline Auriol. Paris.

Thursby J, Jensen R, Thursby M. 2001. Objectives, characteristics and outcomes of university licensing: A survey of major U.S. universities. *Journal of Technology Transfer* 26:59–72.

Wagner CS, Roessner JD, Bobb K, Klein JT, Boyack KW, Keyton J, Rafols I, Börner K. 2011. Approaches to understanding and measuring interdisciplinary scientific research (IDR): A review of the literature. *Journal of Informetrics* 165:14-26.

Wuchty S, Jones B, Uzzi B. 2007. The increasing dominance of teams in production of knowledge. *Science* 316:1036–39.

Zitt M, Bassecoulard E, Okubo Y. 2000. Shadows of the past in international collaboration: Collaboration profiles of the top five producers of science. *Scientometrics* 47(3):627–57.

Chapter 6
Industry, Technology, and the Global Marketplace

List of Sidebars

List of Tables

List of Figures

Highlights

Knowledge- and Technology-Intensive Industries in the World Economy

KTI industries have been a major and growing part of the global economy, with the United States having the highest KTI share of GDP of any large economy.

- Global value added of knowledge- and technology-intensive (KTI) industries, consisting of five knowledge-intensive (KI) service and five high-technology (HT) manufacturing industries, totaled $18.2 trillion in 2010. This represents 30% of estimated world gross domestic product (GDP) in 2010, compared with a 27% share in 1995.
- The U.S. economy had the highest concentration of KTI industries among major economies (40% of U.S. GDP). The KTI concentrations for the European Union (EU) and Japan were 32% and 30%, respectively.
- Major developing economies have lower KTI shares than developed economies. China's KTI industries created 20% of GDP in 2010 compared to 17% in 1995. The KTI shares in Brazil, India, and Russia were similar to China's.

Rising KTI shares in most countries have coincided with growth in productivity. But productivity growth in the world's developed economies since 2000 has been slower than in developing economies.

- Labor productivity growth in the United States and other developed countries slowed from 1.9% in the 1990s to 1.3% from 2000 to 2008, coinciding with slackening growth in their per capita GDP.
- Labor productivity growth in developing countries accelerated from 1.4% in the 1990s to 4.9% from 2000 to 2008, led by China, India, and Russia. China's labor productivity grew at a 10% annual average with its per capita GDP increasing from 8% to 20% of U.S. per capita GDP.

Worldwide Distribution of Knowledge- and Technology-Intensive Industries

The commercial KI service and HT manufacturing industries in the United States are collectively larger than in any other country. China's KI and HT industries have been growing rapidly, making China a major center of global activity.

- The United States has larger output ($3.6 trillion) than any other country in commercial KI service industries (business, financial, and communications). However, the U.S. share of world output fell substantially in the last decade from 42% in 2000 to 33% in 2010.
- China's world share of commercial KI service industries rose from 2% in 1995 to 7% in 2010, led by 20% average annual growth of its communications industry.
- U.S. HT manufacturing industries have a larger share of global output than any other economy. The U.S. global share fell from 34% in 1998 to 28% in 2010.
- China's share of the world's HT manufacturing rose six-fold from 3% in 1995 to 19% in 2010, surpassing Japan in 2007. Its share grew rapidly across all HT manufacturing industries, reaching nearly 50% in computers, 26% in communications, and 17%–18% in pharmaceuticals and semiconductors.

Global output of commercial KI services was flat and HT manufacturing declined in 2009 in the midst of the recession. Global output of commercial KI services and HT manufacturing recovered in 2010 with China and other developing economies leading the recovery.

- Global output of commercial KI services was flat in 2009 as part of the worldwide recession. Output in developed countries declined by 1%. But output grew by 4% in developing economies, led by double-digit growth in China. Commercial KI services resumed growing in 2010, led by a 20% increase by developing countries.
- Global output of HT manufacturing industries declined by 6% in 2009. It dropped by 7% for developed economies, but was flat in developing countries, with China growing by 9%. Global output bounced back in 2010, rising 14%, propelled by China and other developing countries.

Trade and Other Globalization Indicators

Worldwide, commercial KTI exports have grown faster than their KTI production, indicating increased globalization in these industries.

- The export share of commercial KI production rose from 5% in 1995 to 8% in 2010 suggesting a modest rate of globalization. Advances in information and communications technology (ICT) and emerging capabilities in both developed and developing countries, such as India, are driving globalization of commercial KI services.
- The export share of HT manufacturing production rose from 36% to 53% in 2006 before drifting downward to 50% in 2010.

The United States is the second-largest exporter behind the EU of commercial KI services and runs a large surplus. In HT goods, the United States has lost export share and faces a widening trade deficit.

- The United States exported $290 billion of commercial KI services (business, computer and information services, finance, and royalties and fees), with a 22% share of global exports behind the EU's 30%. The Asia-8 and China are the next two largest exporters with global shares of 15% and 8%, respectively.

- The U.S. trade surplus in commercial KI services rose from $55 billion in 2000 to reach more than $100 billion in 2009; during this same period, however, the U.S. trade deficit in HT manufacturing goods grew.
- China's and the Asia-8's surpluses in commercial KI services have grown over the last decade to reach about $30 billion in 2009. The increase in the Asia-8's surplus reflects rising surpluses in computer and information services.

While the U.S. share of global HT exports declined, China became the world's largest exporter of HT goods.

- The U.S. share of global HT exports rose from 19% to 22% from 1995 to 1998 before declining to 14%–15% during the period from 2003 to 2010 because of losses in communications and computers. The U.S. deficit in HT trade widened from $67 billion to $94 billion during the 2000s, driven by rising deficits in communications and computer goods.
- China's share of global HT goods exports more than tripled, from 6% in 1995 to 22% in 2010, making it the single largest exporting country for HT products. China's trade surplus in these products increased from less than $20 billion in 2002 to nearly $160 billion in 2010, largely because of rising surpluses in computer and communications goods.
- China's rise as the world's major assembler and exporter of many electronic goods is reflected in a sharp increase in China's share of imports of intermediate communications and computer goods originating from other Asian economies. Most of China's exports of electronics goods are destined for the United States, the EU, and Japan.

A separate measure of U.S. HT trade shows patterns in U.S. HT trade similar to those found in internationally comparable trade data.

- According to U.S. Census data on U.S. trade in advanced technology products (ATP), the United States first generated a trade deficit in ATP in 2002 that widened to $82 billion by 2010. The deficit in ICT products alone reached more than $120 billion in 2010. Aerospace and electronics generated a combined surplus of $70 billion in 2010.
- The largest U.S. trade deficit in ATP was $87 billion with China, its largest trading partner country in total goods and ATP trade, followed by $17 billion with the Asia-8, and $8 billion with Japan. ICT deficits with these Asian economies were higher, offset by lower deficits or positive trade balances in other ATP categories.

U.S. foreign overseas investment in KTI industries exceeds foreign investment in U.S. KTI industries.

- The stock of U.S. overseas investment in KTI industries was $1.1 trillion, and the stock of foreign direct investment in the United States in these industries was almost $700 billion.
- The bulk of U.S. overseas KTI investment was in service industries ($1 trillion), with less than 15% in HT manufacturing industries ($125 billion) in 2009.
- Financial services had by far the largest share in the stock of U.S. overseas investment in commercial KI service industries (74%), followed by business services (19%). Among HT manufacturing industries, pharmaceuticals (41%) and semiconductors (25%) had the largest shares.
- The stock of foreign direct investment (FDI) in the United States in commercial KI service industries stood at $433 billion in 2009; FDI in U.S. HT manufacturing industries stood at $222 billion.
- Financial services had the largest share (68%) in the stock of FDI in commercial KI service industries, followed by business services (19%) and communications (13%). Pharmaceuticals accounted for 68% of the share for HT manufacturing industries.

Innovation-Related Indicators of the United States and Other Major Economies

U.S. firms in commercial KTI industries reported much higher incidences of innovation than other industries.

- Four HT manufacturing industries—computers, communications, scientific and measuring instruments, and pharmaceuticals—reported rates of product and process innovation that were at least double the U.S. manufacturing sector average.
- In the U.S. nonmanufacturing sector, software firms lead, with 77% of companies reporting the introduction of a new product or service compared to the 7% average for all nonmanufacturing companies. Innovation is also two to three times higher than the nonmanufacturing average in telecommunications/Internet industries.

The U.S. share of patents granted by the U.S. Patent and Trademark Office has declined over the last decade, which may indicate increased technological capacity abroad.

- The U.S. resident share of U.S. Patent and Trademark Office (USPTO) patents granted has gradually fallen since the late 1990s, from 54% in 1998 to 52% in 2002 and down to 49% in 2010. The EU, Japan, and the Asia-8 were the main recipients of USPTO patents granted to non-U.S. countries, with a collective share of nearly 90%.
- The United States has a higher concentration relative to other major economies in USPTO patenting activity in several advanced and science-based technologies, including ICT, automation, biotechnology, and pharmaceuticals.
- The United States has a similar share to the EU and Japan in patents sought in three of the world's largest markets—the United States, the EU, and Japan. The United States, the EU, and Japan have similar shares of these high-value patents, accounting for nearly 90% of the total.
- U.S. microbusinesses (those with fewer than five employees) in industries classified as HT by the Bureau of Labor Statistics (BLS) grew much faster than in other industries

during the period 2000–08. Growth of microfirms in services classified as HT was three times that of other service industries.

- ♦ The three HT services with the largest number of microbusinesses are management, scientific, and technical consulting; computer systems design; and architectural and engineering. HT manufacturing industries with large number of microfirms include navigational, measuring, and electromedical equipment and semiconductors.

Investment and Innovation in Clean Energy and Technologies

According to commercial investment data from Bloomberg, China in 2010 provided more investment in clean energy and technologies than any other country.

- ♦ Chinese commercial investment in clean energy and technologies, which Bloomberg defines to include wind, solar, biofuels, and energy efficiency, rose exponentially from less than $1 billion in 2004 to $53 billion in 2010. The bulk of China's investment was in wind energy ($45 billion).
- ♦ The United States and the EU each provided about $30 billion in clean energy finance in 2010. Wind energy accounts for the largest share (60%) of U.S. investment, with solar the second largest.

The United States is the leading investor of venture capital in clean energy and technologies.

- ♦ Worldwide venture capital investment in clean energy and technologies rose rapidly, more than quadrupling from $1 billion to $4 billion from 2004 to 2010. The United States is the largest source of this type of investment, providing more than 80% of global energy-related venture capital.
- ♦ Two technologies, energy smart/efficiency and solar, dominate venture capital investment. Each has a 40% share.

According to data from the International Energy Administration (IEA), the United States in 2009 invested more in public research, development, and demonstration for clean energy and technologies than other countries/regions.

- ♦ Global public research, development, and demonstration (RD&D) investment for clean energy and related technologies was an estimated $17 billion in 2009. IEA data cover renewable energy, nuclear, fuel cells, carbon capture and storage, and energy efficiency.
- ♦ U.S. public RD&D investment in clean energy and technologies jumped from $2.8 billion in 2008 to $7.0 billion in 2009. However, this increase reflected one-time stimulus funding under the American Recovery and Reinvestment Act (ARRA). In 2010, U.S. public RD&D fell to $4.4 billion, when ARRA funding declined.
- ♦ The EU and Japan each funded about $4 billion in 2009, equivalent to a 24% global share.

Introduction

Chapter Overview

Policymakers in many countries increasingly emphasize the central role of knowledge, particularly R&D and other activities that advance science and technology, in a country's economic growth and competitiveness. This chapter examines the downstream effects of these activities on the economies of the United States and its major competitors in the global marketplace.

Knowledge- and technology-intensive (KTI) industries in both the service and manufacturing sectors are a major focus of the chapter. These industries are considered to have a particularly strong link to science and technology. In many cases, these industries develop technological infrastructure that diffuses across the entire economy. Information and communications technology (ICT), for example, is widely regarded as a transformative "platform" technology that has altered lifestyles and the conduct of business across a wide range of sectors. Industries that are less knowledge and technology intensive, however, remain very important in the world economy and therefore receive some attention in the chapter.

The globalization of the world economy involves the rise of new centers of KTI industries. Although the United States continues to be a leader in these industries, developing economies, especially in Asia, have vigorously pursued national innovation policies in an effort to become major producers and exporters of KTI goods and services. Advances in science and technology have enabled companies to spread KTI activity to more locations around the globe while also maintaining strong interconnections among geographically distant entities.

Innovation is closely associated with technologically led economic growth, and observers regard it as important for advancing living standards. The measurement of innovation is an emerging field, and current data and indicators are limited. However, activities related to the commercialization of inventions and new technologies are regarded as important components of innovation indicators. Such activities include patenting, the creation and financing of new high-technology (HT) firms, and investment in intangible goods and services.

In recent years, innovations aimed at developing improved technologies for generating clean and affordable energy have become increasingly important in both developed and developing countries. Clean energy has a strong link to science and technology. Like ICT, energy is a key element of infrastructure, the availability of which can strongly affect prospects for growth and development. For these reasons, the chapter pays special attention to energy technologies.

Chapter Organization

This chapter is organized into five sections. The first section discusses the increasingly prominent role of KTI industries in regional/national economies around the world. The focus is on the United States, the European Union (EU), Japan, China, and the Asia-8—India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand—which are included because of their substantial activity in KTI production and trade and growing trade ties with China. The timespan is from the early 1990s, roughly the end of the Cold War, to the present.

The second section describes the global spread of KTI industries and analyzes regional and national shares of worldwide production. It discusses shares for the KTI industry groups as a whole and for particular services and manufacturing industries within them. Because technology is increasingly essential for non-HT industries, some data on the latter are presented as well.

The third section examines indicators of increased interconnection of KTI industries in the global economy. Data on patterns and trends in global trade in KTI industries make up the bulk of this section. It presents bilateral trade data to provide a rough indication of the internationalization of the supply chains of HT manufacturing industries, with a special focus on Asia. The section also presents data on U.S. trade in advanced technology products, examining trends in U.S. trade with major economies and in key technologies. Domestic and foreign production and employment of U.S. multinationals in KTI industries are presented as indicators of the increasing involvement of these economically important firms in cross-border activities. To further illustrate the effects of globalization on the United States, the section presents data on U.S. and foreign direct investment abroad, showing trends by region and by KTI industries.

The fourth section presents innovation-related indicators. Using a new classification system, it examines country shares in patents granted by the United States in various technologies. It next examines patterns in country shares of high-value patents. It presents innovation-related data on U.S. industries from the National Science Foundation's new Business R&D and Innovation Survey. A discussion of U.S. HT small businesses includes data on the number of HT small business startups and existing firms, employment, and venture and angel capital investment by industry.

The last section presents data on clean energy and energy conservation and related technologies, which have become a policy focus in developed and developing nations. They are knowledge and technology intensive and thus are closely linked to scientific research and development. Production, investment, and innovation in these energies and technologies are rapidly growing in the United States and other major economies.

Data Sources, Definitions, and Methodology

This chapter uses a variety of data sources. Although several are thematically related, they have different classification systems. The sidebar, "Comparison of Data Classification Systems Used," shows the classification systems used in this chapter.

Comparison of Data Classification Systems Used

Topic	Data provider	Variables	Basis of classification	Coverage	Methodology
Knowledge-intensive (KI) service and high-technology (HT) manufacturing industries	IHS Global Insight, World Industry Service database (proprietary)	Production, value added	Industry basis using International Standard Industrial Classification (ISIC)	KI services—business, financial, communications, health, and education services HT manufacturing—aircraft and spacecraft, pharmaceuticals, office and computer equipment, communications, and scientific and measuring equipment	Uses data from national statistical offices in developed countries and some developing countries, and estimates by IHS for some developing countries
Trade in commercial KI services (new for 2012)	World Trade Organization	Exports and imports	Product basis using Extended Balance of Payments Services Classification	KI services—business, financial, communications, and royalties and fees	Uses data from national statistical offices, International Monetary Fund, and other sources
Trade in HT goods	IHS Global Insight, World Trade Service database (proprietary)	Exports and imports	Product basis using Standard International Trade Classification (SITC)	Aerospace, pharmaceuticals, office and computing equipment, communications equipment, and scientific and measuring instruments	Uses data from national statistical offices and estimates by IHS Global Insight
U.S. trade in advanced-technology products	U.S. Census Bureau	Exports and imports	Product basis using Harmonized Commodity Description and Coding System, 10 technology areas classified by U.S. Census	Advanced materials, aerospace, biotechnology, electronics, flexible manufacturing, information and communications, life science, nuclear technology, optoelectronics, and weapons	Data collected from automated reporting by U.S. customs
Globalization of U.S. multinationals	U.S. Bureau of Economic Analysis (BEA)	Value added, employment, and inward and outward direct investment	Industry basis using North American Industrial Classification System (NAICS)	Commercial KI services—business, financial, communications HT manufacturing—aerospace, pharmaceuticals, office and computer equipment, communications, and scientific and measuring equipment	BEA annual surveys of U.S. multinationals and U.S. subsidiaries of non-U.S. multinationals
U.S. industry innovation activities	NSF, Business R&D and Innovation Survey	Innovation activities	U.S. businesses with more than five employees	Industries classified on industry basis using NAICS	Survey of U.S. located businesses with more than five employees using nationally representative sample

Continued on following page

Comparison of Data Classification Systems Used—continued

U.S. Patent and Trademark Office (USPTO) patents	The Patent Board	Patent grants	Inventor country of origin, technology area as classified by the Patent Board	More than 400 U.S. patent classes, inventors classified according to country of origin and technology codes assigned to grant	Source of data is USPTO
Triadic patent families	Organization for Economic Co-operation and Development (OECD)	Patent applications	Inventor country of origin and selected technology area as classified by OECD	Broad technology areas as defined by OECD, inventors classified according to country of origin	Sources of data are USPTO, European Patent Office, and Japanese Patent Office
U.S. trademarks (new for 2012)	USPTO	Trademark applications	Applicant country of origin, trademark class as determined by USPTO	45 trademark goods/services classes; trademarks, applicants classified by country of origin	Source of data is USPTO
Venture capital	Dow Jones Venture source (new for 2012)	Investment, technology area, country of investor origin	Technology areas as classified by Dow Jones classification system	27 technology areas, investment classified by venture firms' country of location	Data collected by analysts from public and private sources, such as public announcements of venture capital investment deals

Knowledge- and Technology-Intensive Industries in the World Economy

Science and technology are widely regarded as important for the growth and competitiveness of individual industries and for overall national economic growth. Indeed, global economic growth increasingly depends on science, technology, and other knowledge-based assets. Policymakers in developed and developing countries are striving to attract, cultivate, and retain knowledge-based companies and workers to foster national prosperity and to increase national access to the global economy.[1]

The Organisation for Economic Co-operation and Development (OECD 2001, 2007) has identified 10 categories of industries that have a particularly strong link to science and technology.[2] Data on worldwide production in these industries can be used to examine their growing importance in the United States and other major economies.[3] These industries include both knowledge-intensive (KI) service industries and industries that produce high-technology (HT) manufactured goods. Collectively referred to as knowledge- and technology-intensive (KTI) industries, they include:

- Five KI service industries that incorporate HT either in their services or in the delivery of their services. Three of these—financial, business, and communications services (including computer software and R&D)—are generally commercially traded. The others—education and health services—are publicly regulated or provided and remain relatively more location bound.
- Five HT manufacturing industries that spend a large proportion of their revenues on R&D and make products that contain or embody technologies developed from R&D. These are aircraft and spacecraft, pharmaceuticals, computers and office machinery, semiconductors and communications equipment (treated separately in the text), and scientific (medical, precision, and optical) instruments.[4] Trends in aircraft and spacecraft and pharmaceuticals are particularly sensitive to government policies. Aircraft and spacecraft trends are affected by funding for military aircraft, missiles, and spacecraft and by different national flight regulations. National regulations covering drug approval, prices, patent protection, and importation of foreign pharmaceuticals can affect pharmaceuticals.

This report gives special attention to KTI industries in information and communications technology (ICT). ICT combines the HT manufacturing industries of computers and office machinery, communications equipment, and semiconductors with the KI services of communications and computer programming (a subset of business services). ICT industries are important because they provide the infrastructure for many social and economic activities, facilitating innovation and economic growth.[5]

This section examines the role of KTI industries in the global economy. (For a discussion of value added and other measures of economic activity, see sidebar, "Industry and Trade Data and Terminology"). For context, selected data are presented on wealth, productivity growth, and ICT infrastructure of selected economies, with a focus on the United States and other economies in which KTI industries play a particularly large or rapidly growing role.

Industry and Trade Data and Terminology

The data and indicators reported here permit the tracing and analysis of broad patterns and trends that shed light on the broadening and shifting distribution of global knowledge- and technology-intensive capabilities. The industry-level production and trade data used in this chapter derive from a proprietary IHS Global Insight database that assembles data from the United Nations and the Organisation for Economic Co-operation and Development to cover 70 countries in a consistent way. IHS estimates some missing data for some of the developing countries.

Two measures of industry activity—value added and trade volume—are expressed in current dollars. Value added is the amount contributed by an economic entity—country, industry, or firm—to the value of a good or service. It excludes purchases of domestic and imported supplies as well as inputs from other countries, industries, or firms.

Value added is an imperfect measure. It is credited to countries or regions based on the reported location of the activity, but globalization and the fragmentation of supply chains mean that the precise location of an activity is often uncertain. Companies use different reporting and accounting conventions for crediting and allocating production performed by their subsidiaries or companies in foreign countries. Moreover, the value added of a company's activity is assigned to a single industry based on the largest share of the company's business. However, a company classified as manufacturing may include services, and a company classified in a service industry may include manufacturing or may directly serve a manufacturing company. Thus, value-added trends should be interpreted as broad and relatively internally consistent indicators of the changing distribution of where economic value is generated.

Data on exports and imports represent the market value of products in international trade. This measure is not comparable with the value-added measure of industry production. Exports and imports are credited to the country where the product was "substantially transformed" into final form, but for exports produced in multiple economies, the assigned country may not be the location with the highest value added.

Growth of Knowledge- and Technology-Intensive Industries in the World and Major Economies

KTI industries have become a major part of the global economy and represent a growing share of many countries' total economic activity. Global value added of these industries totaled $18.2 trillion in 2010 (figure 6-1 and appendix table 6-1). This represents 30% of estimated world gross domestic product (GDP), compared with a 27% share of a much smaller global economy 15 years earlier (figure 6-2 and appendix table 6-2). Almost all of the share increase occurred between 1995 and 2001. Most of the increase in the KTI share of the world economy stemmed from growth in KTI industries in the United States, the European Union (EU), Japan, and several developing economies.

The KTI shares of the total economic output of the United States, EU, and Japan rose by 4–7 percentage points from 1995 to 2010, reaching 40% in the United States, 32% in the EU, and 30% in Japan (figure 6-3). The higher U.S. share relative to the EU and Japan reflects a greater intensity of commercial KI services, notably finance and business services. The KTI share increases in the economies of South Korea and Taiwan were larger, rising by 7–10 percentage points to 29% and 32%, respectively, with increases occurring in both manufacturing and service industries. South Korea and Taiwan both became wealthy, developed economies during this period.

KTI shares also grew in most of the developing economies. China's KTI share grew by 3 percentage points to reach 20%, driven by a doubling of HT manufacturing share and increases in commercial KI services and education (figure 6-3). In India and Russia, the KTI shares each rose 2–4 percentage points to reach 19% and 20% of GDP, respectively, driven by the increases in commercial and public KI service shares.

Commercial Knowledge-Intensive Services

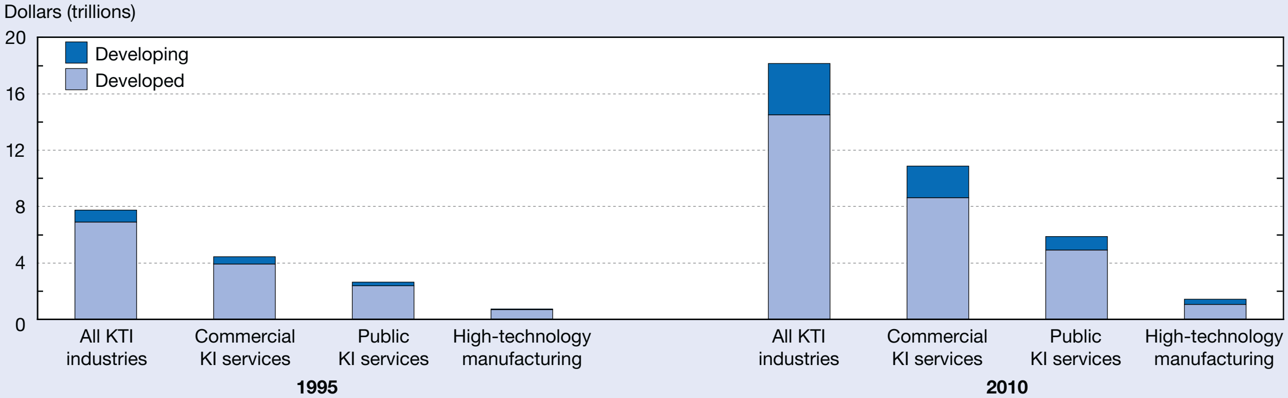
Value added of commercial KI services more than doubled from $4.4 trillion in 1995 to $10.9 trillion in 2010, representing 60% of the value added of all KTI industries ($18.2 trillion) (figure 6-1 and appendix table 6-3). In the 15 years leading up to 2010, commercial KI services increased their share of world economic activity from 15% to 18% (appendix table 6-2). Public KI services, especially education, also increased their share of the growing global GDP (figure 6-2 and appendix tables 6-4 and 6-5).

In the United States, value added of commercial KI services increased from 20% to 25% of GDP, the highest share of any large economy (figure 6-3 and appendix table 6-3). For the EU, the comparable figure rose by 4 percentage points to reach 18%, with France and Germany near the EU average and the UK above it. Japan's share rose from 15% to 17%.

The trend in large developing economies varied, with the shares of China and Brazil remaining roughly steady at 12%–14% (figure 6-3 and appendix tables 6-2 and 6-3). India's and Russia's shares each climbed by 3 percentage points to reach 13% and 14%, respectively. The differences among these economies reflect their stage of development and government policies, and may also reflect differences in the difficulty in measuring economic activity of service industries.

Commercial KI services as a percentage of non-government services (i.e., including health, education, and all commercial services) also increased (figure 6-4), and national

Figure 6-1
Global value added of knowledge- and technology-intensive industries for developed and developing countries: 1995 and 2010



KI = knowledge-intensive; KTI = knowledge- and technology-intensive

NOTES: Output of knowledge- and technology-intensive industries on value-added basis. Value added is amount contributed by country, firm, or other entity to value of good or service and excludes purchases of domestic and imported materials and inputs. Knowledge- and technology-intensive industries include knowledge-intensive services and high-technology manufacturing industries classified by the Organisation for Economic Co-operation and Development. Knowledge-intensive services include business, financial, communications, education, and health. Commercial knowledge-intensive services include business, financial, and communications services. Public knowledge-intensive services include education and health. High-technology manufacturing industries include aerospace, communications and semiconductors, computers and office machinery, pharmaceuticals, and scientific instruments and measuring equipment.

SOURCE: IHS Global Insight, World Industry Service database (2011). See appendix tables 6-1, 6-3, 6-4, 6-5, and 6-11.

Science and Engineering Indicators 2012

differences in rates of increase were generally, but not always, similar to those for commercial KI services alone.

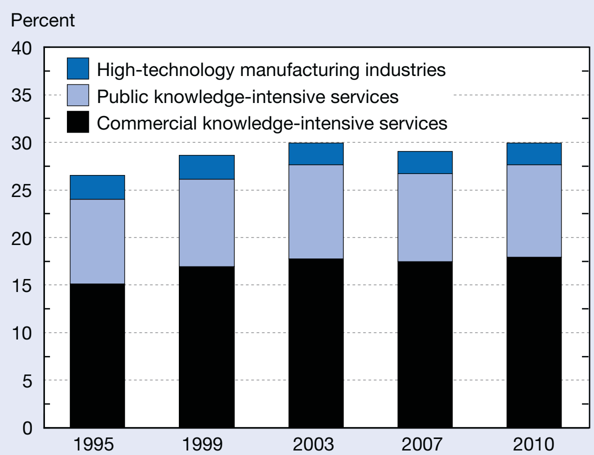
The three commercial KI service industries contributed uneven value-added amounts. The largest, business services, provided \$5.7 trillion (52% of global total value added in 2010) (appendix table 6-6). Business services include the S&T intensive R&D services and computer programming industries (appendix tables 6-7 and 6-8). The second-largest, finance, provided \$3.9 trillion (36% of global value added) (appendix table 6-9). Communications, crucial for information and data transactions in today's knowledge-based economies, provided \$1.3 trillion (12% of global value added) (appendix table 6-10).[6]

Education and Health Services

The education and health sectors generated an estimated global value added of \$2.6 and \$3.3 trillion, respectively, in 2010 (table 6-1 and appendix tables 6-4 and 6-5).[7] International comparison of these two sectors is complicated by variations in market structure, the size and distribution of each country's population, and the degree of government involvement and regulation. As a result, differences in market-generated value added may not accurately reflect differences in the relative value of these services.

Between 2000 and 2010, the value added generated by education services in developed countries nearly doubled, rising from \$1.1 trillion to \$2.0 trillion (appendix table 6-4). Output in the developing world tripled, increasing from \$190 billion to \$600 billion. China's output more than quadrupled, and Brazil's output nearly tripled. Russia's and India's outputs, starting from a low base, expanded more than fivefold

Figure 6-2
Output of knowledge- and technology-intensive industries as share of GDP: 1995–2010



GDP = gross domestic product

NOTES: Output of knowledge- and technology-intensive industries on value-added basis. Value added is amount contributed by country, firm, or other entity to value of good or service and excludes purchases of domestic and imported materials and inputs. Knowledge- and technology-intensive industries include knowledge-intensive services and high-technology manufacturing industries classified by the Organisation for Economic Co-operation and Development. Knowledge-intensive services include business, financial, communications, education, and health. Commercial knowledge-intensive services include business, financial, and communications services. Public knowledge-intensive services include education and health. High-technology manufacturing industries include aerospace, communications and semiconductors, computers and office machinery, pharmaceuticals, and scientific instruments and measuring equipment.

SOURCE: IHS Global Insight, World Industry Service database (2011). See appendix tables 6-1, 6-2, 6-4, 6-5, and 6-11.

Science and Engineering Indicators 2012

Table 6-1
Global value added of health and education services, by selected region/country/economy: 1995, 2000, 2005, and 2010

Characteristic	1995	2000	2005	2010
Education				
World ($ billions)	1,209.9	1,329.9	1,882.8	2,552.8
United States	30.5	36.3	33.9	31.6
EU	34.1	28.5	33.3	29.9
Japan	15.9	12.8	8.4	6.9
China	1.7	3.1	4.0	6.7
Asia-8	4.3	4.7	5.4	6.2
ROW	13.5	14.6	15.0	18.7
Health and social services				
World ($ billions)	1,394.7	1,553.6	2,370.3	3,334.9
United States	33.3	38.1	35.2	33.3
EU	37.3	31.0	36.0	33.9
Japan	13.8	14.1	11.0	10.3
China	1.1	1.7	1.9	2.8
Asia-8	2.5	3.1	3.4	4.4
ROW	12.0	11.9	12.5	15.3

EU = European Union; ROW = rest of world

NOTES: Value added is amount contributed by country, firm, or other entity to value of good or service and excludes purchases of domestic and imported materials and inputs. Asia-8 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. China includes Hong Kong. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia.

SOURCE: IHS Global Insight, World Industry Service database (2011). See appendix tables 6-4 and 6-5.

Science and Engineering Indicators 2012

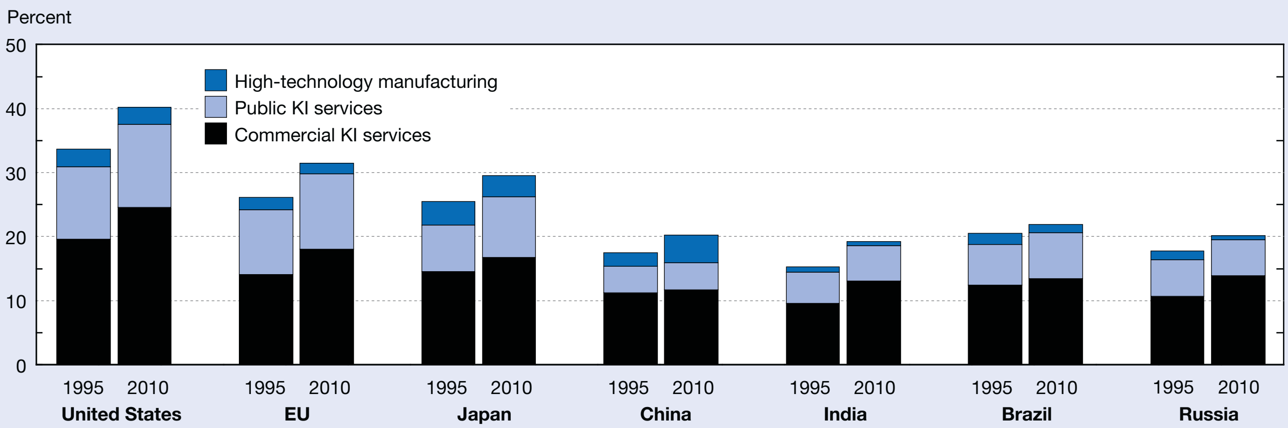
and threefold, respectively (table 6-1). Increases by these large developing economies coincided with the rapid expansion of university enrollments and graduation of new degree holders. (See "Global Trends in Higher Education in S&E" in chapter 2 for a discussion of international trends in S&E higher education.)

As with education services, production of health care services in developed countries also doubled from 2000 to 2010, rising from $1.4 trillion to $2.9 trillion (appendix table 6-5). The United States and the EU have the largest health care sectors, as measured by share of global value added (34% each) (table 6-1). The growth trend in health care for these two developed economies was similar to that in education.

High Technology Manufacturing

The global value-added output of HT manufacturing industries increased from about $700 billion in 1995 to $1.4 trillion in 2010 (appendix table 6-11). However, the share of HT manufacturing industries in the global economy remained broadly steady during this period (figure 6-2 and appendix table 6-2) because of stronger overall growth in service industries than in manufacturing. In most nations, the HT manufacturing share of the economy remained flat or declined somewhat (figure 6-3). China was an exception. The HT manufacturing share of its economy doubled from 2% to 4%. This likely reflects a shift of final assembly of these goods from other Asian economies and developed economies to China.

Figure 6-3
Output of knowledge- and technology-intensive industries as a share of GDP, by selected region/country: 1995 and 2010



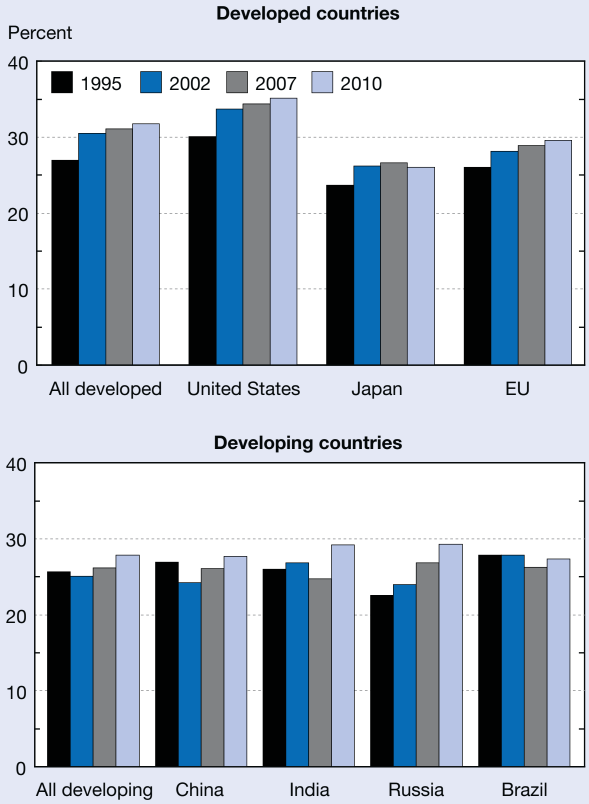
EU = European Union; GDP = gross domestic product; KI = knowledge-intensive

NOTES: Output of knowledge- and technology-intensive industries on value-added basis. Value added is amount contributed by country, firm, or other entity to value of good or service and excludes purchases of domestic and imported materials and inputs. Knowledge- and technology-intensive industries include knowledge-intensive services and high-technology manufacturing industries classified by the Organisation for Economic Co-operation and Development. Knowledge-intensive services include business, financial, communications, education, and health. Commercial knowledge-intensive services include business, financial, and communications services. Public knowledge-intensive services include education and health. High-technology manufacturing industries include aerospace, communications and semiconductors, computers and office machinery, pharmaceuticals, and scientific instruments and measuring equipment. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia. China includes Hong Kong.

SOURCE: IHS Global Insight, World Industry Service database (2011). See appendix tables 6-2, 6-3, 6-4, 6-5, and 6-11.

Science and Engineering Indicators 2012

Figure 6-4
Commercial KI service share of nongovernment services, by selected region/country: Selected years, 1995–2009



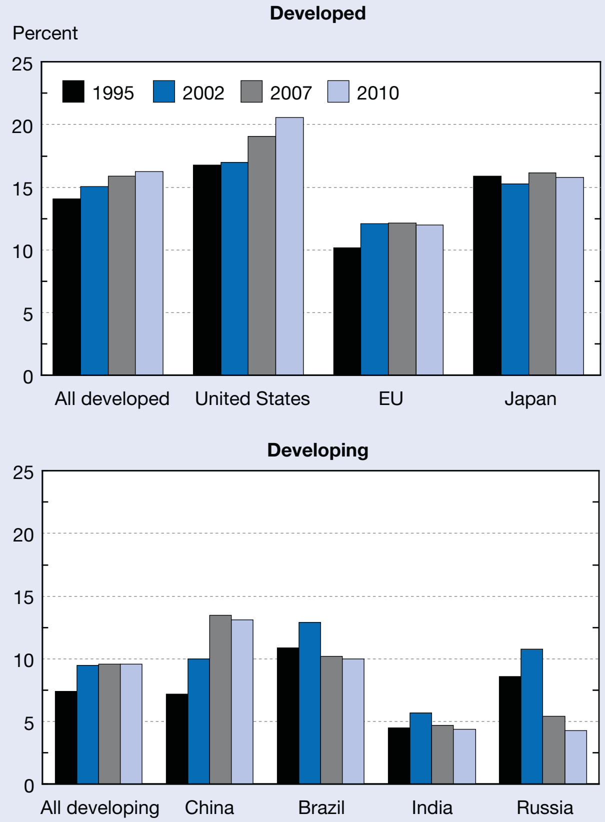
EU = European Union; KI = knowledge-intensive

NOTES: Output of commercial knowledge-intensive and nongovernment service industries on value-added basis. Value added is amount contributed by country, firm, or other entity to value of good or service and excludes purchases of domestic and imported materials and inputs. Commercial knowledge-intensive services are classified by the Organisation for Economic Co-operation and Development and include business, financial, and communications services. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia. China includes Hong Kong.

SOURCE: IHS Global Insight, World Industry Service database (2011).

Science and Engineering Indicators 2012

Figure 6-5
High-technology share of manufacturing sector for selected regions/countries: 1995–2010



EU = European Union

NOTES: Output of manufacturing industries on a value-added basis. Value added is amount contributed by country, firm, or other entity to value of good or service and excludes purchases of domestic and imported materials and inputs. High-technology manufacturing industries are classified by the Organisation for Economic Co-operation and Development and include aerospace, communications and semiconductors, computers and office machinery, pharmaceuticals, and scientific instruments and measuring equipment. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia. China includes Hong Kong.

SOURCE: IHS Global Insight, World Industry Service database (2011). See appendix tables 6-11 and 6-12.

Science and Engineering Indicators 2012

Within the manufacturing sector, many economies experienced a modest shift toward HT industries. In both developed and developing economies, the HT share of the manufacturing sector has increased by 2 percentage points since 1995, reaching 16% and 10%, respectively (figure 6-5 and appendix tables 6-11 and 6-12). The HT share of the U.S. manufacturing sector, at 21% in 2010, is larger than in either the EU or in Japan. In China, the HT share increased from 7% to 13% of its total manufacturing base, similar to the proportion in the EU. However, other large developing countries underwent almost no change on this indicator.

Information and Communications Technology Industries

Many economists regard information and communications technology (ICT) as a general-purpose platform technology that fundamentally changes how and where economic activity is carried out in today's knowledge based economies, much as earlier general-purpose technologies (e.g., the steam engine, automatic machinery) propelled growth during the Industrial Revolution.[8] Thus ICT facilitates broad development of new markets (e.g., for mobile computing, data exchange, and communications). Because of the shift to knowledge-based production, ICT infrastructure can be as important as or more important than physical infrastructure to raising living standards and remaining economically competitive.

The OECD has identified four ICT industries: two are manufacturing industries—semiconductors and communications equipment and computers—and two are service industries—communications and computer programming and data processing.

Value added of ICT industries more than doubled from $1.2 trillion in 1995 to $2.8 trillion in 2010 (appendix table 6-13). In 2010, developed countries generated a collective $1.9 trillion in value added, with $1.7 trillion generated by the United States, the EU, and Japan. The ICT share of the global economy, and of most major economies, showed little change between 1995 and 2010 (increasing from a 4% to a 6% share of GDP) (appendix table 6-2). In contrast, the ICT share of the Chinese economy doubled from 3% to 6%, driven by its huge expansion in ICT goods produced for export and rapid growth of its communications services.

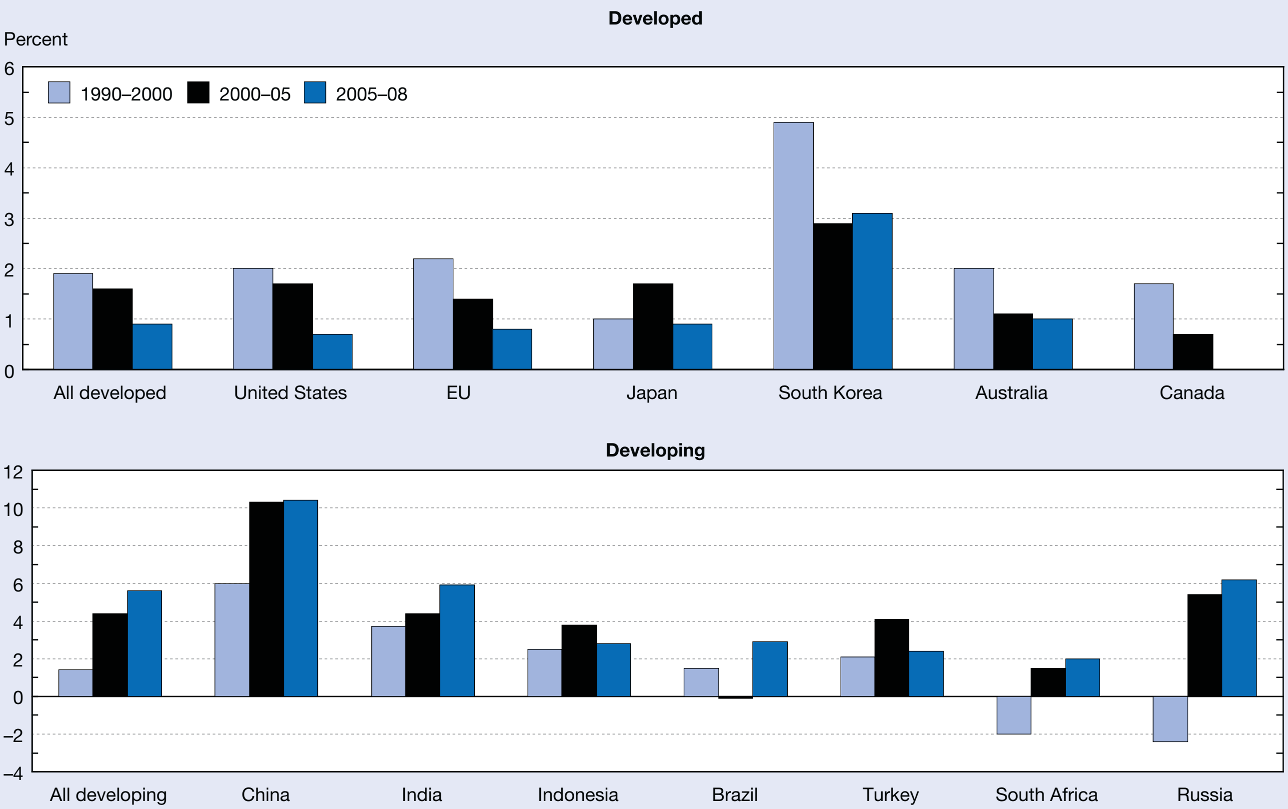
Productivity

Productivity growth is considered essential for maintaining or advancing living standards. The growth and rise in the concentration of KTI industries in the United States, the EU, Japan, and many developing economies coincided with elevated or rapidly rising productivity. The most accurate measure of productivity—output per hour—is unavailable for many emerging economies. GDP per employed person is the proxy measure used here, spanning 1990 to 2008.

Labor productivity growth of developed economies slowed from 1.9% in the 1990s to 1.6% from 2000 to 2005 and dropped to 0.9% from 2005 to 2008 (figure 6-6 and appendix table 6-14). Growth trends in the United States and the EU were very similar to the developed world average. After lagging behind the United States and the EU in the 1990s, Japan's growth accelerated to reach the rate of the United States and the EU in the 2000s. South Korea's productivity slowed but continued to grow twice as fast (3%) as most of the large developed economies.

The growth in labor productivity in developing economies accelerated from 1.4% in the 1990s to 4.4% from 2000 to 2005 and to 5.6% for 2005–08 (figure 6-6 and appendix table 6-14). China drove this increase; its labor productivity registered the fastest growth of any large economy, from 6% in the 1990s to more than 10% for both periods in the 2000s.

Figure 6-6
Growth in GDP per employed person for selected regions/countries: 1990–2008



EU = European Union; GDP = gross domestic product; PPP = purchasing power parity

NOTES: GDP is in 2010 PPP dollars. EU includes current member countries. China includes Hong Kong. Brazil's growth in 2000–05 was –0.1%.

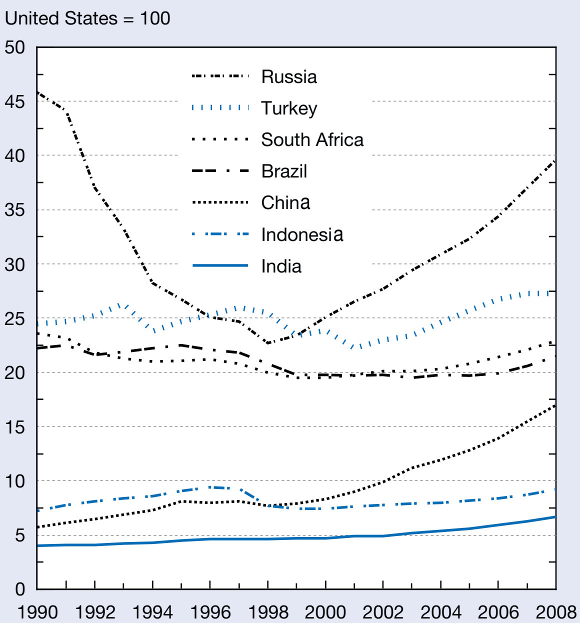
SOURCE: The Conference Board, Total Economy Database on Output and Labor Productivity (November 2010), http://www.conference-board.org/data/productivity.cfm, accessed 15 November 2010. See appendix table 6-14.

Science and Engineering Indicators 2012

Russia's labor productivity moved from negative growth in the 1990s to a 5.4% growth rate from 2000 to 2005 and further increased to a 6.2% growth rate from 2005 to 2008. India's growth in labor productivity advanced from 3.7% to 4.4% to 5.9% over these three periods. Brazil's labor productivity grew much more slowly for much of the 2000s than the other three large developing economies, but its growth accelerated from –0.1% from 2000 to 2005 to nearly 3% from 2005 to 2008.

Rapidly rising living standards, expressed as per capita GDP, accompanied the acceleration of productivity growth in developing economies and narrowed their gap with developed countries (figure 6-7 and appendix table 6-15). Despite sustained rapid productivity growth by China and several other emerging economies, however, their gap with the United States and other developed economies is substantial and is likely to remain so for some time even if their high growth is sustained. Per capita GDP in China and Brazil remains at less than a fifth of that in the United States and in Russia at less than half. India's and Indonesia's per capita GDP remains at less than 10% of that in the United States.

Figure 6-7
GDP per capita for selected developing economies: 1990–2008



GDP = gross domestic product; PPP = purchasing power parity

NOTES: GDP is in 2010 PPP dollars. China includes Hong Kong.

SOURCE: The Conference Board, Total Economy Database on Output and Labor Productivity (November 2010), http://www.conference-board.org/data/productivity.cfm, accessed 15 November 2010.

Science and Engineering Indicators 2012

Information and Communications Technology Infrastructure

This section examines three broad ICT indicators: the percentage of households with broadband access; the ICT share of total fixed capital investment; and indexes of business, consumer, and government ICT infrastructure.[9] For developing economies, only the ICT infrastructure indexes are available.

The U.S. ICT infrastructure compares favorably in these three indicators to other large developed economies. South Korea is the leading country in fixed broadband penetration, with nearly 100% of its households having broadband access (figure 6-8). The United States is in the next group with household penetration of about 60% along with Australia, Canada, and Germany. The United States exceeds the EU average, France, and Japan in broadband penetration.

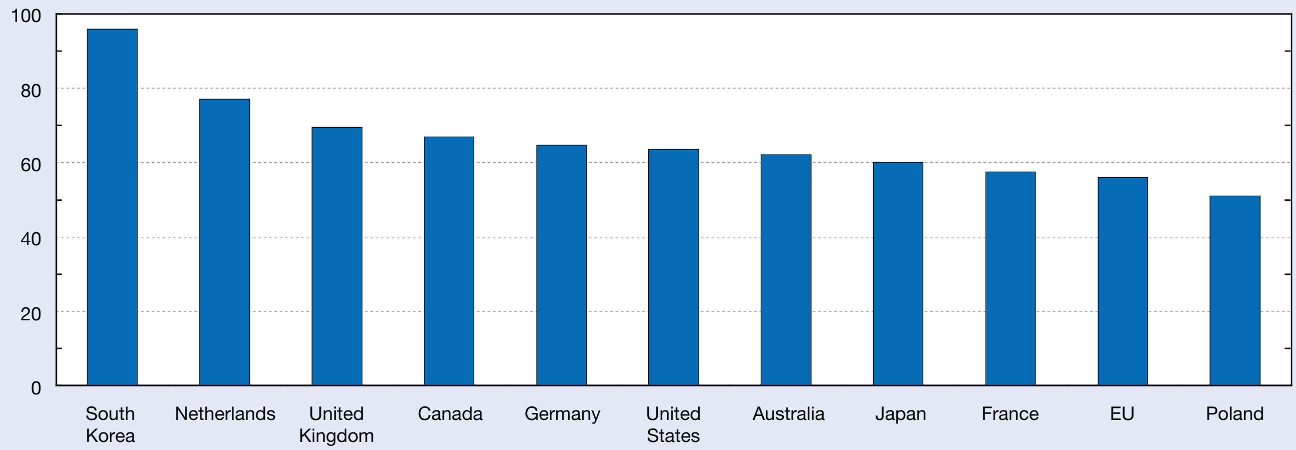
The United States has the highest ICT share of fixed capital investment (26%) of large OECD economies, with the United Kingdom a close second (figure 6-9). Five countries, Australia, Canada, Japan, France, and Germany, have shares of 13%–15%. In all of these countries, the ICT investment share has declined by large percentages since 2000; this most likely reflects rapidly falling prices of semiconductors, computers, and other ICT goods.

The United States is the leader in ICT business infrastructure among the larger developed economies (table 6-2), with an index score substantially higher than those of France, Germany, the United Kingdom, Japan, and South Korea. The United States scores near the top in ICT government infrastructure and about the same as France, Germany, the United Kingdom, Australia, and Canada in consumer infrastructure. South Korea and Japan have significantly higher scores in consumer infrastructure than the other developed economies, reflecting their lead in deployment of 3G connectivity and advanced mass-market broadband over other developed economies.

Employment data reinforce the close connection between ICT infrastructure and KTI industrial activity generally. In the United States, for example, commercial KI service industries employed about 16 million workers in 2009, or 1 of every 7 workers in the private sector, and they had a higher share of highly skilled workers than other service industries. Four commercial KI services—finance; scientific, technical, and professional services; telecommunications; and data processing hosting—have twice as high a share of workers with ICT skills compared to all service industries (figure 6-10).

Separate ICT infrastructure indexes for developing economies show wide variation among Brazil, China, India, and Russia (table 6-2). China scores third among these four economies in business infrastructure and second in consumer and government infrastructure. China's relatively weak score in ICT business infrastructure reflects very low penetration of secure Internet servers and limited international Internet bandwidth. India scores the lowest among the four in the three indexes, reflecting factors such as limited

Figure 6-8
Household broadband penetration, by selected region/country: 2009



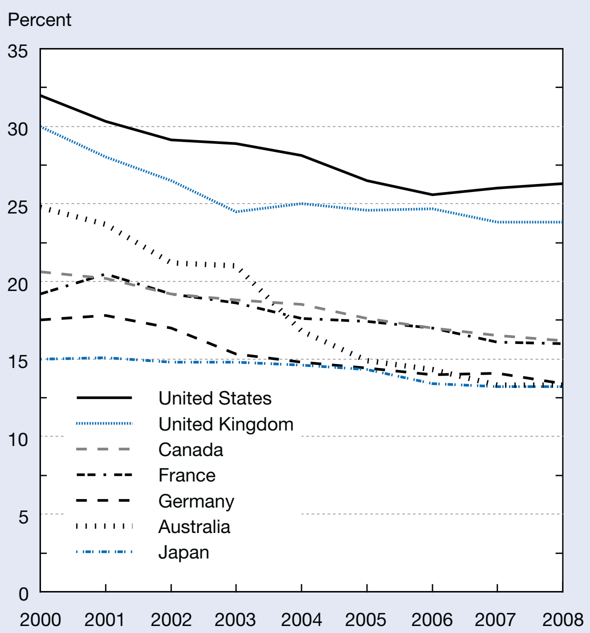
EU = European Union

NOTE: EU includes current member countries.

SOURCE: Organisation for Economic Co-operation and Development (OECD), Directorate for Science Technology and Industry, OECD Broadband Portal, http://www.oecd.org/document/54/0,3746,en_2649_33703_38690102_1_1_1_1,00.html, accessed 15 February 2011.

Science and Engineering Indicators 2012

Figure 6-9
ICT share of fixed capital investment for selected countries: 2000–08



ICT = information and communications technology

SOURCE: Organisation for Economic Co-operation and Development, Statistics Portal, Productivity, http://www.oecd.org/topicstatsportal/0,3398,en_2825_30453906_1_1_1_1_1,00.html, accessed 15 February 2011.

Science and Engineering Indicators 2012

availability of public telephone lines, modest Internet usage and subscriber levels, and very low penetration of secure Internet servers.

Of the four large developing economies, Brazil ties with Russia as having the highest score in business infrastructure and with China for second in consumer infrastructure (table 6-2). Brazil's score in business infrastructure reflects higher penetration rates of secure Internet servers and personal computers. Brazil has the highest score in ICT government infrastructure.

Among the four large developing economies, Russia leads in consumer infrastructure, ties with Brazil in business infrastructure, and scores roughly the same as China in government infrastructure. Russia's relatively high score in consumer infrastructure reflects its levels of fixed and mobile telephone penetration and strong Internet and broadband subscription levels. Russia's business infrastructure score reflects a relatively high penetration of personal computers and telephones offset by low penetration of secure Internet servers and limited international Internet bandwidth.

Worldwide Distribution of Knowledge- and Technology-Intensive Industries

As national and regional economies change, the worldwide centers of KTI industries shift in importance. Shifts take place for this entire group of industries and for individual service and manufacturing industries within the group. This section will examine the positions of the United States and other major economies in KTI industries.

Table 6-2
Indexes for ICT infrastructure for selected countries, by economic sector: 2010

	ICT infrastructure index		
Country	Business	Consumer	Government
Developed countries			
United States	85	57	79
Australia	80	53	77
Canada	79	48	79
France	60	46	73
Germany	59	49	72
Japan	63	77	75
South Korea	57	96	88
Sweden	85	72	87
United Kingdom	74	50	71
Developing countries			
Brazil	50	64	85
China	23	69	48
India	6	24	39
Iran	17	53	32
Malaysia	60	77	78
Russia	52	93	51
Turkey	59	77	80
South Africa	56	52	74

ICT = information and communications technology

NOTES: Developed and developing countries have separate index scores. Country scores are benchmarked against the highest scoring developed and developing country. Scores are based on a variety of data and metrics. For more information on methodology and data sources, see http://www.connectivityscorecard.org/methodology/.

SOURCE: ICT Connectivity Scorecard 2010, http://www.connectivity scorecard.org/, accessed 15 February 2011.

Science and Engineering Indicators 2012

Health and Education Services

International comparison of the health and education sectors is complicated by variations in the size and distribution of each country's population, market structure, and the degree of government involvement and regulation. As a result, differences in market-generated value added may not accurately reflect differences in the relative value of these services.

The United States and the EU are the world's largest providers of education services, with world shares of 32% and 30%, respectively (table 6-1 and appendix table 6-4). Other large economies have comparatively small shares—Japan (7%); China (7%); and the Asia-8, a group of economies consisting of India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand (6%).

The U.S. global share of education services fell 4 percentage points from 36% to 32% during the first decade of the century, whereas the EU's share stayed roughly flat (30%) (table 6-1 and appendix table 6-4). Third-ranked Japan's share fell from 13% to 7% because of stagnant growth. China's global share of education services more than doubled from 3% to 7% to nearly equal Japan's share.

Patterns and trends in the health care sector are similar to those for education—domination of both sectors by the EU and the United States, declining global shares of production in the United States and Japan, and a growing share by China (table 6-1 and appendix table 6-5).

Commercial Knowledge-Intensive Service Industries

The United States has the largest commercial KI service industries—business, financial, and communications—with $3.6 trillion of value added in 2010 (figure 6-11 and appendix table 6-3). The EU was second at $2.9 trillion, trailed by Japan with $900 billion. China had the largest output among developing countries, nearly equal to Japan, with $700 billion. The Asia-8 region was in fifth place with $600 billion.

From 1995 to 2010, the value added of developing countries grew far faster than in the developed world (figure 6-12 and appendix table 6-3). The value added of developing countries more than quadrupled from $500 billion to $2.3 trillion, whereas value added of developed countries more than doubled from $3.9 trillion to $8.6 trillion. Two factors driving the growth of KI service industries in developing countries are the rapid advancement of living standards in these economies and the growth of international trade in these services. Although these industries remain largely based in developed economies, these factors are helping to build local capacity in the developing world.

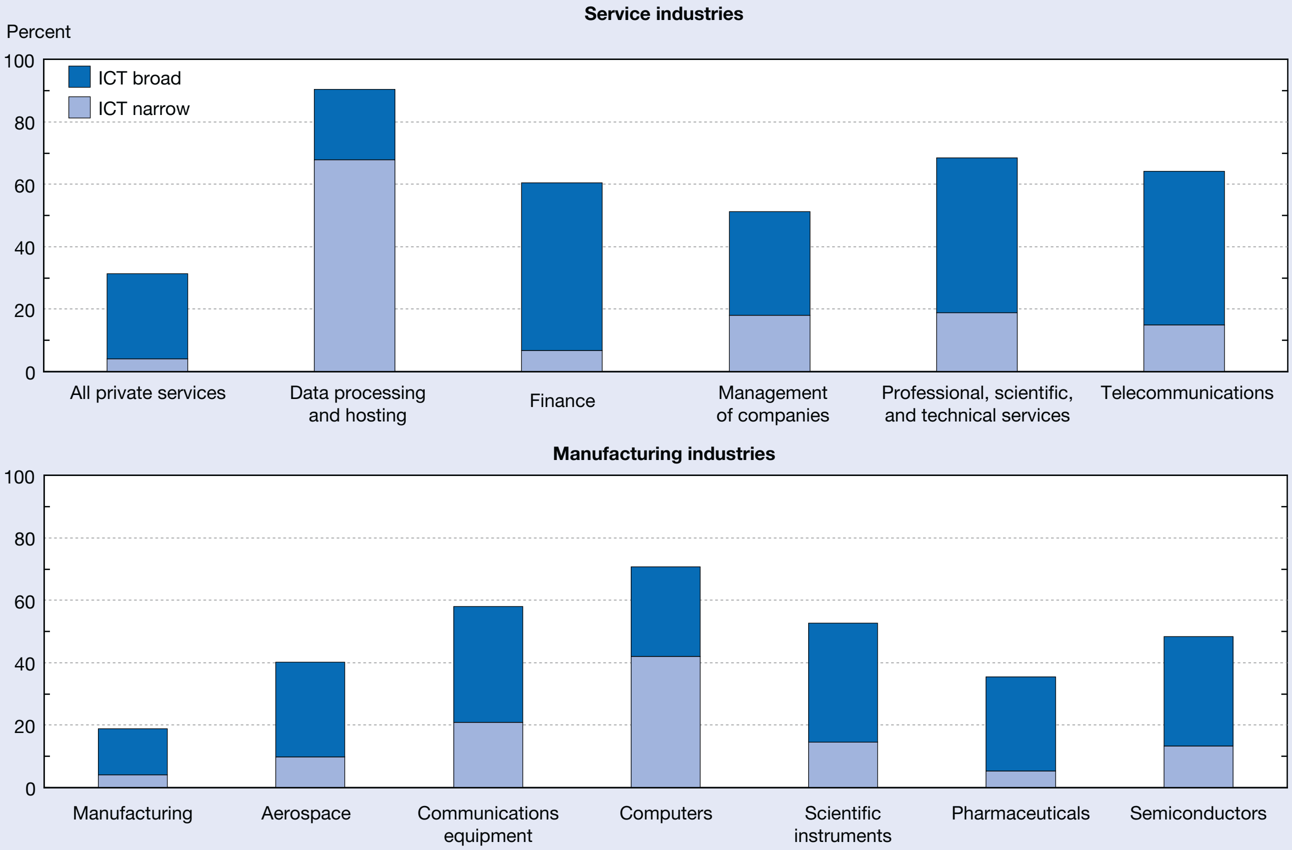
Faster growth of KI services industries in developing countries during the last 15 years resulted in their share of global output rising from 12% to 21% (appendix table 6-3). China's output rose sevenfold, tripling its world share from 2% to 6% (figure 6-11). Brazil, India, and Russia each reached shares of 2%–3%.

Rapidly rising output by China across all commercial KI service industries, combined with the declining Japanese share of worldwide production in these industries through 2007, has substantially altered the national distribution of these services within the Asian region.

Because of the worldwide recession, total global output of commercial KI service industries was stagnant in 2009, compared to 8% growth in 2008 (appendix table 6-3). But developed and developing countries were affected very differently. Output was flat in the developed countries (–0.1%), but it grew by 4% in developing countries (figure 6-13). As a result, a growing share of world output shifted to the developing world. Double-digit growth in China was largely responsible for the difference, but India also increased its output rapidly. The recovery in global output in 2010 (8%) was led by double-digit increases by most major developing economies, continuing the shift in global share from developed to the developing countries. Output of developed countries grew by 5%, with the United States and Japan growing at the same rate. The EU had stagnant growth.

The U.S. share of worldwide commercial KI services, which rose from 1995 to 2001 to reach a peak of 44%, dropped steadily thereafter to 33% in 2010 (figure 6-11 and

Figure 6-10
Share of U.S. workers with ICT skills, by selected industry: 2009



ICT = information and communications technology

NOTE: U.S. workers with ICT skills based on those with occupations that use narrow or broadly related ICT skills based on Organisation for Economic Co-operation and Development (OECD) methodology.

SOURCES: Bureau of Labor Statistics, Occupational Employment Statistics, http://www.bls.gov/oes/#data, accessed 15 October 2010; OECD, New Perspectives on ICT Skills and Employment (2005), http://www.oecd.org/dataoecd/ 26/35/34769393.pdf, accessed 15 October 2010.

Science and Engineering Indicators 2012

appendix table 6-3). The United States had a slight loss in its share of the commercial KI services market during the recent global recession. In 2009, however, U.S. commercial KI services outperformed other U.S. service industries, maintaining their production level while other private services experienced a 1% decline. U.S. commercial KI services grew by 5% in 2010, faster than other services (3%) in that year (figure 6-14).

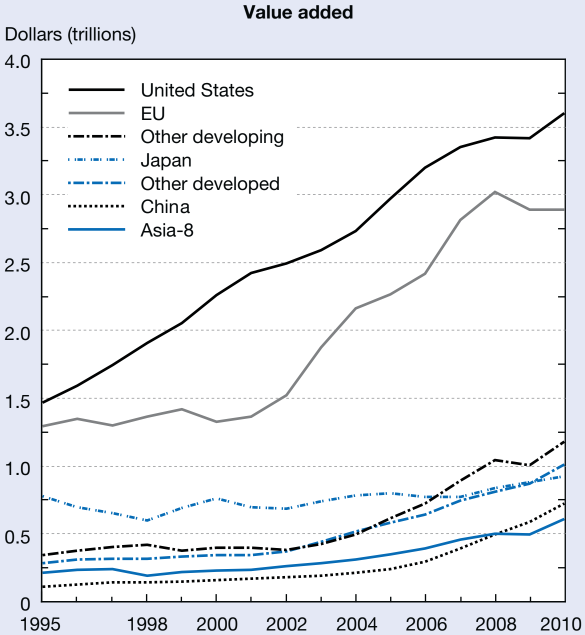
The EU's share of worldwide commercial KI services rose from 24% in 2000 to 30% in 2007–08 before dropping to 26% in 2010 (figure 6-11 and appendix table 6-3). Japan's world share dropped from 17% in 1995 to 8%–9% for the 2006–10 period. (Fluctuations in the shares of the United States, the EU, and Japan may in part reflect changes in the dollar/euro/yen exchange rates.)

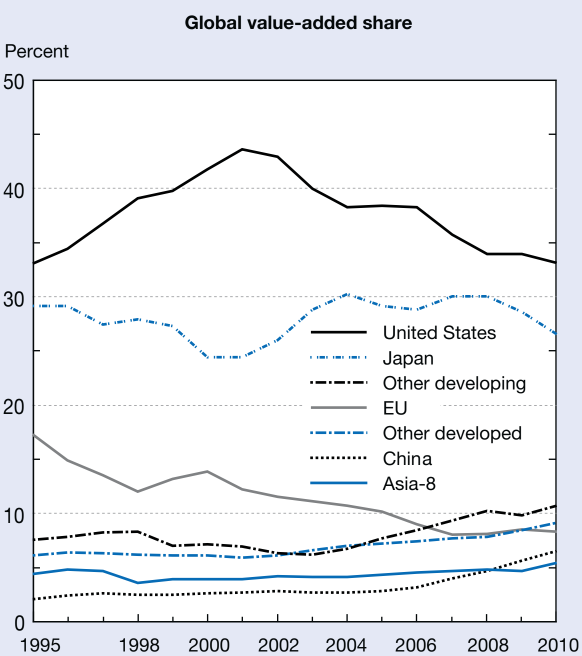
Trends in national and regional shares of production in individual commercial KI service industries sometimes varied substantially from the corresponding trends for the group as a whole:

- ♦ The U.S. share of the world's communications services declined continuously from 39% in the early 2000s to 26% in 2010 (figure 6-15 and appendix table 6-10).
- ♦ The EU's share remained roughly steady in business services and finance for the latter half of the 2000s before falling 2–3 percentage points in 2009–10 to reach 31% for business services and 22% for finance during the recession (appendix tables 6-6 and 6-9). The EU share in communications showed a more pronounced drop from 26% in 2004 to 19% in 2010 (figure 6-15 and appendix table 6-10).

Some large developing economies showed gains in some of these industries but from a low base. Brazil's share in finance rose from 2% to 3% between 2001 and 2010 (appendix table 6-9). Its share in communications more than doubled from 2% to 5% (appendix table 6-10). Russia's share in finance rose from less than 0.5% in 1995 to 2% in 2010. India's share in communications doubled from 1% in 1995 to 2% in 2010.

Figure 6-11
Value added of commercial KI services, by selected region/country: 1995–2010





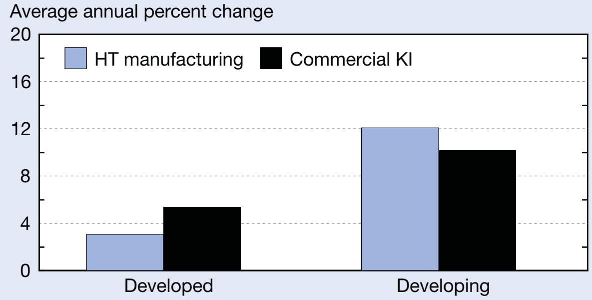
EU = European Union; KI = knowledge-intensive

NOTES: Output of knowledge- and technology-intensive industries on value-added basis. Value added is amount contributed by country, firm, or other entity to value of good or service and excludes purchases of domestic and imported materials and inputs. Commercial KI services are classified by the Organisation for Economic Co-operation and Development and include business, financial, and communications services. Asia-8 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia. China includes Hong Kong.

SOURCE: IHS Global Insight, World Industry Service database (2011). See appendix table 6-3.

Science and Engineering Indicators 2012

Figure 6-12
Growth of HT manufacturing and commercial KI industries for developed and developing countries: 1995–2010



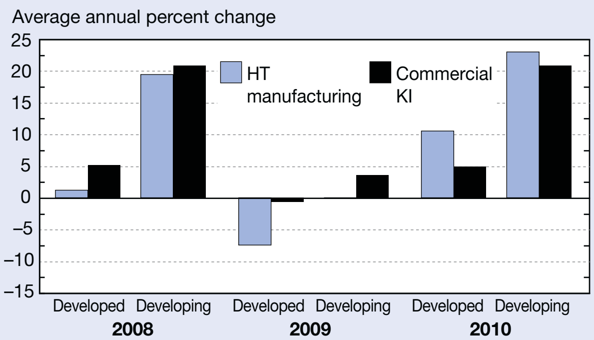
HT = high-technology; KI = knowledge-intensive; OECD = Organisation for Economic Co-operation and Development

NOTES: Output of commercial KI and HT manufacturing industries on value-added basis. Value added is amount contributed by country, firm, or other entity to value of good or service and excludes purchases of domestic and imported materials and inputs. Commercial KI services are classified by the OECD and include business, financial, and communications services. Public KI services include education and health. HT manufacturing industries are classified by the OECD and include aerospace, communications and semiconductors, computers and office machinery, pharmaceuticals, and scientific instruments and measuring equipment.

SOURCE: IHS Global Insight, World Industry Service database (2011). See appendix tables 6-3 and 6-11.

Science and Engineering Indicators 2012

Figure 6-13
Growth of HT manufacturing and commercial KI services for developed and developing countries: 2008–10



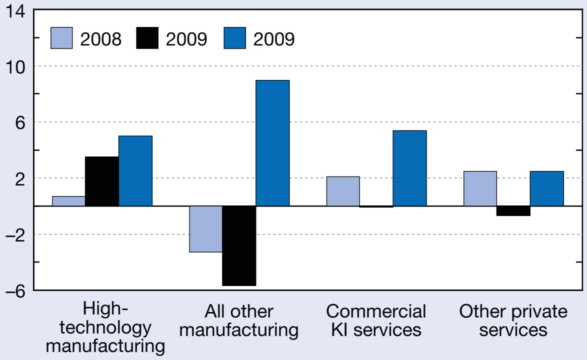
HT = high-technology; KI = knowledge-intensive; OECD = Organisation for Economic Co-operation and Development

NOTES: Output of commercial KI and HT manufacturing industries on value-added basis. Value added is amount contributed by country, firm, or other entity to value of good or service and excludes purchases of domestic and imported materials and inputs. Commercial KI services are classified by the OECD and include business, financial, and communications services. Public KI services include education and health. HT manufacturing industries are classified by the OECD and include aerospace, communications and semiconductors, computers and office machinery, pharmaceuticals, and scientific instruments and measuring equipment.

SOURCE: IHS Global Insight, World Industry Service database (2011). See appendix tables 6-3 and 6-11.

Science and Engineering Indicators 2012

Figure 6-14
Growth of selected U.S. industries: 2008–09



KI = knowledge-intensive; OECD = Organisation for Economic Co-operation and Development

NOTES: Output of commercial knowledge-intensive and high-technology manufacturing industries on value-added basis. Value added is amount contributed by country, firm, or other entity to value of good or service and excludes purchases of domestic and imported materials and inputs. Commercial knowledge-intensive services are classified by the OECD and include business, financial, and communications services. Public knowledge-intensive services include education and health. High-technology manufacturing industries are classified by the OECD and include aerospace, communications and semiconductors, computers and office machinery, pharmaceuticals, and scientific instruments and measuring equipment. Growth rate for commercial KI services in 2009 was –0.1 percent.

SOURCE: IHS Global Insight, World Industry Service database (2011). See appendix tables 6-3 and 6-11.

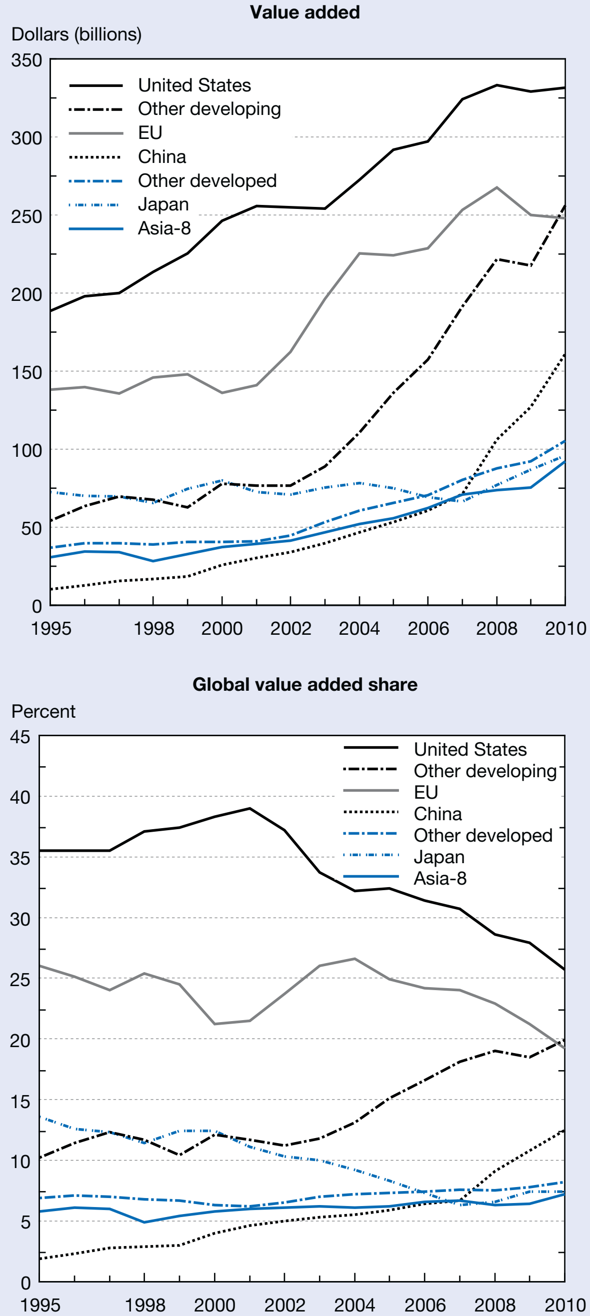
Science and Engineering Indicators 2012

High-Technology Manufacturing Industries

The United States has the world's largest set of HT manufacturing industries, with $390 billion of global value added in 2010 (figure 6-16 and appendix table 6-11). The EU and China are the second and third largest with about $270 billion and $260 billion, respectively, of global value added in 2010. The EU and China lead the world in apparent domestic consumption of HT goods with the United States close behind (see sidebar, "Apparent Consumption of High-Technology Manufactured Goods"). The Asia-8 and Japan each have HT manufacturing output of about $175 billion.

The dampening effects of the recessions in the early and late 2000s on these industries' output are clearly visible and remarkably similar. Overall worldwide output declined by about 13% from 2000 to 2001, from $850 to $740 billion (appendix table 6-11). Output slipped by 14% in the developed economies but maintained its volume in the developing world. From 2008 to 2009, total world HT manufacturing output declined by 6%. It dropped by 7% for developed economies, but stayed constant for the rest of the world (figure 6-13). Only China's output grew throughout the entire period (figure 6-16). World HT manufacturing output rebounded in 2010, growing at 13%, with developing countries averaging more than 20% growth in their output. Output of developed countries rose by 10%, led by a 30% increase in Japan's output.

Figure 6-15
Value added for communications services, by selected region/country: 1995–2010



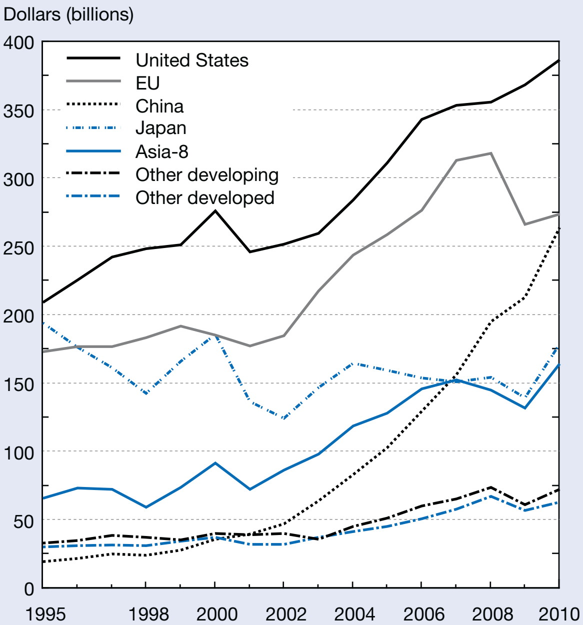
EU = European Union

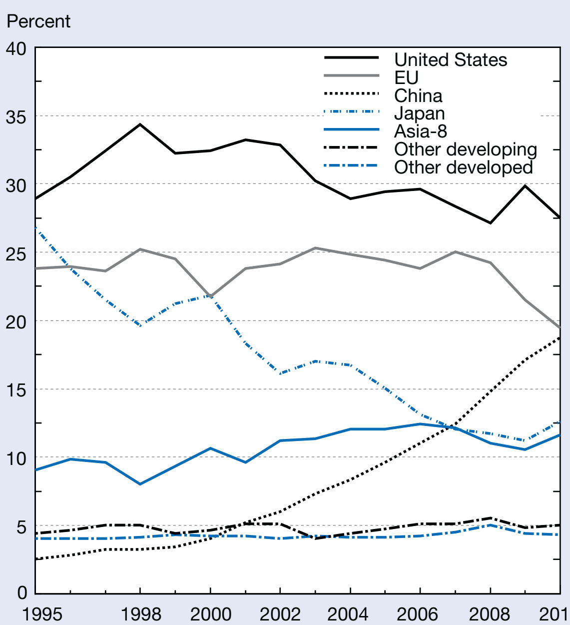
NOTES: Output on value-added basis. Value added is amount contributed by country, firm, or other entity to value of good or service and excludes purchases of domestic and imported materials and inputs. Asia-8 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia. China includes Hong Kong.

SOURCE: IHS Global Insight, World Industry Service database (2011). See appendix table 6-10.

Science and Engineering Indicators 2012

Figure 6-16
Value added of high-technology manufacturing industries, by selected region/country: 1995–2010





EU = European Union

NOTES: Output of high-technology manufacturing industries on value-added basis. Value added is amount contributed by country, firm, or other entity to value of good or service and excludes purchases of domestic and imported materials and inputs. High-technology manufacturing industries are classified by the Organisation for Economic Co-operation and Development and include aerospace, communications and semiconductors, computers and office machinery, pharmaceuticals, and scientific instruments and measuring equipment. Asia-8 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia. China includes Hong Kong.

SOURCE: IHS Global Insight, World Industry Service database (2011). See appendix table 6-11.

Science and Engineering Indicators 2012

Output of the United States and EU grew far more slowly, expanding by 5% and 3%, respectively. The relatively less severe effects of the two recessions on developing nations combined with China's rapid, uninterrupted growth to produce global share shifts: from 3% in 1995 to 19% in 2010 for China and from 9% in 1995 to 29% in 2010 for the developing world as a whole (figure 6-16 and appendix table 6-11). The U.S. share declined from 34% in 1998 to 28% in 2010, while the EU's share, long at 25%, dropped to 20% by 2010. Japan's share plummeted from 27% in 1995 to 11% in 2009 before rising to 13% in 2010.

The six HT manufacturing industries contribute uneven value-added amounts. The largest, pharmaceuticals, provided $346 billion, 25% of the global total in 2010. The others, in order, were semiconductors ($312 billion, 22%); scientific and measuring equipment, which includes medical and measuring equipment ($275 billion, 20%); communications equipment ($200 billion, 14%); aircraft and spacecraft ($137 billion; 10%); and computers ($127 billion, 9%) (appendix tables 6-16, 6-17, 6-18, 6-19, 6-20, 6-21, and 6-22). Size variations have not been stable over the 1995–2010 period, in part reflecting steep price declines for computers, semiconductors, and communications equipment.

The U.S. share of global value added was relatively stable in the aircraft and spacecraft, computer, and pharmaceutical industries between 1995 and 2010 (figures 6-17 and 6-18 and appendix tables 6-16, 6-21, and 6-22). The United States is the world's leading producer in aircraft and spacecraft (51% of global value added in 2010) and ties with the EU as the leading producer of pharmaceuticals. The U.S. share in scientific and measuring instruments rose modestly (from 31% to 35%), surpassing the EU in 2010 to become the world's largest producer (appendix table 6-18). The U.S. share fell in communications (from 26% to 20%), and semiconductors (from 25% to 19%) (appendix tables 6-17 and 6-20). Researchers and policymakers have concluded that the location of HT manufacturing and R&D activities overseas may also lead to the migration of higher value activities abroad.

China's communications and semiconductor industries grew more than fivefold over the decade, their world shares climbing from 5%–6% to 17% in semiconductors and 26% in communications equipment (figure 6-18 and appendix tables 6-17 and 6-20). China surpassed the United States and Japan to become the largest producer in communications and overtook the EU to become the third largest in semiconductors, narrowing its gap with the United States. China's rapid growth in these two industries owes much to the establishment in China of manufacturing operations of U.S., EU, and developed Asian-based companies, but Chinese-based companies in these industries are also emerging and successfully competing both domestically and globally. China's computer industry grew even faster than its communications and semiconductor industries, expanding from 4% to 47% of the world total (figure 6-18 and appendix table 6-22). China's dominant position in computer manufacturing has been largely due to its success as the low-cost assembly center of computer components primarily manufactured and designed

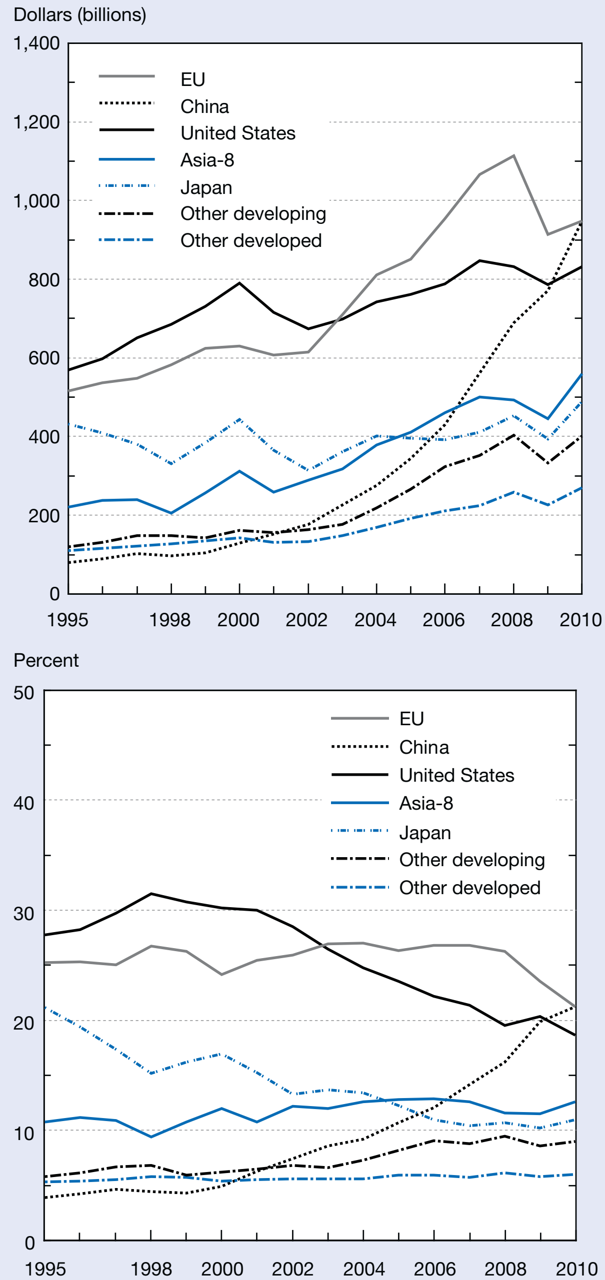
Apparent Consumption of High-Technology Manufactured Goods

Production of HT goods feeds both domestic and foreign markets. A broad measure of domestic use is provided by adding domestic sales to imports and subtracting exports. However, use so defined encompasses two types of economic activity, consumption of final goods and capital investment for further production (intermediate goods). Available data series do not permit the examination of these two types of activity separately.

Patterns of the world's use of HT manufactures have changed considerably over the past decade. The U.S. share of domestic use, as defined above, fell from 30% in 2000 to 19% in 2010 (figure 6-A). The EU's share stayed broadly the same at 26%–27% over much of the decade before falling to 21% in 2010. The EU overtook the United States in 2003 to become the leading consumer of HT goods between 2003 and 2009. China's share surged from 5% in 2000 to 21% in 2010, overtaking the United States and reaching the EU's level. Japan's share declined from 17% in 2000 to 11% in 2010.

The Chinese trend underscores the difficulty of teasing out final consumption from use as intermediate goods. The strong rise in the Chinese trend is considered by many observers to reflect the rising flow of intermediate goods—often previously produced in China—from other Asian manufacturing centers into China, where they undergo further assembly before being exported to final consumers.

Figure 6-A
Apparent domestic consumption of high-technology manufacturing industries, by selected region/country/economy: 1995–2010



EU = European Union

NOTES: Apparent consumption is sum of domestic production and inputs less exports. High-technology manufacturing industries are classified by the Organisation for Economic Co-operation and Development and include aerospace, communications and semiconductors, computers and office machinery, pharmaceuticals, and scientific instruments and measuring equipment. Asia-8 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia.

SOURCE: IHS Global Insight, World Industry Service database (2011).

Science and Engineering Indicators 2012

in other countries; acquisition of Western computer companies also played a role.[10] China's achievement of designing and building the world's fastest supercomputer—albeit as yet with largely foreign-designed input— indicates its drive to become a global competitor in a range of technologically sophisticated, high-value-added activities (see sidebar, "China's Progress in Supercomputers").

China's growth in other HT industries was also rapid—China more than tripled its world share in pharmaceuticals, scientific instruments, and aircraft and spacecraft (figure 6-17 and appendix tables 6-16, 6-18, and 6-21).

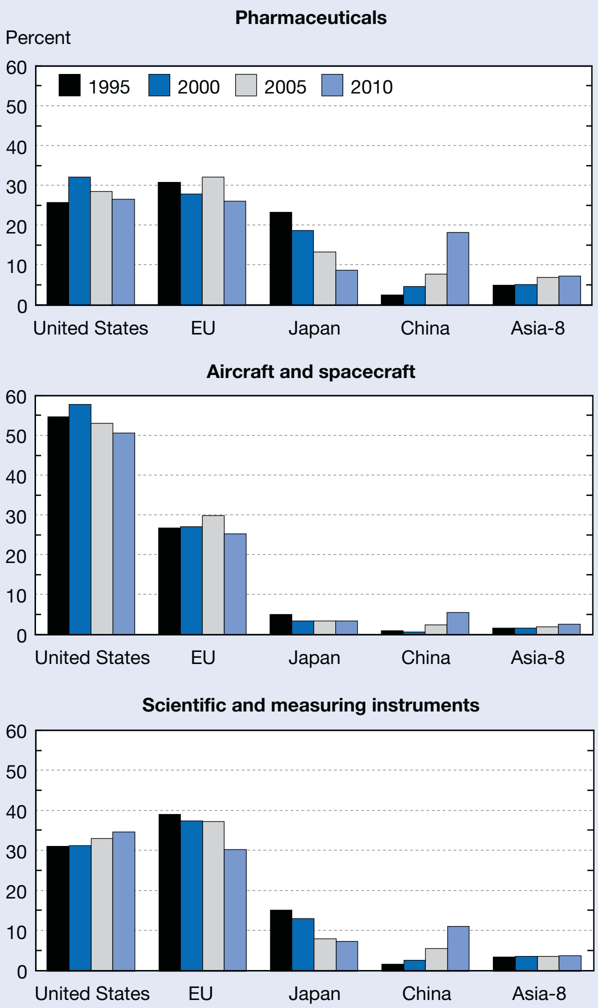
The EU's share stayed roughly stable over the decade in two industries: aircraft and spacecraft (25%) and pharmaceuticals (26%) (figure 6-17 and appendix tables 6-16 and 6-21). Its share fell in computers (from 16% to 8%), communications (from 13% to 9%), semiconductors (from 15% to 12%), and scientific instruments (from 38% to 30%) (figure 6-18 and appendix tables 6-17, 6-18, 6-20, and 6-22).

Japan's share loss, driven primarily by the communications, semiconductor, and computer and office machinery industries, also extended to pharmaceuticals and scientific instruments (figures 6-17 and 6-18 and appendix tables 6-16, 6-17, 6-18, 6-20, and 6-22). However, the decline of Japan's semiconductor industry was interrupted by very strong growth in 2010 that raised its world share from 18% in 2009 to 22% in 2010, resulting in a 7-percentage-point fall in its world share over the decade. This broad downward trend may reflect the Japanese economy's lengthy stagnation and the shift of production to China and other Asian economies.

The Asia-8 rapidly increased its global share in semiconductors from 20% to 26% over the decade, surpassing Japan and the United States to become the largest world producer in this industry (figure 6-18 and appendix table 6-17). The Asia-8's rapid rise was driven by Taiwan and South Korea, which together had a 20% global share. The success of South Korea and Taiwan in this industry reflects both the output of companies based in these locations and investments in manufacturing facilities by Intel and other multinational firms. Many Taiwanese firms have shifted production to mainland China, which may overstate China's global market share and understate Taiwan's.

The Asia-8 slightly increased its share in pharmaceuticals from 5% to 7%, with growth driven by activity in India

Figure 6-17
Value added for selected manufacturing industries, by global share of selected region/country/economy: 1995, 2000, 2005, and 2010



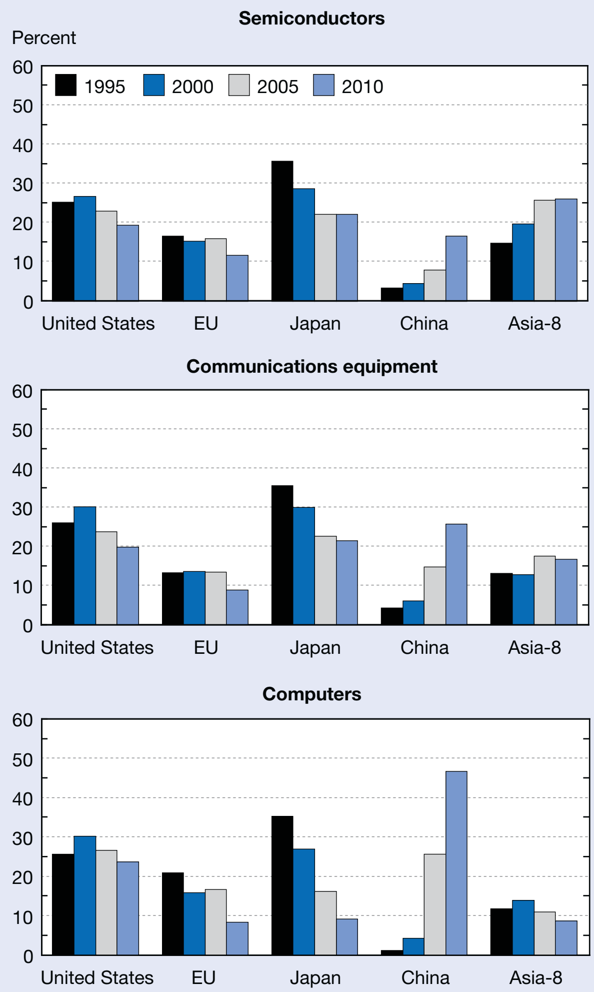
EU = European Union

NOTES: Output of industries on value-added basis. Value added is amount contributed by country, firm, or other entity to value of good or service and excludes purchases of domestic and imported materials and inputs. Asia-8 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia. China includes Hong Kong.

SOURCE: IHS Global Insight, World Industry Service database (2011). See appendix tables 6-16, 6-18, and 6-21.

Science and Engineering Indicators 2012

Figure 6-18
Value added for selected high-technology manufacturing industries, by global share of selected region/country/economy: 1995, 2000, 2005, and 2010



EU = European Union

NOTES: Output of industries on value-added basis. Value added is amount contributed by country, firm, or other entity to value of good or service and excludes purchases of domestic and imported materials and inputs. Asia-8 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia. China includes Hong Kong.

SOURCE: IHS Global Insight, World Industry Service database (2011). See appendix tables 6-17, 6-20, and 6-22.

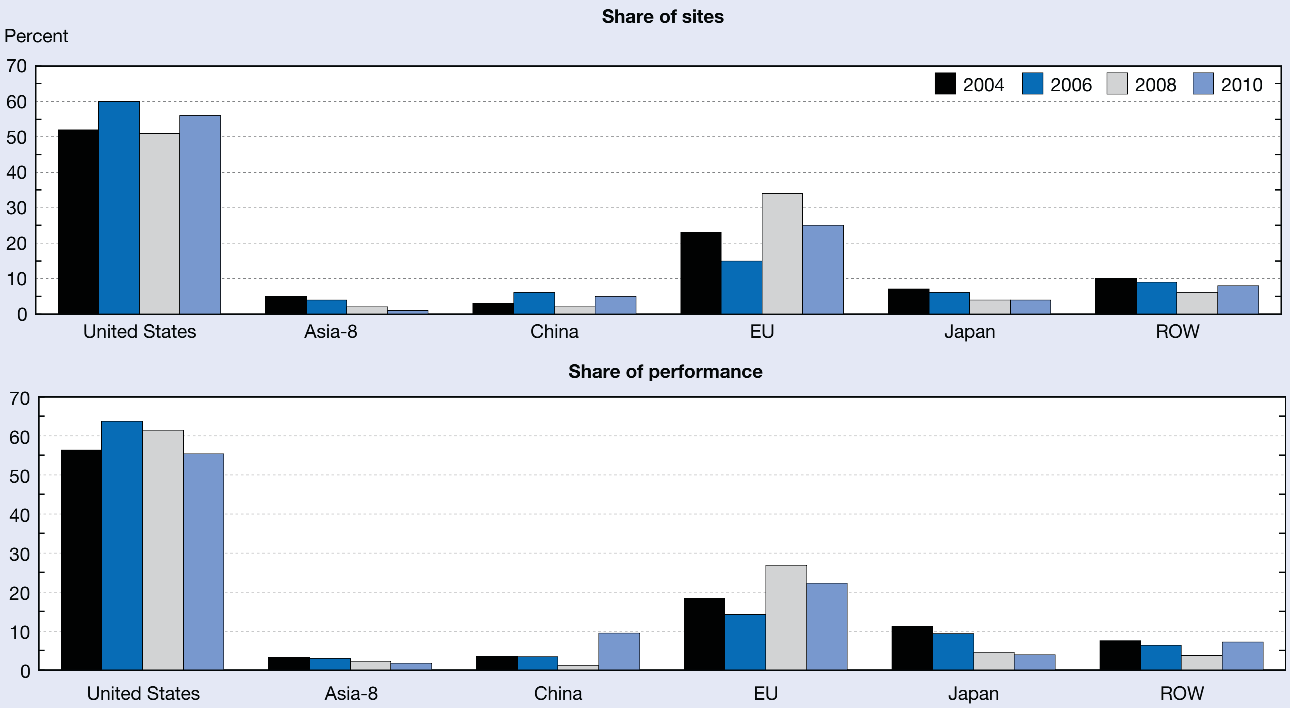
Science and Engineering Indicators 2012

China's Progress in Supercomputers

The TOP500, an organization composed of computer scientists and industry specialists, has been tracking the world's fastest performing supercomputers since 1993. It provides an annual update with information, including the origin, performance, type of application, and technology of high-performance supercomputers. According to the November 2010 report, China was ranked for the first time as having the world's fastest supercomputer at the National Supercomputing Center in Tianjin. The Tianjin supercomputer uses existing component technology from the United States and other countries with energy-saving technology developed in China.* A second Chinese supercomputer was ranked third, giving China 2 slots in the top 10 supercomputers. The United States was ranked second, and had 4 other supercomputers in the top 10. In 2005, TOP500 had ranked the United States first, and 6 other U.S. supercomputers were ranked in the top 10. China's highest ranking in that year was 26th. The United States continues to dominate in the number of supercomputers ranked in the top 500 and in the number of high-performance supercomputers. China's share of high-performance supercomputers has increased rapidly, from 1% in 2008 to 9% in 2010 (figure 6-B).

*See Ernst (2011) for information on China's Taijin supercomputer.

Figure 6-B
Top 500 supercomputers by selected region/country: Selected years, 2004–10



EU = European Union; ROW = rest of world

NOTES: Asia-8 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. Data on Philippines and Thailand are not available. EU includes Austria, Belgium, Cyprus, Czech Republic, Denmark, Finland, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Poland, Portugal, Slovenia, Spain, Sweden, and the United Kingdom. China includes Hong Kong.

SOURCE: Top 500 Supercomputer Sites, Statistics, http://www.top500.org/drilldown, accessed 15 March 2011.

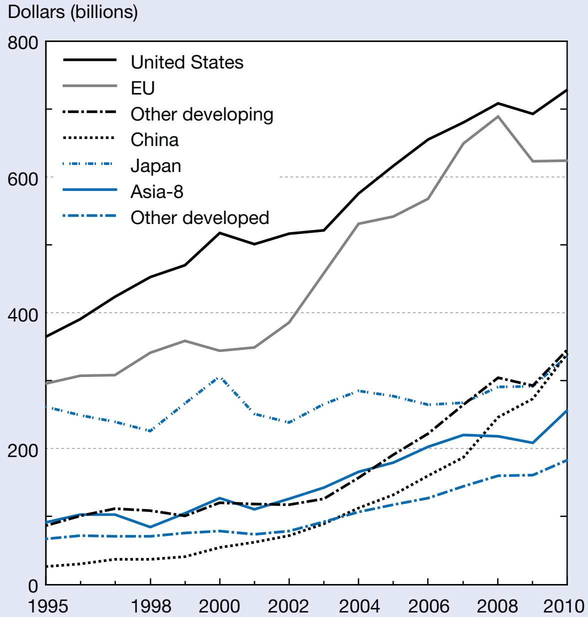
Science and Engineering Indicators 2012

and Singapore (figure 6-17 and appendix table 6-16). Indian firms have become significant world producers, particularly in generic drugs. In addition, U.S. firms and other multinationals have established a presence in India to access the growing consumer market and collaborate with India-based firms. Firms based in India and Singapore have also become contractors for manufacturing and clinical trials conducted by U.S. and EU-based firms.

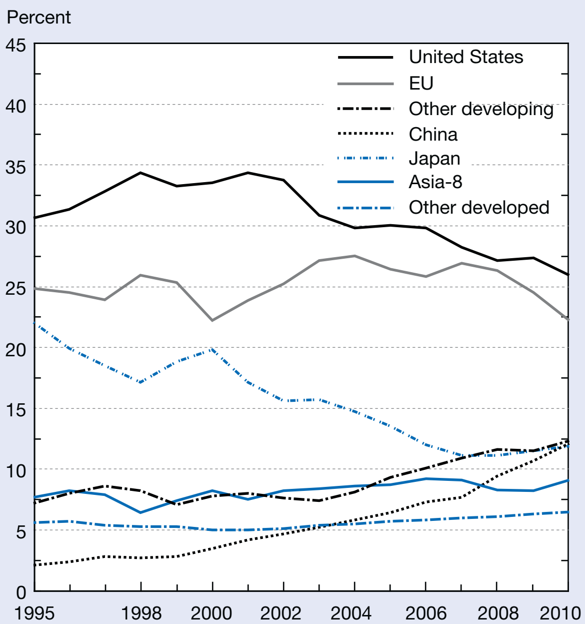
Information and Communications Technology Industries

In 2010, the United States had the largest ICT industry with $729 billion (26% global share), closely followed by the EU with $625 billion (22%) (figure 6-19 and appendix table 6-13). China and Japan, each with about $340 billion in value added, tied for third place, with 12% global shares.

Figure 6-19
Value added for ICT industries, by selected region/country/economy: 1995–2010



Global value-added share



EU = European Union; ICT = information and communications technology

NOTES: Output of ICT industries on value-added basis. Value added is amount contributed by country, firm, or other entity to value of good or service and excludes purchases of domestic and imported materials and inputs. ICT industries are classified by the Organisation for Economic Co-operation and Development and include communications and computer and data processing services and semiconductors and communications and computer manufacturing industries. Asia-8 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia. China includes Hong Kong.

SOURCE: IHS Global Insight, World Industry Service database (2011). See appendix table 6-13.

Science and Engineering Indicators 2012

The U.S. global share rose from 31% in 1995 to 34% in the early 2000s before falling steadily to reach 26% in 2010 (figure 6-19 and appendix table 6-13). The EU's share remained roughly stable at 26%–27% for much of the 2000s before falling to 22% in 2010. Japan's share fell steeply from 22% in 1995 to reach 11%–12% in the latter half of the 2000s, mirroring its downward trends in share in both HT manufacturing and commercial KI service industries. China's share rose by sixfold from 2% to 12% because of strong gains in its shares of both HT and KI industries. The Asia-8's share was roughly steady at 8% during this period. India's share rose from 0.5% to 1.5%; Brazil's and Russia's shares had similar trends.

Industries That Are Not Knowledge or Technology Intensive

Science and technology are used in many industries besides HT manufacturing and KI services. Services not classified as knowledge intensive may incorporate advanced technology in their services or in the delivery of their services, albeit at a lower intensity than the KI services discussed above. Manufacturing industries not classified as HT by the OECD may use advanced manufacturing techniques, incorporate technologically advanced inputs in manufacture, and/or perform or rely on R&D. Some industries not classified as either manufacturing or services also incorporate recent science and technology in their products and processes (see sidebar, "Trends in Industries Not Classified as Services or Manufacturing").

Non-Knowledge-Intensive Commercial Services

Commercial services not classified as KI include the wholesale and retail, restaurant and hotel, transportation and storage, and real estate industries. The United States and the EU are the two largest providers in the wholesale and retail industry—the largest of these industries ($7.0 trillion)—and in the real estate and restaurant and hotel industries (table 6-3). The EU is the largest provider in transportation and storage (27% share of global value added), leading the next two economies, the United States and China (14% share each of global value added), by a wide margin. Allowing for fluctuations, the U.S. and EU shares declined and the Asia-8's share remained stable or showed a slightly upward trend between 1995 and 2010. China showed rapid growth, with its shares of global value added at least tripling across all these industries. Japan's global shares fell significantly across all of these industries.

Non-High-Technology Manufacturing Industries

Non-HT manufacturing industries are divided into three categories, as classified by the OECD: medium-high technology, medium-low technology, and low technology. Medium-high technology includes motor vehicle manufacturing and chemicals production, excluding pharmaceuticals; medium-low technology includes rubber and plastic production and basic metals; and low technology includes paper and food product production.

Trends in Industries Not Classified as Services or Manufacturing

Agriculture, construction, mining, and utilities are not classified as either manufacturing or service industries and are not categorized by their level of technology or knowledge intensity. However, these industries depend on or use science and technology. For example, agriculture relies on breakthroughs in biotechnology, construction uses knowledge from materials science, mining depends on earth sciences, and utilities rely on advances in energy science.

The United States ranks second in construction, mining, and utilities, and third in agriculture as measured by share of global value added among the five major economies—United States, EU, Japan, China, and the Asia-8 (table 6-A). The U.S. share in construction fell from 29% in 2002 to 20% in 2008 and 16% in 2010, in part because of the recession and crisis in the housing sector. The U.S. share remained stable in agriculture and fell slightly in mining and utilities. The EU's share was steady in construction and utilities but fell substantially in mining and agriculture. Japan's share fell sharply in all of these industries. China had gains across all industries, and became the largest producer among the five economies in agriculture and mining. The Asia-8's shares were stable or grew slightly during the 2000s.

Table 6-A
Share of global value added for selected industries, by region/country/economy: Selected years, 1995–2010
(Percent distribution)

Industry and region/country/economy	1995	1999	2002	2005	2008	2010
Agriculture						
Global value added (current $billions)	1,108.1	1,034.4	1,043.6	1,385.3	2,052.6	2,359.0
All countries	100.0	100.0	100.0	100.0	100.0	100.0
United States	8.2	9.0	9.0	9.2	7.8	6.5
EU	22.0	19.5	17.7	16.4	14.1	10.7
Japan	9.3	7.9	6.5	5.0	3.4	3.3
China	13.1	17.3	19.2	19.8	23.6	26.3
Asia-8	18.8	18.7	17.9	18.7	19.0	21.2
ROW	28.6	27.6	29.7	30.9	32.1	32.0
Construction						
Global value added (current $billions)	1,641.6	1,627.8	1,680.3	2,352.2	3,174.0	3,100.1
All countries	100.0	100.0	100.0	100.0	100.0	100.0
United States	17.9	26.3	29.4	26.0	19.6	16.3
EU	29.7	27.7	28.1	31.2	32.3	27.2
Japan	26.5	20.6	16.1	12.3	9.1	10.1
China	3.1	4.4	5.0	5.6	8.7	13.8
Asia-8	7.4	5.7	5.9	7.1	7.8	9.6
ROW	15.4	15.3	15.5	17.8	22.5	23.0
Mining						
Global value added (current $billions)	494.1	481.7	657.0	1,388.9	2,497.9	2,358.4
All countries	100.0	100.0	100.0	100.0	100.0	100.0
United States	15.5	17.0	16.7	13.8	12.7	11.9
EU	14.6	12.4	10.6	7.7	6.5	5.0
Japan	1.8	1.2	0.7	0.3	0.1	0.1
China	4.4	6.0	6.1	7.8	11.2	14.5
Asia-8	7.4	7.3	7.1	6.1	5.7	7.4
ROW	56.3	56.1	58.8	64.3	63.8	61.1
Utilities						
Global value added (current $billions)	713.7	687.1	694.2	922.3	1,268.6	1,298.6
All countries	100.0	100.0	100.0	100.0	100.0	100.0
United States	24.6	25.1	26.1	22.3	20.7	21.2
EU	26.7	24.9	23.7	26.9	28.9	24.6
Japan	25.6	23.8	21.1	17.0	10.9	13.4
China	2.8	4.8	6.6	8.6	12.9	15.8
Asia-8	5.2	5.6	6.3	6.0	4.7	5.3
ROW	15.1	15.8	16.2	19.2	21.9	19.7

EU = European Union; ROW = rest of world

NOTES: Value added is amount contributed by country, firm, or other entity to value of good or service and excludes purchases of domestic and imported materials and inputs. Asia-8 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. China includes Hong Kong. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia. Percents may not add to 100% because of rounding.

SOURCE: IHS Global Insight, World Industry Service database (2011).

Science and Engineering Indicators 2012

The share trends in all of these industry segments are generally the same as for HT—share losses for the United States and the EU, larger share losses for Japan, stable or slight increases for the Asia-8, and strong share gains across all segments for China.

- **Medium-High-Technology Industries:** These industries produced $2.9 trillion in global value added in 2010. The U.S. share fell from 22% to 14% between 1995 and 2010 (table 6-4), and the EU's share fell from 34% to 24%. Japan's share fell from 24% to 13%. China's share grew more than eightfold from 3% to 26%, as it joined the EU as one of the two largest producers among these economies. The Asia-8's share rose slightly from 6% to 8%.
- **Medium-Low-Technology Industries:** The U.S. share of these industries ($3.0 trillion global value added) fell 1 percentage point between 1995 and 2010, to 18% in 2010 (table 6-4). The EU's share fell more steeply, from 31% to 23%. China's share rose nearly sevenfold, from 3% to 20%, making it the second-largest producer among these economies. Japan's share fell from 24% to 10%, its steepest loss among these three segments.
- **Low-Technology Industries:** These industries produced $1.2 trillion in global value added in 2010. The U.S. share fell from 25% in 1994 to 19% in 2010, and the EU's share was down more sharply, from 33% to 22% (table 6-4). China's share grew by ninefold, from 3% to 28%.

Table 6-3

Global value added for selected service industries, by region/country/economy: Selected years, 1995–2010

(Percent distribution)

Service industry and region/country/economy	1995	1997	1999	2001	2004	2006	2008	2010
Wholesale and retail								
Global value added (current $billions)	3,692.4	3,732.6	3,791.4	3,836.2	4,855.6	5,570.3	6,775.7	6,956.5
All countries/regions/economies	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
United States	26.7	29.9	32.5	34.3	30.5	29.5	24.5	24.7
EU	26.1	24.8	25.2	23.6	27.8	26.3	26.9	23.2
Japan	23.0	18.4	18.2	16.1	13.9	11.4	10.7	10.6
China	2.3	3.0	3.2	3.8	3.9	4.5	6.3	8.7
Asia-8	5.9	6.2	5.7	5.9	6.3	7.3	7.5	8.8
ROW	16.0	17.7	15.2	16.2	17.5	20.9	24.1	24.2
Real estate								
Global value added (current $billions)	2,592.6	2,625.7	2,770.6	2,899.1	3,745.9	4,217.9	5,165.1	5,094.3
All countries/regions/economies	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
United States	31.9	35.1	36.9	40.1	35.7	35.3	32.7	31.5
EU	31.5	30.0	29.3	26.9	33.1	33.1	34.4	31.0
Japan	21.9	17.7	18.0	16.7	14.8	12.3	11.6	13.4
China	1.4	1.7	1.8	2.2	2.5	3.2	4.2	6.7
Asia-8	3.3	3.7	3.1	3.2	3.2	3.6	3.5	3.8
ROW	10.0	11.8	10.9	10.9	10.8	12.4	13.5	13.6
Transport and storage								
Global value added (current $billions)	1,181.3	1,179.6	1,199.6	1,218.0	1,616.9	1,876.3	2,342.3	2,426.5
All countries/regions/economies	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
United States	16.5	18.7	20.3	20.7	17.7	17.4	14.8	14.1
EU	30.6	29.8	30.7	28.8	33.3	31.7	32.4	27.2
Japan	23.7	17.8	17.6	15.9	13.4	10.6	9.8	10.5
China	4.1	5.1	6.0	7.6	7.7	8.8	10.4	13.9
Asia-8	6.8	7.2	6.6	6.7	7.3	8.0	7.8	8.8
ROW	18.3	21.4	18.7	20.3	20.6	23.5	24.8	25.6
Restaurants and hotels								
Global value added (current $billions)	704.2	733.6	799.8	817.1	1,053.7	1,202.2	1,441.0	1,483.3
All countries/regions/economies	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
United States	26.9	30.1	33.1	36.3	32.6	32.0	27.8	27.6
EU	29.0	28.1	28.4	26.9	32.2	31.6	32.6	29.4
Japan	21.2	17.5	16.8	14.9	13.1	10.9	10.7	11.8
China	2.7	3.3	3.5	4.1	4.6	5.4	7.0	7.9
Asia-8	6.0	6.0	4.9	5.0	5.2	6.0	6.0	6.8
ROW	14.2	15.1	13.3	13.0	12.2	14.1	15.8	16.5

EU = European Union; ROW = rest of world

NOTES: Value added is amount contributed by country, firm, or other entity to value of good or service and excludes purchases of domestic and imported materials and inputs. Asia-8 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. China includes Hong Kong. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia. Percents may not add to 100% because of rounding.

SOURCE: IHS Global Insight, World Industry Service database (2011).

Science and Engineering Indicators 2012

Trade and Other Globalization Indicators

In the modern world economy, production is more often globalized (i.e., value is added to a product or service in more than one nation) and less often vertically integrated (i.e., conducted under the auspices of a single company and its subsidiaries) than in the past. These trends have affected all industries, but their impact has been particularly strong in many commercial KTI industries. The broader context is the rapid expansion of these industrial and service capabilities in many developing countries, both for export and internal consumption, accompanied by an increasing supply of skilled, internationally mobile workers. (See chapter 3 for a discussion on the migration of highly skilled labor).

This section will focus on international KI services and HT trade and U.S. trade of advanced technology products (ATP). (See "U.S. Trade in Advanced Technology Products" later in this chapter for a discussion of how the U.S. Census Bureau's product-based classification of advanced technology products differs from the OECD's industry-based classification of HT products.) It will also examine several globalization measures of U.S. multinationals in KTI industries.

Trade data are a useful though imperfect indicator of globalization. Trade data are classified by product or type of service, while corresponding production data are classified by industry (see sidebars "Industry and Trade Data and Terminology" and "Product Classification and Determination of Country of Origin of Trade Goods"). An export classified as a computer service may originate from a firm classified as a computer manufacturer. Trade data also cannot provide a precise measure of where value is added to a product or service. For example, China is credited with the full value (i.e., factory price plus shipping cost) even when exporting a smart phone that was assembled in China with inputs and components imported from other countries.

Table 6-4
Global value added for manufacturing industries, by selected technology level and region/country/economy: Selected years, 1995–2010
(Percent distribution)

Manufacturing technology level and region/country/economy	1995	1998	2000	2002	2004	2006	2008	2010
Medium high								
Global value added (current $billions)	1,526.9	1,431.8	1,459.6	1,452.9	1,820.9	2,114.5	2,653.2	2,897.1
All countries/regions/economies	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
United States	21.7	25.5	25.5	24.9	20.4	18.8	14.3	14.4
EU	33.7	35.0	30.1	32.2	34.9	32.7	31.6	24.2
Japan	23.6	18.4	20.8	17.4	16.7	14.4	12.5	12.5
China	2.8	3.6	4.6	6.2	8.2	12.2	18.9	26.0
Asia-8	5.8	4.4	6.0	6.3	6.7	7.3	7.0	8.1
ROW	12.3	13.0	13.1	13.0	13.0	14.5	15.6	14.7
Medium low								
Global value added (current $billions)	1,365.9	1,280.8	1,328.0	1,280.2	1,784.1	2,198.8	2,878.3	2,983.2
All countries/regions/economies	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
United States	19.4	22.8	24.5	25.3	22.4	21.7	18.4	17.6
EU	30.8	29.3	30.1	28.0	29.7	26.8	26.4	23.3
Japan	23.5	19.8	18.9	17.4	15.4	13.4	9.6	9.8
China	3.4	3.9	4.2	5.7	7.4	10.0	14.4	19.7
Asia-8	7.4	7.5	6.7	6.7	7.6	7.8	8.0	7.5
ROW	15.4	16.8	15.7	17.0	17.4	20.2	23.1	22.1
Low								
Global value added (current $billions)	815.6	741.3	759.7	725.0	864.8	968.2	1,160.3	1,221.1
All countries/regions/economies	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
United States	24.8	29.0	30.5	29.8	26.4	24.5	19.3	18.6
EU	32.5	33.0	28.3	30.1	31.9	29.1	28.6	22.4
Japan	16.7	12.0	12.7	9.8	8.8	6.5	6.1	5.9
China	3.3	4.3	5.1	6.8	9.1	14.2	20.6	27.7
Asia-8	7.7	5.6	7.0	7.2	6.6	6.9	6.2	6.7
ROW	15.0	16.1	16.4	16.3	17.2	18.8	19.2	18.8

EU = European Union; ROW = rest of world

NOTES: Value added is amount contributed by country, firm, or other entity to value of good or service and excludes purchases of domestic and imported materials and inputs. Technology level of manufacturing classified by Organisation for Economic Co-operation and Development on basis of R&D intensity of output. Asia-8 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. China includes Hong Kong. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia. Percents may not add to 100% because of rounding.

SOURCE: IHS Global Insight, World Industry Service database (2011).

Science and Engineering Indicators 2012

Countries whose firms provide these high-value components and services (design, marketing, software development, etc.) are not credited for their contributions (see sidebar, "Tracing the Geography of the Value Chain of Products").

This discussion of trade trends in KI services and HT manufactured products focuses on (1) the world's large, highly developed countries and regions—the United States, the EU, and Japan; (2) China, which is rapidly taking on an increasingly important role in KTI trade; and (3) the Asia-8, which generates a substantial and increasing trade volume within the group and maintains strong trade ties with China.

Both Europe and East Asia have substantial volumes of intraregional trade. This section treats trade within these two regions in different ways. Intra-EU exports are not counted because the EU is an integrated trading bloc with common external trade tariffs and few restrictions

Tracing the Geography of the Value Chain of Products

Several studies have attempted to estimate more precisely the geographic contribution of the global value chain involved in the production of several electronic goods. These studies essentially show that the largest returns accrue to the firms and countries that harbor special design, engineering, and marketing expertise. Because value-added data are not readily available at the product or firm level, these studies estimate the cost of direct labor, inputs, design, marketing, and distribution and retail (table 6-B).

A study of Apple's iPad estimates that the United States receives 33% of the retail price of the iPad, almost all of it (30%) consisting of Apple's gross profit (figure 6-C). The estimated share for manufacture and assembly of components for the iPad is 23%, largely apportioned to South Korea with smaller distributions to Japan, Taiwan, the EU, and the United States.

China, the location of final assembly, receives an estimated 2% share of the iPad's price (figure 6-C). The study estimates that China's value added is very small because final assembly of these products requires only a few minutes and China's wages for assembly workers are very low compared to those in more developed countries.

Because final assembly of the iPad and other electronic goods manufactured by foreign multinationals yields little value for China, observers claim that bilateral trade statistics are misleading. The large U.S. trade deficit with China in electronic goods is due in part to crediting China for the entire shipping cost of these goods, even though much of the value of these goods derives from imported parts and components from other Asian countries, the EU, and the United States.

A study by Xing (2010) estimates that crediting exports to countries on the basis of their value-added contribution would lower the value of China's exports of Apple iPhones to the United States in 2009 from an estimated $2 billion to less than $100 million. The remaining $1.9 billion would be credited to countries that supply components to China—South Korea, Japan, Germany, and others.

Table 6-B
Value chain of Apple iPad, by location and activity: 2010
(Percent)

Characteristic	Activity	Location	Amount/cost (dollars)	Share of retail price (%)
Distribution and retail	Manufacturer's suggested retail price	Worldwide	499	100.0
	Distribution	Worldwide	75	15.0
	Wholesale price (received by Apple)	United States	424	85.0
Value capture................	Total value capture		238	47.7
	U.S. total	United States	162	32.5
	Design/marketing	Apple	150	30.1
	Manufacturing of components	U.S. suppliers	12	2.4
	Manufacturing of components	Japan	7	1.4
	Manufacturing of components	South Korea	34	6.8
	Manufacturing of components	Taiwan	7	1.4
	Manufacturing of components	EU	1	0.2
	Manufacturing of components	Unidentified	27	5.4
Direct labor...................	Total direct labor		33	6.6
	Labor to manufacture components	Unidentified	25	5.0
	Labor for final assembly	China	8	1.6
Inputs............................	Nonlabor costs	Worldwide	154	30.9

EU = European Union

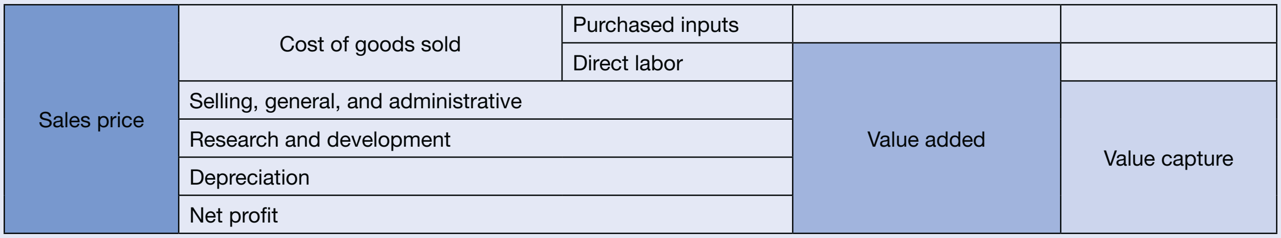
NOTES: iPad is configured with 16GB of memory and no cellular access. Value added is amount contributed by country, firm, or other entity to value of good or service and excludes purchases of domestic and imported materials and inputs. Value capture is value added excluding the cost of direct labor, which is the same as gross profit. Detail may not add to total due to rounding.

SOURCE: Linden G, Kraemer KL, Dedrick J. Who profits from innovation in global value chains? Estimates for the iPhone and iPad, Personal Computing Center, University of California–Irvine (2011), unpublished manuscript dated June 15.

Science and Engineering Indicators 2012

Tracing the Geography of the Value Chain of Products—continued

Figure 6-C
Components of value added and value capture



NOTES: Value added is amount contributed by country, firm, or other entity to value of good or service and excludes purchases of domestic and imported materials and inputs. Value capture is value added excluding the cost of direct labor.

SOURCE: Dedrick J, Kraemer KL, Linden G, Who Profits from Innovation in Global Value Chains? A Study of the iPod and notebook PCs, Personal Computing Industry Center, University of California–Irvine (2008), http://pcic.merage.uci.edu/index.htm, accessed 7 November 2009.

Science and Engineering Indicators 2012

on intra-EU trade. By the same token, HT trade between China and Hong Kong is excluded because it is essentially intra-country trade. Intra-Asian trade is counted because it allows the delineation of a developing Asia-8/China trade zone in the absence of the kind of formal structures that bind the EU together.

Global Trade in Commercial KTI Goods and Services

Exporting goods and services to other countries is one measure of a country's economic success in the global market—the goods and services it produces compete in a world market.

Global trade in commercial KTI goods and services consists of three services—business, communications, and finance—and six HT products—aerospace, communications, computers, pharmaceuticals, semiconductors, and scientific instruments.[11] The data on commercial KI service trade also include trade in royalties and fees, which do not correspond to a specific industry.

The value of commercial KTI exports has risen faster than their global production, resulting in an increase in the export share of production from 12% in 1995 to plateau at 15%–16% in the latter half of the 2000s (figure 6-20). The rise in export intensity indicates the growing importance of international suppliers involved in production of goods and provision of services. Data on multinational companies and cross-border investment likewise indicate growing interconnection among the world's economies.

The global value of commercial KTI exports increased from $1 trillion in 1995 to $3.5 trillion in 2008, then declined to a recession-induced $3.2 trillion in 2009 but rebounded to $3.6 trillion in 2010 (figure 6-20). This mirrored the trend in global output of commercial KTI industries during this period (figure 6-11 and appendix table 6-3). The decline of commercial KTI exports in 2009 was far sharper than in the recession in the early 2000s (figure 6-20).

The EU is the largest exporter of commercial KI goods and services, with $719 billion in 2009 (23% of global value) (figure 6-21). The Asia-8 closely follows with $683 billion. The United States is next largest with $564 billion (18% of global value), followed by China with $500 billion (16% of global value). Japan trails with $199 billion.

The U.S. global share fluctuated between 20% and 23% from 1995 to 2001 before declining to 17%–18% from 2002 to 2009 (figure 6-21). The EU and Asia-8's shares fluctuated between 20% and 23% for much of the period. China's share rose rapidly from 6% to 15% from 1995 to 2006, surpassing Japan in 2003, then rose more slowly to 16% from 2006 to 2009.

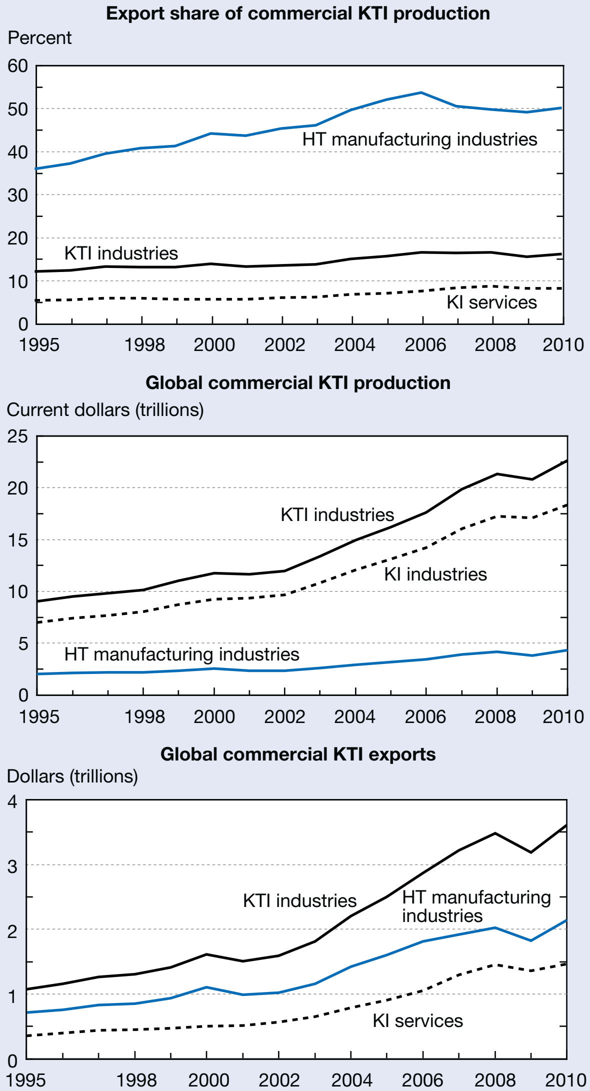
Commercial Knowledge-Intensive Services

Global exports of commercial KI services grew faster than global production of these services over the 15-year period from 1995 to 2010 (figure 6-20). The gradual rise in the export share of commercial KI production (from 5% to 8%) suggests a modest rate of globalization in these service industries, in contrast to the earlier and more rapid pace in HT manufacturing. Advances in ICT technologies and emerging capabilities in other developed and developing countries, such as India, are driving globalization of commercial KI services.

The EU is the largest exporter of commercial KI services with $409 billion in 2009 (30% of global value) (figure 6-22). The United States is the second-largest economy and single largest country exporter with $293 billion in 2009 (22% of global value). The Asia-8 is the third-largest exporter group with $204 billion (15% of global value), with India and Singapore being the major exporters in this region. China is the fourth-largest exporter with $110 billion, although its exports include trade between China and Hong Kong, which is likely substantial.[12] Japan is the fifth largest with $84 billion.

The dollar value of total global exports (excluding intra-EU) of commercial KI services rose almost fourfold over a decade and a half, from $360 billion in 1995 to $1.5 trillion

Figure 6-20
Global commercial KTI exports and production: 1995–2010



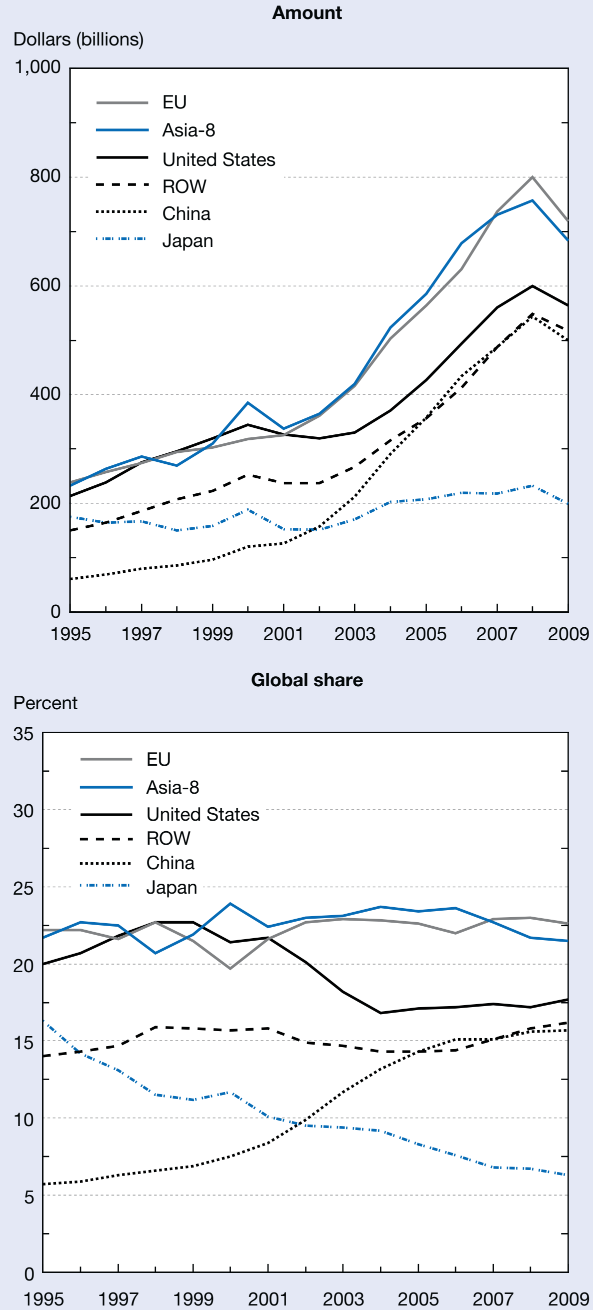
HT = high-technology; KI = knowledge-intensive; KTI = knowledge- and technology-intensive

NOTES: Production is gross revenue, which includes purchases of domestic and imported materials and inputs. KTI industries include knowledge-intensive services and high-technology manufacturing industries classified by Organisation for Economic Co-operation and Development. Knowledge-intensive services include business, financial, communications, education, and health. Commercial knowledge-intensive services include business, financial, and communications services. Public knowledge-intensive services include education and health. High-technology manufacturing industries include aerospace, communications and semiconductors, computers and office machinery, pharmaceuticals, and scientific instruments and measuring equipment. KTI trade consists of trade of four services (business, financial, computer and communications services, and royalties and fees) and five products (aerospace, communications and semiconductors, scientific instruments, computers, and pharmaceutical products). EU exports in KI services for 2010 is estimated.

SOURCES: IHS Global Insight, World Trade Service database (2010); World Trade Organisation, International trade and tariff data, http://www.wto.org/english/res_e/statis_e/statis_e.htm, accessed 15 November 2010.

Science and Engineering Indicators 2012

Figure 6-21
Global commercial KTI exports, by selected region/country/economy: 1995–2009



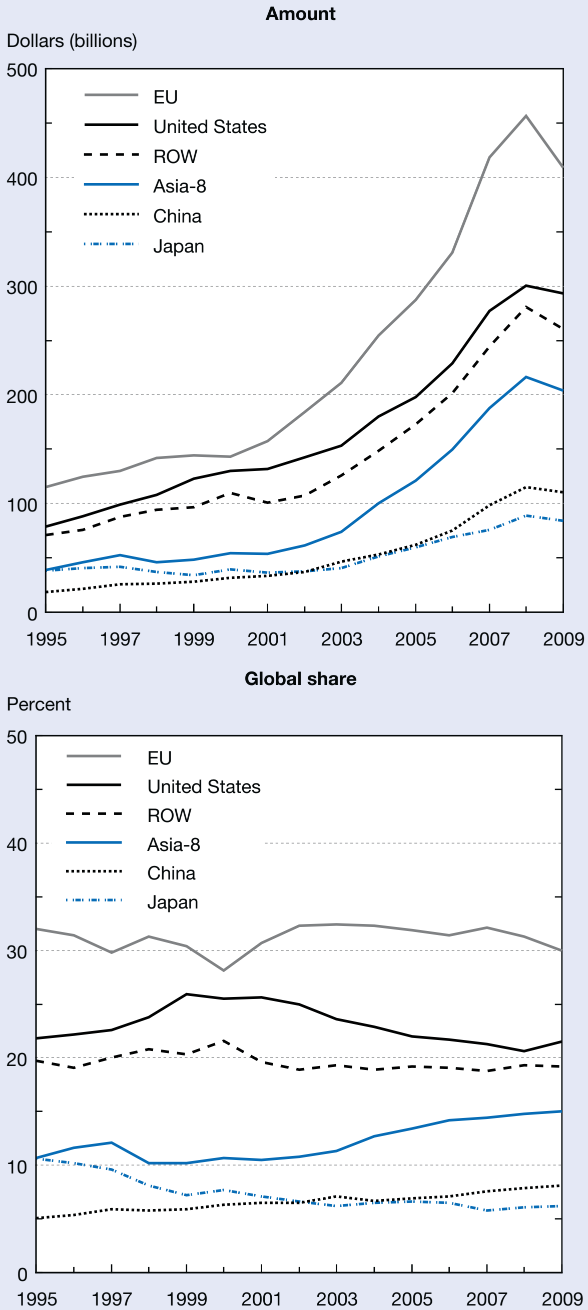
EU = European Union; KTI = knowledge- and technology-intensive; ROW = rest of world

NOTES: KTI trade consists of trade of four services (business, financial, computer and communications services, and royalties and fees) and five products (aerospace, communications and semiconductors, scientific instruments, computers, and pharmaceutical products). Asia-8 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. China includes Hong Kong. EU includes current member countries. Data for China and ROW not available for 2010.

SOURCES: IHS Global Insight, World Trade Service database (2010); World Trade Organisation, International trade and tariff data, http://www.wto.org/english/res_e/statis_e/statis_e.htm, accessed 15 November 2010.

Science and Engineering Indicators 2012

Figure 6-22
Exports of commercial knowledge-intensive services, by selected region/country/economy: 1995–2009



EU = European Union; ROW = rest of world

NOTES: Commercial knowledge-intensive trade consists of trade in business, financial, computer and communications services, and royalties and licensing fees. Asia-8 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. China includes Hong Kong and trade between China and Hong Kong. EU includes current member countries. China and ROW not available for 2010.

SOURCE: World Trade Organisation, International trade and tariff data, http://www.wto.org/english/res_e/statis_e/statis_e.htm, accessed 15 November 2010.

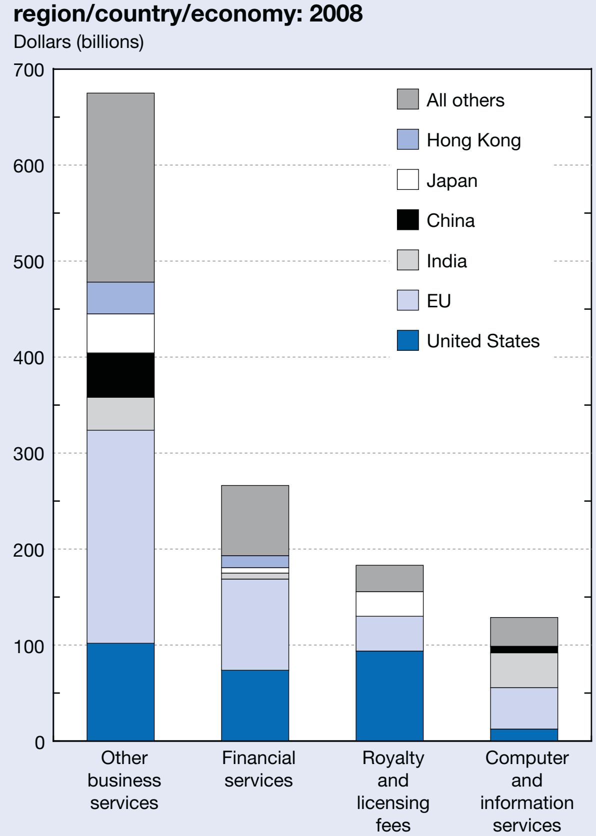
Science and Engineering Indicators 2012

in 2008, before declining to $1.4 trillion in 2009, in contrast to the flattening of output during the earlier recession (figure 6-20). Global exports resumed growth in 2010, returning to their 2008 level ($1.5 trillion).

The U.S. and EU global shares fluctuated at 22%–26% and 29%–31%, respectively, over the period (figure 6-22). The Asia-8's share rose from 11% to 15%, led by India and Singapore. China's share nearly doubled from 5% to 8%, surpassing Japan in 2007. Japan's share declined from 11% to 6% during this period.

Commercial KI service exports comprise four categories: business services (including legal, management, advertising, R&D, and engineering services), valued at $675 billion; financial services (banking and insurance), valued at $267 billion; royalties and licensing fees, valued at $183 billion; and computer and information services, valued at $129 billion (figure 6-23).[13]

Figure 6-23
Global exports of selected services, by selected region/country/economy: 2008



EU = European Union

NOTES: EU includes current member countries. Royalty and licensing fees data not available for China and India. Financial services data not available for China.

SOURCE: World Trade Organisation, International trade and tariff data, http://www.wto.org/english/res_e/statis_e/statis_e.htm, accessed 15 November 2010.

Science and Engineering Indicators 2012

The EU is the largest world exporter of business services with value added of $222 billion in 2008 (33% of global value) (figure 6-23). The United States is the second largest with $102 billion (15% of global value added), far below the EU's level. China (including Hong Kong) is slightly below the United States with $79 billion (12% of global value added).

The EU is the largest exporter of financial services with $95 billion in 2008 (36% of global value added), closely followed by the United States with $63 billion (28% of global value added) (figure 6-23). Data on China, Japan and the Asia-8 economies show much lower levels of financial services exports.

The United States is the world's largest exporter in royalties and licensing fees with $102 billion (51% of global value) (figure 6-23). The EU and Japan are the second and third largest with $36 billion and $26 billion, respectively. These three economies collectively account for 85% of global value of these exports.

The EU is the largest exporter of communications and information services with $43 billion (33% of global value) (figure 6-23). India is the second-largest exporter with $36 billion (28% of global value), reflecting its strong position in providing these services for companies based in the United States, EU, and other developed countries. The United States is the third largest with $13 billion (10% of global value).

Trade Balance Trends in Commercial Knowledge-Intensive Services

The EU and the United States have enjoyed substantial and rising positive balances in their trade of commercial KI services, particularly over the last decade (figure 6-24). Both exceeded $80 billion in 2009, even as the EU's surplus dropped steeply and the U.S. surplus flattened as a result of the 2008–09 recession. The U.S. surplus rose from $55 billion in 2000 to more than $100 billion in 2007–09, even as the U.S. trade deficit in HT goods deepened during the same period.

The United States has substantial surpluses in royalties and fees ($68 billion) and other business services ($36 billion). It has small deficits in financial services and computer and information services ($2–$3 billion). The composition of the EU's surplus is similar to that of the United States.

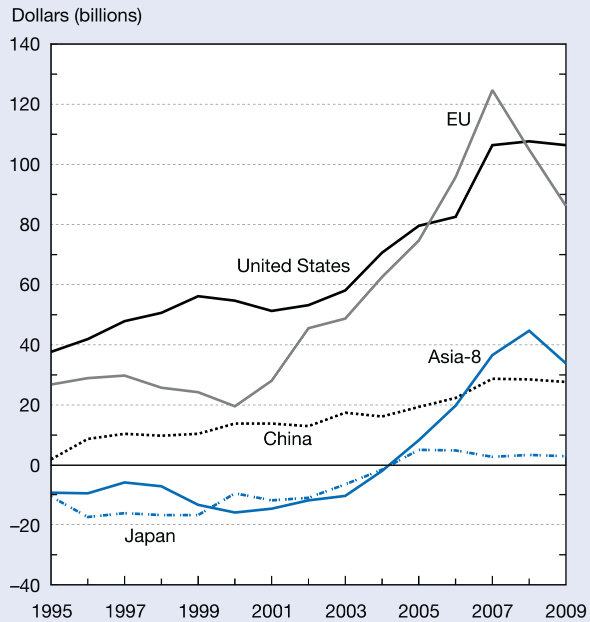
China had a surplus of $28 billion in 2009, up from the $13–$16 billion surplus it had run in the early 2000s (figure 6-24). The Asia-8 as a group had a surplus of $34 billion in 2009 with India having a $32 billion surplus, the largest among these economies (figure 6-24). The rise in India's surplus was driven by its substantial rise in computer and information services. Brazil and Russia have deficits in their KI services trade, ranging up to $29 billion for Russia.

High-Technology Goods

The global production of HT manufacturing industries more than doubled from $2.0 trillion to $4.3 trillion over the last 15 years. The value of HT export goods grew faster than global production, suggesting that globalization has continued in these already highly competitive and geographically dispersed industries. The export share rose from 36% to 53% in 2006 before drifting downward to 50% in 2010 (figure 6-20).

The HT export shares of the major economies—i.e., the percentage of total production that is exported—vary widely, with the shares of the United States and EU and Japan considerably lower than those of China and the Asia-8, the largest global exporters (figure 6-25). The export shares of the United States and the EU each rose about 15 percentage points between 1995 and 2010 to reach 43% in the United States and 38% in the EU. Japan's share stayed roughly stable at 29%. The Asia-8's export share fluctuated between 80% and 90% of their total production. China's export share rose from 63% to 71% from 1995 to 2004 before falling sharply to 43% in 2010, helping to account for the slight decline in the proportion of global HT production that was exported. The decline in China's export share could be a result of growing domestic consumption of these goods, higher labor costs in China that have prompted some relocation of manufacturing facilities to other countries, and higher shipping costs. Conversely, it may reflect the impact of the global recession that caused a sharper decline in China's exports than in production in 2009.

Figure 6-24
Trade balance in commercial KI services for selected region/country/economy: 1995–2009



EU = European Union; KI = knowledge-intensive

NOTES: Commercial knowledge-intensive trade consists of trade in business, financial, computer and communications services, and royalties and licensing fees. Asia-8 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. China includes Hong Kong. EU includes current member countries. Data for China not available for 2010.

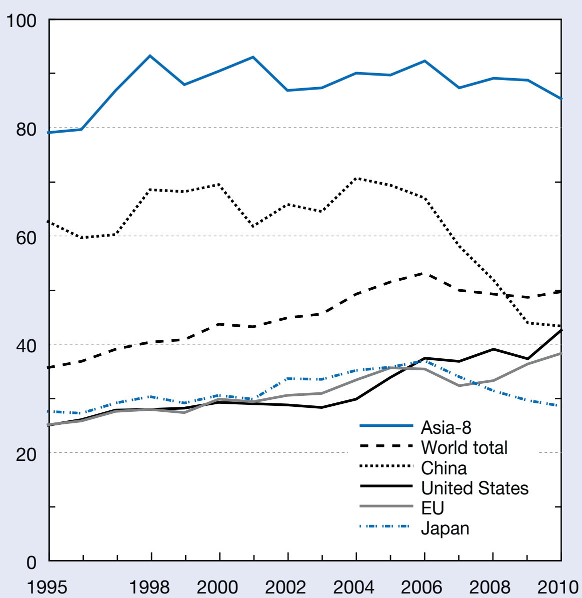
SOURCE: World Trade Organisation, International trade and tariff data, http://www.wto.org/english/res_e/statis_e/statis_e.htm, accessed 15 November 2010.

Science and Engineering Indicators 2012

Global exports of HT goods in 2010 were $2.1 trillion, including a combined $1.1 trillion exported by China and the Asia-8 and a collective $800 billion exported by the United States, the EU, and Japan (figure 6-26 and appendix table 6-24). Global HT exports comprised nearly one-fifth of the $11 trillion in exports of all manufactured goods (appendix table 6-25). The largest single exporter in HT manufacturing is the Asia-8 group with $570 billion (27% of global value) (figure 6-26). The second-largest exporter is China with $476 billion (22% of global value). The United States and EU follow China with exports of around $330 billion each (16% of global value). Japan was fifth with exports of $140 billion.

The value of global exports rose from $700 billion in 1995 to $2.0 trillion in 2008 before falling sharply in 2009 to $1.8 trillion, coinciding with the contraction of global HT manufacturing output during the recession (figures 6-16 and

Figure 6-25
Export share of high-technology manufacturing production, by selected region/country/economy: 1995–2010



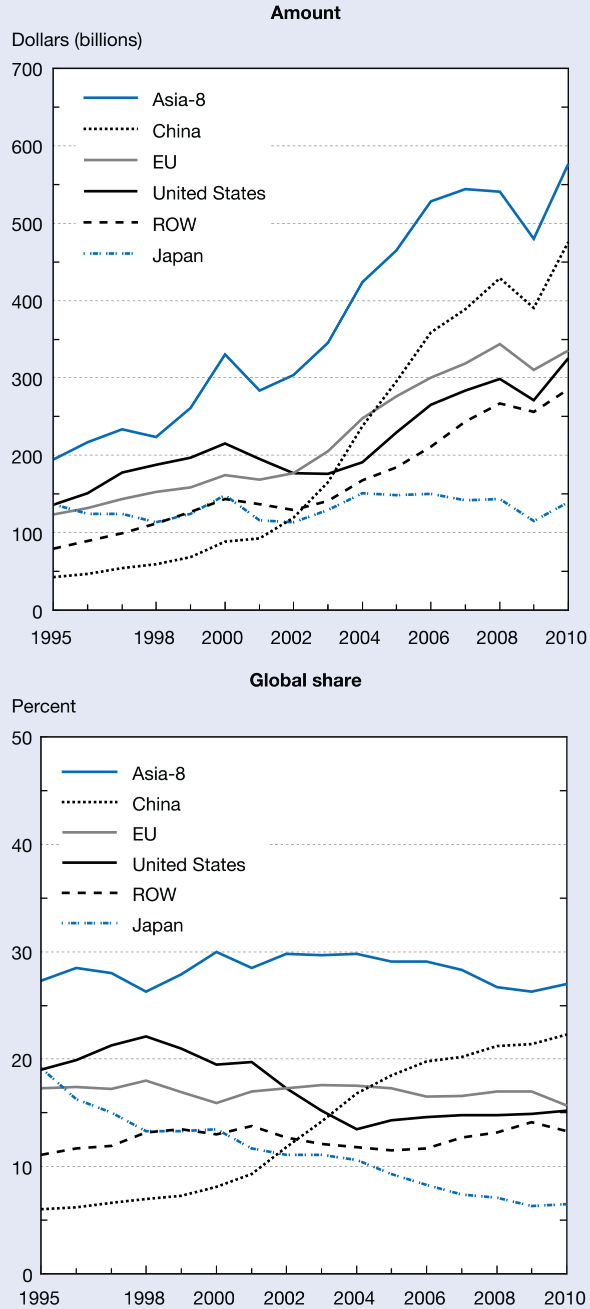
EU = European Union

NOTES: Production is gross revenue, which includes purchases of domestic and imported materials and inputs. High-technology manufacturing industries are classified by the Organisation for Economic Co-operation and Development and include aerospace, communications and semiconductors, computers and office machinery, pharmaceuticals, and scientific instruments and measuring equipment. High-technology exports are on a product basis, and include exports of aerospace, communications and semiconductors, computers and office machinery, pharmaceuticals, and scientific instruments and measuring equipment. Asia-8 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. China includes Hong Kong. EU includes current member countries.

SOURCE: IHS Global Insight, World Trade Service database (2011).

Science and Engineering Indicators 2012

Figure 6-26
Exports of high-technology goods, by selected region/country/economy: 1995–2010



EU = European Union; ROW = rest of world

NOTES: High-technology products include aerospace, communications and semiconductors, computers and office machinery, pharmaceuticals, and scientific instruments and measuring equipment. Asia-8 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. China includes Hong Kong. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia.

SOURCE: IHS Global Insight, World Trade Service database (2011). See appendix tables 6-24 and 6-32.

Science and Engineering Indicators 2012

6-26 and appendix table 6-24). Global exports sharply rebounded in 2010 to reach $2.1 trillion, slightly greater than their 2008 levels.[14]

The U.S. share of global HT manufacturing exports rose from 19% to 22% from 1995 to 1998 before declining to a range of 13%–15% from 2003 to 2010 (figure 6-26 and appendix table 6-24). China's share nearly quadrupled from 6% to 22%. The Asia 8's global share fluctuated between 27% and 30% from 1995 to 2010. Japan's share fell sharply from 19% to 7% over the 15-year period.

Among the six HT products, ICT products account for $1.3 trillion (61%) of the $2.1 trillion in global exports. These include communications ($505 billion), semiconductors ($422 billion), and computers ($385 billion) (appendix tables 6-26, 6-27, and 6-28). The others are, in decreasing order: scientific and measuring instruments ($361 billion), pharmaceuticals ($286 billion), and aerospace ($176 billion) (table 6-5 and appendix tables 6-29, 6-30, and 6-31).

The U.S. global export share in computers declined substantially, driving the loss in the U.S. overall ICT export share (table 6-5 and appendix tables 6-26, 6-27, and 6-28). The U.S. share was down by about half, reaching a level of 11%. The United States had a more modest decline in communications (from 13% to 11%) and semiconductors (from 15% to 11%). The EU had comparatively greater declines in communications and semiconductors and a smaller decline in computers. Japan had steep losses across all three goods categories.

China's share rose sharply in communications and computers, becoming the world's largest exporter in these two goods (table 6-5 and appendix tables 6-26 and 6-28). China's share increased from 10% to 39% in communications and from 6% to 45% in computers. China's rise in semiconductors was more modest, increasing from 4% to 10% (appendix table 6-27). The Asia-8's share in communications fluctuated between 24% and 29% and was down in computers (from 39% to 27%). The Asia-8's share in semiconductors rose from 40% to 59%, driven by rapid gains in South Korea and Taiwan. The Asia-8's sizeable export share in ICT goods reflects its role as a manufacturing supplier zone for ICT goods assembled in China.

The U.S. share in scientific and measuring instruments fell slightly from 22% to 19% (table 6-5 and appendix table 6-29). The EU's share also fell slightly, declining from 20% to 18%. Japan's share was down by half from 23% to 12%. The Asia-8 region's share more than doubled from 10% to 22%. China's share rose sharply from 8% to 14%.

The U.S. share in pharmaceutical exports was stable at 16% between 1995 and 2010 (table 6-5 and appendix table 6-30). The EU's share declined from 48% to 44%. China's share was stable at 4%. The Asia-8's share rose from 4% to 6%, driven by gains in India and Singapore.

The United States maintained a dominant position in aerospace exports, with its share rising from 40% in 1995 to 48% in 2005 before dropping to 44% in 2010 (table 6-5 and appendix table 6-31). The EU's share dropped from 40% to 31%.

Trade Balance Trends in High-Technology Goods

The United States had a trade surplus in HT manufactured products throughout the 1980s and early 1990s, in contrast to deficits for other U.S. manufacturing products.[15] Growing U.S. imports in the late 1990s shifted the U.S.

Table 6-5
Exports of high-technology products, by selected product and region/country/economy: Selected years, 1995–2010

Export	1995	2000	2005	2010
Communications				
World ($billions)	150.5	225.2	394.9	506.9
United States	13.4	13.1	7.1	9.1
EU	16.1	17.2	15.4	9.2
Japan	19.7	13.7	9.5	6.6
China	10.2	12.9	28.1	38.5
Asia-8	29.1	24.5	26.6	23.8
Semiconductors				
World ($billions)	163.5	274.0	327.9	421.8
United States	15.2	17.4	13.2	11.2
EU	9.2	9.1	7.0	4.4
Japan	26.5	16.5	12.6	10.7
China	3.8	4.0	7.2	10.2
Asia-8	39.9	46.0	55.6	58.7
Computers				
World ($billions)	185.7	300.6	380.8	385.1
United States	19.2	15.3	9.7	10.0
EU	9.1	8.7	8.8	6.6
Japan	20.1	12.8	7.0	2.4
China	5.8	10.9	34.5	45.4
Asia-8	39.1	44.1	34.1	27.2
Scientific instruments				
World ($billions)	106.8	150.9	236.0	361.4
United States	22.4	26.0	19.7	19.1
EU	20.0	19.3	21.4	17.6
Japan	22.7	19.8	15.6	11.6
China	8.1	9.0	10.6	13.9
Asia-8	9.5	8.7	16.0	22.0
Pharmaceuticals				
World ($billions)	44.1	69.3	156.8	285.6
United States	14.6	18.6	16.4	15.6
EU	47.6	47.5	50.3	44.0
Japan	4.3	4.4	2.9	2.3
China	3.5	2.7	2.5	3.9
Asia-8	3.5	3.7	4.5	6.4
Aerospace				
World ($billions)	62.4	81.9	101.9	176.5
United States	39.5	48.7	48.2	44.9
EU	39.9	27.7	29.2	31.2
Japan	1.0	1.9	1.6	1.7
China	0.4	0.4	0.5	0.8
Asia-8	2.3	1.5	2.1	3.3

EU = European Union

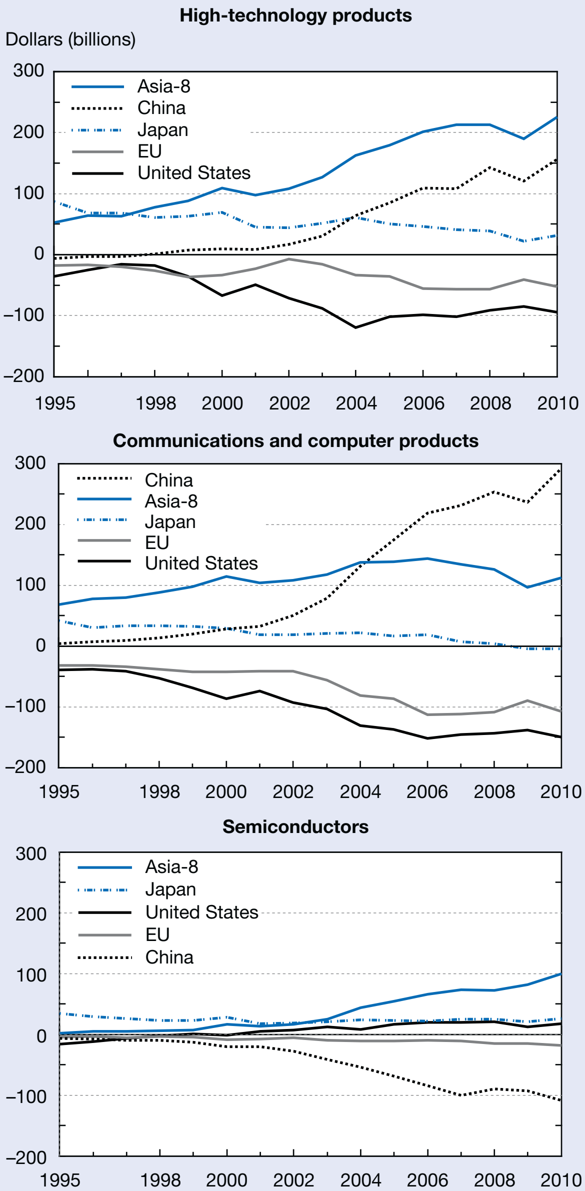
NOTES: Asia-8 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. China includes Hong Kong. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia.

SOURCE: IHS Global Insight, World Trade Service database (2011). See appendix tables 6-26–6-31.

Science and Engineering Indicators 2012

balance into a $67 billion deficit by 2000. After reaching a level of $100–120 billion in 2004–07 prior to the recession, the deficit dropped to $90 billion by 2010 (figure 6-27 and appendix table 6-24).

Figure 6-27
Trade balance of high-technology products, by selected product and region/country/economy: 1995–2010



EU = European Union

NOTES: High-technology products include aerospace, communications and semiconductors, computers and office machinery, pharmaceuticals, and scientific instruments and measuring equipment. Asia-8 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. China includes Hong Kong. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia.

SOURCE: IHS Global Insight, World Trade Service database (2011). See appendix tables 6-24, 6-26–6-28, and 6-32.

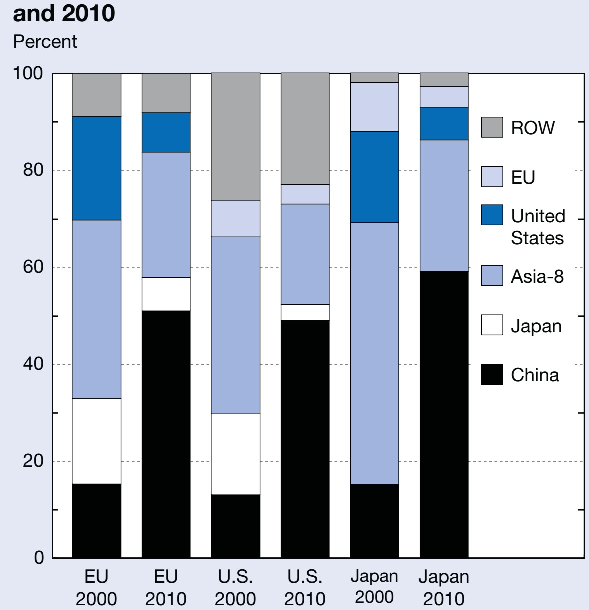
Science and Engineering Indicators 2012

The EU had a small deficit from 1995 to 2005, which widened to $50–$60 billion in 2006-10 (figure 6-27 and appendix table 6-24). Japan's surplus declined from $90 billion to $30 billion over the 15-year period. The other Asian economies also ran surpluses: China's trade position in HT products increased from a small surplus in 2000 to almost $160 billion in surplus in 2010. The Asia-8's trade surplus doubled over the last decade to reach $230 billion in 2010.

Two categories of ICT goods, communications and computers, are largely responsible for producing the substantial shifts in the trade positions of the United States, the EU, Japan, and China (figure 6-27 and appendix tables 6-26 and 6-28). The U.S. deficit in these goods rose from $39 billion in 1995 to nearly $100 billion in 2002 and further widened to $150 billion in 2010; the EU's trend was similar. Japan's trade surplus in these ICT goods fell from $40 billion to a small deficit.

The widening EU and U.S. deficits in these goods and the shrinking Japanese surplus were driven by a sharp rise in their imports from China. This in turn reflected the structural shifts towards Asia in production of these ICT goods (Athukorala and Yamashita 2006, Ng and Yeats 2003, Rosen and Wing 2005). China's share of U.S., EU, and Japanese global imports of these ICT goods rose from 13%–15% in 2000 to 49% or more by 2010 (figure 6-28 and appendix tables 6-33 and 6-34). China's surplus in these ICT goods

Figure 6-28
U.S., EU, and Japan imports of communications and computer products, by selected origin: 2000 and 2010



EU = European Union; ROW = rest of world

NOTES: Asia-8 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. China includes Hong Kong. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia.

SOURCE: IHS Global Insight, World Trade Service database (2011). See appendix tables 6-32 and 6-33.

Science and Engineering Indicators 2012

Product Classification and Determination of Country of Origin of Trade Goods

Trade data are based on a classification of goods or services themselves, not the industry that produces them. Data on product trade are recorded at the exporting country's ports of exit and the importing country's ports of entry. Because many imported products are assessed an import duty and these duties vary by product category, a customs agent for the receiving country inspects or reviews the shipment to make the final determination of the proper product code and country of origin. The customs agent assigns a product trade code according to the Harmonized System.*

The value of products entering or exiting a country's ports may include the value of components, inputs, or services classified in different product categories or originating from countries other than the country of origin.

Data on international product trade assign products to a single country of origin. For goods manufactured with international components, the country of origin is determined by where the product was "substantially transformed" into its final form.

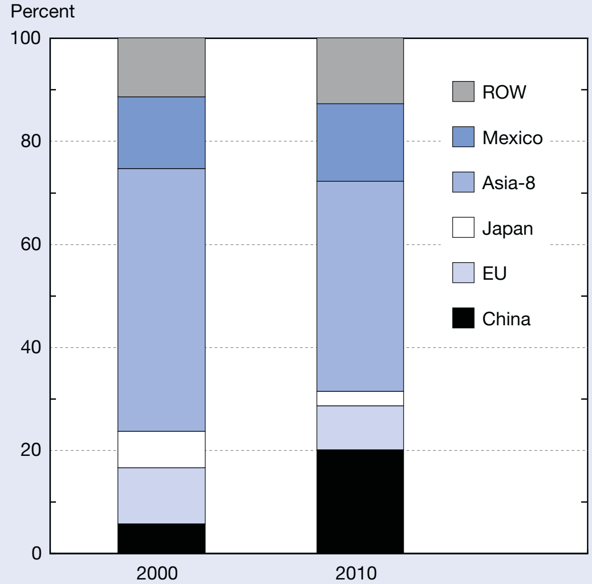
*The Harmonized Commodity Description and Coding System, or Harmonized System (HS), is a system for classifying goods traded internationally that was developed under the auspices of the Customs Cooperation Council. Beginning on 1 January 1989, HS numbers replaced schedules previously adhered to in more than 50 countries, including the United States. For more information, see http://www.census.gov/foreign-trade/guide/sec2.html#htsusa.

rose from $3 billion in 1995 to $28 billion in 2000, and then leaped to more than $200 billion in 2006 and almost $300 billion in 2010 (figure 6-27 and appendix tables 6-26, 6-27, and 6-28).

In semiconductors, the United States and Japan ran modest surpluses over the last decade (figure 6-27 and appendix table 6-27). The largest market for U.S. exports of semiconductors was the Asia-8, largely South Korea and Taiwan (41% of U.S. exports), with China the second largest at 20%, up sharply from only 6% in 2000 (figure 6-29 and appendix table 6-34). The Asia-8 ran surpluses in semiconductors, reflecting their growing role as suppliers to each other's and China's factories and assembly lines. The surpluses widened over the decade from less than $20 billion in 2000 to $100 billion in 2010, coinciding with rapid growth in Asia-8 exports destined for China for final assembly or manufactured under contract by U.S.- and Japanese-based semiconductor firms (figure 6-30 and appendix table 6-27).

China must import semiconductors for use in its production. Its deficit in semiconductor trade widened from $20 billion in 2000 to $110 billion in 2010, driven by increased imports from the Asia-8 (figure 6-27 and appendix tables

Figure 6-29
U.S. exports of semiconductors, by selected destination: 2000 and 2010



EU = European Union; ROW = rest of world

NOTES: Asia-8 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. China includes Hong Kong. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia.

SOURCE: IHS Global Insight, World Trade Service database (2011). See appendix tables 6-32 and 6-34.

Science and Engineering Indicators 2012

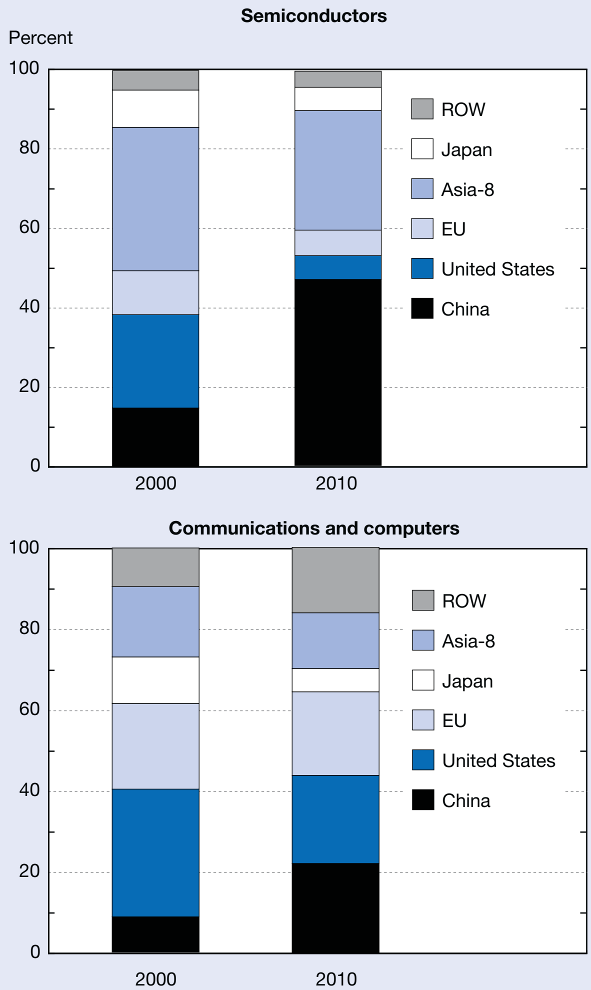
6-27 and 6-34). The Asia-8's share of Chinese semiconductor imports rose from 61% to 77%, with Taiwan accounting for about half of China's imports from this region (figure 6-31).

In aerospace, the United States has run a consistent surplus over the decade and a half from 1995 to 2010 (appendix tables 6-31 and 6-35). The U.S. surplus increased from about $20 billion in the early 2000s to $60 billion in 2010, partially offsetting its growing deficit in communications and computers. The EU ran a small surplus.

In scientific instruments and pharmaceuticals, the United States had small deficits in most years since 1995, while the EU had a surplus in pharmaceuticals that grew from $11 billion in 1995 to $55 billion in 2010 (appendix tables 6-29 and 6-30). The Asia-8's trade position in scientific instruments shifted from a small deficit to surplus in 2005, and steadily grew to $31 billion in 2010. The trend was similar in pharmaceuticals, driven by exports from India and Singapore.

Since 1995, the United States and EU have become more important destinations for pharmaceutical exports from India and Singapore. The U.S. share of India's pharmaceutical exports rose from 5% in 2000 to 29% in 2010, and its share of Singapore's pharmaceutical exports jumped from 5% to 30% during the same period (figure 6-32 and appendix table 6-36). The trend was similar in the EU.

Figure 6-30
Asia-8 exports of selected goods, by type and destination: 2000 and 2010



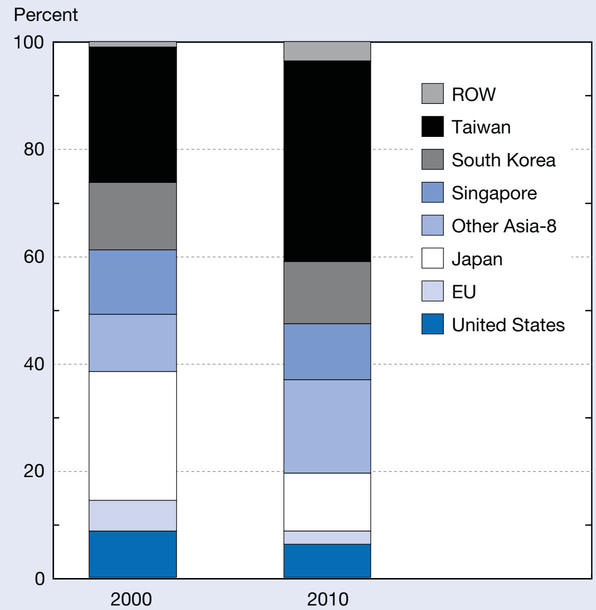
EU = European Union; ROW = rest of world

NOTES: Asia-8 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. China includes Hong Kong. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia.

SOURCE: IHS Global Insight, World Trade Service database (2011). See appendix table 6-33 and 6-34.

Science and Engineering Indicators 2012

Figure 6-31
China's imports of semiconductors, by selected origin: 2000 and 2010



EU = European Union; ROW = rest of world

NOTES: Other Asia-8 includes India, Indonesia, Malaysia, Philippines, and Thailand. China includes Hong Kong. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia.

SOURCE: IHS Global Insight, World Trade Service database (2011). See appendix table 6-34.

Science and Engineering Indicators 2012

Trade in Medium- and Low-Technology Manufactured Products

The U.S. export performance in manufactured products associated with less knowledge intensity and less use of R&D provides a context for interpreting its HT trade. In these industries, the United States has world export shares below those of the EU and Asia-8 (across all three categories: medium-high, medium-low, and low technology) and China (medium-low and low technology).

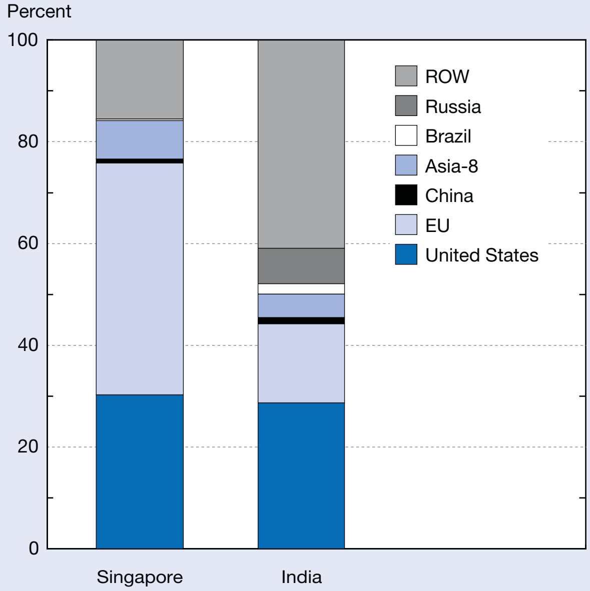
The U.S. share of world exports in medium-high-technology products (i.e., motor vehicles, chemicals, railroad equipment) was 14% in 2010, roughly the same as its share in HT industries (table 6-6), placing it at about the same level as China, Japan, and the Asia-8. The world export shares of these economies are significantly below the leading global exporter, the EU (23% share of global value). The U.S. and EU shares have fallen 3 percentage points over the past decade and a half, while Japan's share has fallen more steeply from 22% to 13%. China has rapidly expanded its share of global exports from 4% to 14% (excluding trade between China and Hong Kong), reaching rough parity with the United States, the Asia-8, and Japan.

The United States has roughly the same share (8%) as Japan in world exports in medium-low-technology products, behind the EU (15%), China (11%), and the Asia-8 (21%) (table 6-6). The U.S. share of global exports of low-technology products in 2010 (11%) placed it well behind all the other major economies except for Japan (2% share). In both of these industry groups, China's world export share expanded greatly since the mid-1990s but not to the same degree as for HT exports.

U.S. Trade in Advanced Technology Products

The Census Bureau has developed a classification system for internationally traded products based on the degree to which they embody new or leading-edge technologies. This classification system has significant advantages for

Figure 6-32
India and Singapore's exports of pharmaceuticals, by selected destination: 2010



EU = European Union; ROW = rest of world

NOTES: Asia-8 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. China includes Hong Kong. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia.

SOURCE: IHS Global Insight, World Trade Service database (2011). See appendix tables 6-32 and 6-36.

Science and Engineering Indicators 2012

determining whether products are HT and may be a more precise and comprehensive measure than the industry-based OECD classification.

This system allows a highly disaggregated, focused examination of technologies embodied in U.S. imports and exports. It categorizes advanced technology product (ATP) trade into 10 major technology areas:

- **Advanced materials**—the development of materials, including semiconductor materials, optical fiber cable, and videodisks, that enhance the application of other advanced technologies.
- **Aerospace**—the development of aircraft technologies, such as most new military and civilian airplanes, helicopters, spacecraft (excluding communications satellites), turbojet aircraft engines, flight simulators, and automatic pilots.
- **Biotechnology**—the medical and industrial application of advanced genetic research to the creation of drugs, hormones, and other therapeutic items for both agricultural and human uses.
- **Electronics**—the development of electronic components (other than optoelectronic components), including integrated circuits, multilayer printed circuit boards, and surface-mounted components (such as capacitors and resistors) that improve performance and capacity and, in many cases, reduce product size.
- **Flexible manufacturing**—the development of products for industrial automation, including robots, numerically controlled machine tools, and automated guided vehicles, that permit greater flexibility in the manufacturing process and reduce human intervention.
- **Information and communications**—the development of products that process increasing amounts of information in shorter periods of time, including computers, videoconferencing, routers, radar apparatus, communications satellites, central processing units, and peripheral units such as disk drives, control units, modems, and computer software.
- **Life sciences**—the application of nonbiological scientific advances to medicine. For example, advances such as nuclear magnetic resonance imaging, echocardiography, and novel chemistry, coupled with new drug manufacturing techniques, have led to new products that help control or eradicate disease.
- **Optoelectronics**—the development of electronics and electronic components that emit or detect light, including optical scanners, optical disk players, solar cells, photosensitive semiconductors, and laser printers.
- **Nuclear**—the development of nuclear production apparatus (other than nuclear medical equipment), including nuclear reactors and parts, isotopic separation equipment, and fuel cartridges. (Nuclear medical apparatus is included in the life sciences rather than this category.)
- **Weapons**—the development of technologies with military applications, including guided missiles, bombs, torpedoes, mines, missile and rocket launchers, and some firearms.

U.S. trade in ATP products is an important component of overall U.S. trade, accounting for about one-fifth of its combined nonpetroleum exports and imports for the past two decades. In 2010, U.S. exports of ATP products were $273 billion (24% of total U.S. goods exports) and imports were $355 billion (23% of total U.S. goods imports) (figure 6-33 and appendix table 6-37). As with world HT product trade accounts, U.S. imports of ATP products have grown faster than exports since the early 1990s. This sent the U.S. trade balance in ATP products into deficit in 2002. The deficit leveled off at $55–60 billion for 2007–09 before reaching a new record high of $82 billion in 2010.

After growing for much of the last decade, exports and imports both fell 10% in 2009 during the global recession (figure 6-33 and appendix table 6-37). Both bounced back in 2010, exports growing 11% and imports growing 18%. Exports returned to their 2008 value, and imports reached a new high of $354 billion.

The growing U.S. trade deficit in these goods reflects not only changing world production and trade patterns but also factors that are hard to measure and cannot be adequately accounted for, including exchange rate movements and new business and production processes.

Table 6-6
Exports of manufactured products, by selected technology level and region/country/economy: Selected years, 1995–2010
(Percent distribution)

Manufacturing technology level and region/country/economy	1995	1998	2001	2004	2006	2008	2010
Medium high							
Global exports (current $billions)	646.0	715.7	816.7	1,189.6	1,523.7	1,987.5	1,877.4
All countries	100.0	100.0	100.0	100.0	100.0	100.0	100.0
United States	16.5	17.0	15.7	13.3	13.9	13.1	13.7
EU	25.9	25.7	24.7	25.2	23.9	24.6	23.1
Japan	22.0	19.0	17.4	16.7	15.4	14.1	12.9
China	3.8	4.9	6.6	9.3	11.5	13.4	14.3
Asia-8	1.5	1.3	1.8	2.7	2.9	2.7	3.4
All other countries	30.3	32.1	33.8	32.8	32.4	32.1	32.6
Medium low							
Global exports (current $billions)	417.7	433.8	520.0	855.2	1,304.6	1,976.0	1,871.4
All countries	100.0	100.0	100.0	100.0	100.0	100.0	100.0
United States	9.3	10.5	9.6	7.0	7.3	7.0	7.6
EU	20.8	19.7	17.0	16.8	16.8	16.1	14.8
Japan	12.6	10.4	8.3	7.7	6.6	6.4	7.4
China	5.0	5.4	6.5	8.9	10.2	11.6	10.6
Asia-8	14.8	16.1	15.9	16.5	17.8	18.7	20.8
All other countries	37.5	38.0	42.2	42.5	41.3	39.5	37.1
Low							
Global exports (current $billions)	608.5	621.8	649.5	909.7	1,075.6	1,291.0	1,266.0
All countries	100.0	100.0	100.0	100.0	100.0	100.0	100.0
United States	9.7	12.5	12.2	9.5	10.8	10.8	11.0
EU	16.4	20.1	18.7	19.5	18.4	18.3	16.5
Japan	3.5	4.0	3.7	2.7	2.5	2.1	2.1
China	9.9	11.3	13.6	15.4	17.9	20.2	21.0
Asia-8	14.7	13.5	13.4	12.0	11.4	10.3	12.4
All other countries	45.8	38.6	38.4	40.9	39.0	38.3	37.0

EU = European Union

NOTES: Global exports exclude intra-EU exports and exports between China and Hong Kong. EU exports exclude intra-EU exports, and China exports exclude exports between China and Hong Kong. Manufacturing technology level classified by Organisation for Economic Co-operation and Development. Asia-8 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. China includes Hong Kong. EU excludes Cyprus, Luxembourg, Malta, and Slovenia. Percents may not add to 100% because of rounding.

SOURCE: IHS Global Insight, World Trade Service database (2011).

Science and Engineering Indicators 2012

U.S. Advanced Technology Product Trade, by Technology

Four technology areas—ICT, aerospace, electronics, and the life sciences—accounted for a combined share of 85% of U.S. ATP product exports in 2010 (figure 6-34 and appendix tables 6-37, 6-38, 6-39, 6-40, 6-41, 6-42, and 6-43). Aerospace had the largest single share (30%), followed by ICT (28%), electronics (17%), and the life sciences (10%). ICT technologies have generated the largest trade deficits of any technology area—$127 billion in 2010. This deficit in ICT, widening from $35 billion to more than $120 billion over the decade, drove the increase in the U.S. ATP trade deficit.

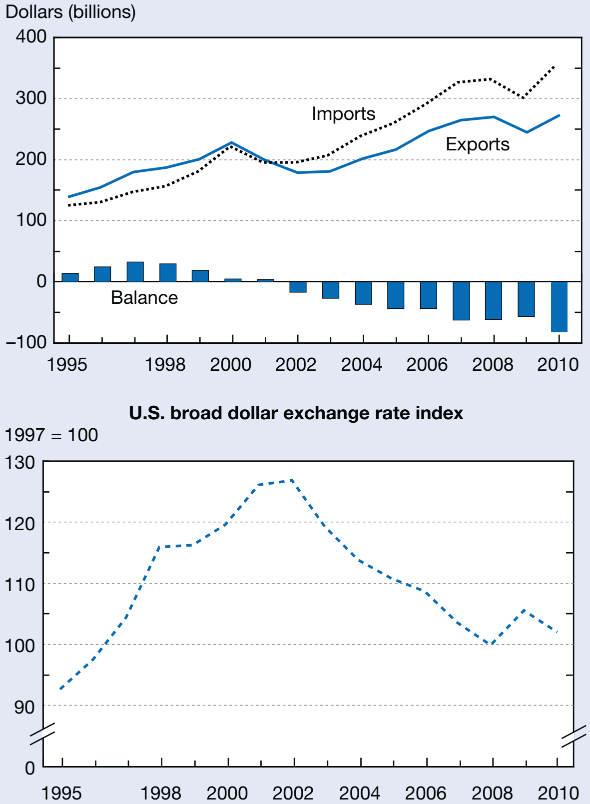
Two technologies, aerospace and electronics, have generated a combined trade surplus of $70 billion in 2010 (figure 6-34 and appendix tables 6-39 and 6-40). The United States is the leading producer of aerospace products; it had a trade surplus of $51 billion in 2010 ($24 billion more than in 2000), as exports jumped from $53 billion to $81 billion and imports increased more moderately from $26 billion to $29 billion. The surplus in electronics was $18 billion in 2010.

U.S. Advanced Technology Products Trade, by Region and Country

About 80% of U.S. ATP exports go to three regions: the EU (24%), Asia (Asia-8, China, and Japan) (36%), and the North American Free Trade Agreement (NAFTA) trade zone (20%) (figure 6-34 and appendix table 6-37).

China, Japan, and the Asia-8. China is the single largest U.S. trading partner in both total goods trade and ATP products, exporting $117 billion worth of ATP products to the United States (about one-third of U.S. imports of these products) and importing $30 billion from the United States in 2010 (figure 6-34 and appendix table 6-37).[16] The U.S. deficit in ATP and all products with China is larger than its deficits with any other country. Nearly 90% of U.S. ATP

Figure 6-33
U.S. trade in advanced technology products and U.S. exchange rate: 1995–2010



SOURCES: U.S. Census Bureau, Foreign Trade Statistics, Advanced Technology Trade database, http://www.census.gov/foreign-trade/statistics/country/index.html, accessed 15 March 2011; U.S. Federal Reserve, Statistical Releases, Exchange rates and international data, http://www.federalreserve.gov/releases/g17/, accessed 15 March 2011. See appendix table 6-37.

Science and Engineering Indicators 2012

imports from China are ICT goods (appendix table 6-38). U.S. ATP exports to China include aerospace, electronics, and ICT (appendix tables 6-39 and 6-40).

U.S. ATP data show that ICT imports from China have increased much faster than its exports to China (appendix table 6-38). The steep rise in imports and flat export growth widened the U.S. deficit with China in ICT from $6 billion in 2000 to $87 billion in 2010 (figure 6-34).

ICT products also constituted 40% of all U.S. imports from Japan in 2010 (figure 6-34 and appendix table 6-38). Among U.S. ATP exports to Japan, aerospace accounted for the largest share (34%); life sciences ranked second (22%) (appendix tables 6-39 and 6-40).

The United States exported $36 billion of ICT goods to the Asia-8 and imported $60 billion from this region (figure 6-34 and appendix table 6-38). The $17 billion U.S. deficit with the Asia-8 in ICT consists of $5–$7 billion deficits with Malaysia, South Korea, Taiwan, and Thailand and a small surplus with Singapore. As with China, ICT products constituted the largest share of total U.S. ATP trade with the Asia-8. Important suppliers are Malaysia ($10 billion), South Korea ($13 billion), and Taiwan ($11 billion). U.S. imports of $48 billion and exports of $7 billion produced a deficit with these Asian economies of $41 billion in ICT products in 2010.

The European Union. The EU exported $60 billion to the United States and imported $66 billion from it, for a $6-billion U.S. surplus in 2010 (figure 6-34 and appendix table 6-37). Four EU members—France, Germany, the Netherlands, and the United Kingdom (UK)—accounted for nearly 75% of U.S. ATP exports. Three technology areas—aerospace, ICT, and the life sciences—had a combined 75% share of U.S. exports to the EU, with aerospace having the single largest export share (40%) (appendix tables 6-38, 6-39, and 6-41).

The United States had substantial surpluses with the EU in aerospace ($11 billion) and ICT goods ($6 billion) (figure 6-34 and appendix tables 6-38 and 6-39). Important EU customers of aerospace and ICT are France, Germany, and the UK; the Netherlands purchases the most U.S. ICT goods of any EU country. The life sciences produced a $16-billion deficit (appendix table 6-41). Ireland was by far the largest EU supplier of life sciences products to the United States, accounting for more than half of the EU's $27 billion in exports to the United States in 2010. Other substantial suppliers were Belgium, France, Germany, and the UK.

The U.S. trade surplus in ATP goods with the EU narrowed from $16 billion in 2000 to $400 million in 2010, reflecting the deficit in the life sciences, which rose from $6 billion to $16 billion because of accelerating growth of imports (figure 6-34 and appendix tables 6-37 and 6-41).

NAFTA Trade Zone. The United States exported $55 billion to Canada and Mexico in 2010 and imported $62 billion from those countries (figure 6-34 and appendix table 6-37). The United States has a $22 billion deficit with Mexico, largely in ICT and optoelectronics, reflecting in part Mexico's duty-free imports of U.S. components and their assembly and free re-export to the United States (appendix tables 6-38 and 6-42). The United States imported $13 billion from Canada and exported $24 billion, resulting in a surplus of $12 billion, largely in ICT goods.[17]

U.S. Multinational Companies in Knowledge- and Technology-Intensive Industries

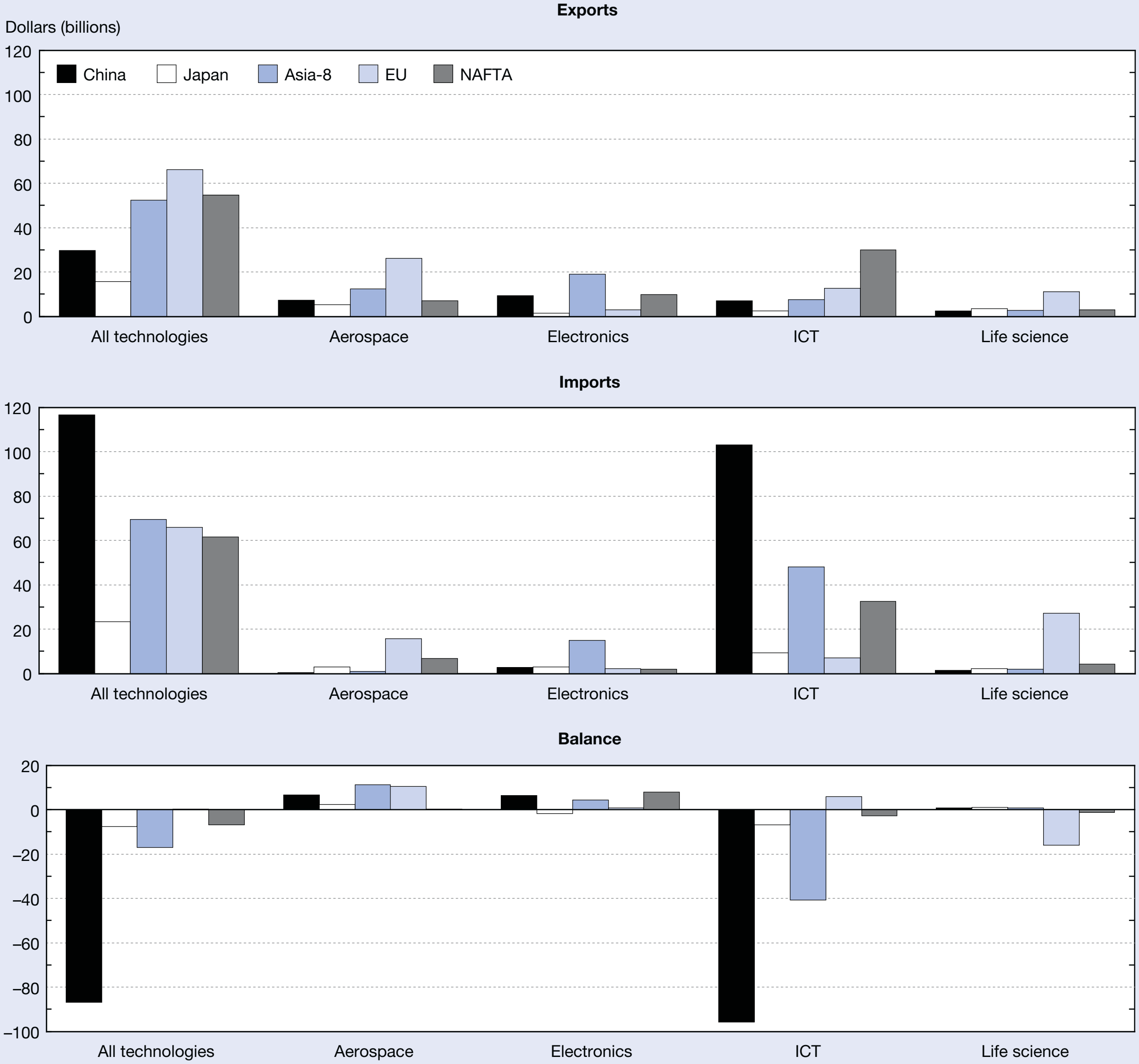
The Bureau of Economic Analysis (BEA) conducts an annual survey of U.S. multinationals that includes firms in KTI industries. The BEA data are not directly comparable with the world industry data used in the previous sections. However, the BEA data provide additional information on the globalization of activity and the employment of U.S. multinationals in these industries.

Since 2000, an increasing proportion of the goods and services produced by U.S. multinational companies in KTI industries has been produced outside the United States. The proportion of jobs in these companies that are outside the United States has likewise increased.

Commercial Knowledge-Intensive Service Industries

U.S. multinationals in commercial KI service industries generated $722 billion in value added in 2008, of which 79% ($573 billion) occurred in the United States (figure 6-35). Communications ranks first by value added ($264 billion), followed by business services ($261 billion) and finance ($197 billion).[18] The proportion of U.S. value added was highest in communications (90%), followed by Internet and data processing and financial services (76%–77%) and business services (70%). The U.S. share of value added declined across all these industries between 2000 and 2008, suggesting globalization of their production.

Figure 6-34
U.S. trade in advanced technology products, by selected region/country/economy and technology: 2010



EU = European Union; ICT = information and communications technology; NAFTA = North American Free Trade Agreement

NOTES: China includes Hong Kong. Asia-8 includes India, Indonesia, Malaysia, Singapore, South Korea,Taiwan,and Thailand. EU includes current member countries. Advanced technology product trade classified by the Census Bureau and consists of advanced materials, aerospace, biotechnology, electronics, flexible manufacturing, information and communications technology, life sciences, optoelectronics, nuclear, and weapons.

SOURCE: U.S. Census Bureau, Foreign Trade Statistics, Advanced Technology Trade database, http://www.census.gov/foreign-trade/statistics/country/index.html, accessed 15 March 2011. See appendix tables 6-37–6-41.

Science and Engineering Indicators 2012

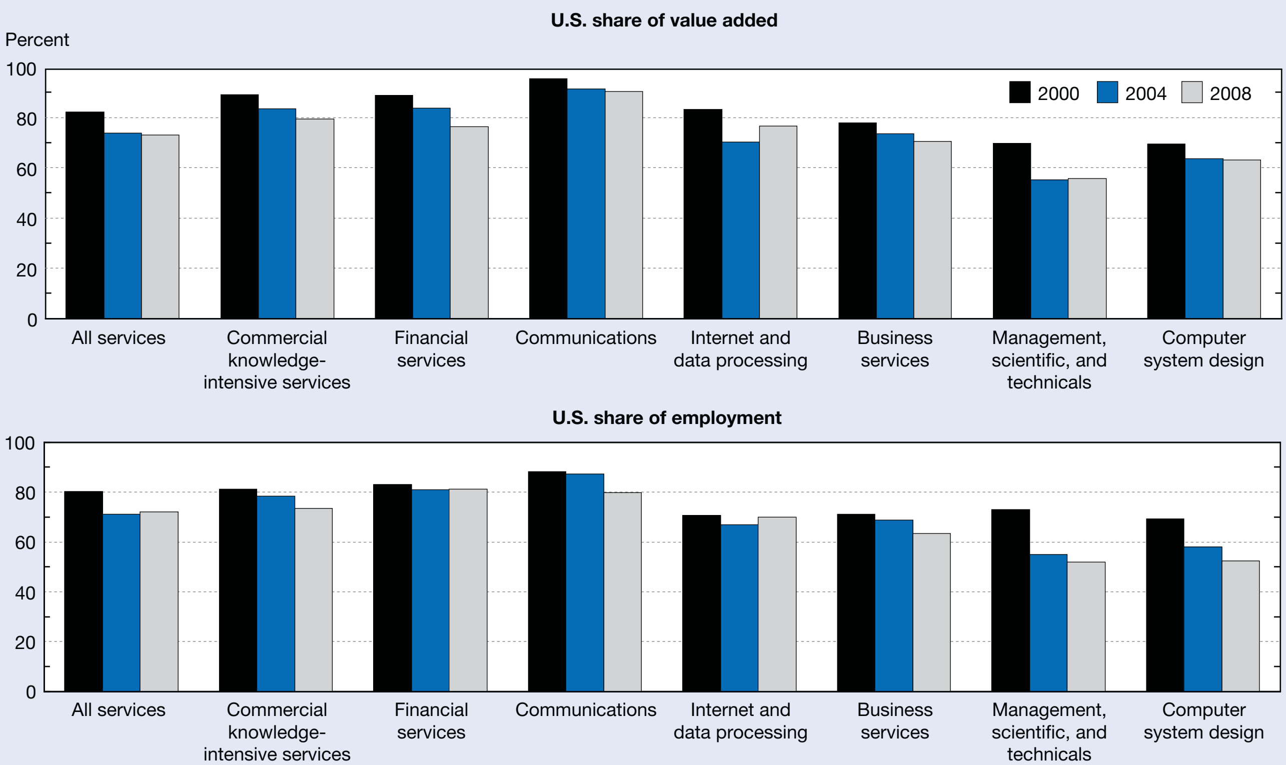
U.S. multinationals in commercial KI service industries employed 5.2 million workers worldwide, of which 3.8 million (73%) were employed in the United States (figure 6-35). U.S. employment was highest in communications services, at 1.4 million, closely followed by 1.3 million employed in business services and 1.0 million employed in financial services. The financial and communications industry employed 81% of their workers in the United States, with business services employing a smaller share of their workers in the United States (63%). Between 2000 and 2008, the U.S. share of employment fell nearly 10 percentage points in business and communications services, but by larger amounts (17%–21%) for computer systems design and management and for scientific, and technical services. The U.S. share in financial services stayed stable.

High-Technology Manufacturing Industries

U.S. multinationals in four of five HT manufacturing industries generated more than $300 billion worldwide in value added in 2008, of which about two-thirds originated in the United States, down from three-quarters in 2000 (figure 6-36). Production in the semiconductor industry was the most globalized, as measured by the distribution between U.S. and foreign value added, with 57% of value added originating from the United States in 2008, down from 77% in 2000. Pharmaceuticals and communication equipment showed a more modest shift, with the U.S. shares of value added falling 5 percentage points to 65% and 81%, respectively. The distribution of value added of the other two industries remained stable between 2000 and 2008.

U.S. multinationals in HT manufacturing employed 2.2 million workers worldwide with 1.3 million workers (about 60%) employed in the United States in 2008 (figure 6-36). More than half (58%) of the semiconductor workforce of half a million workers is employed abroad, the highest share among these industries. Three industries—computers, communications and pharmaceuticals—employ around 40% of their workforce abroad, equal to the average for all manufacturing industries. The navigational and measuring equipment industry has 25% of its workforce abroad, much lower than other industries. The U.S. share of worldwide employment showed little change or increase in computers and

Figure 6-35
Globalization indicators of U.S. multinationals in commercial knowledge-intensive services: 2000, 2004, and 2008



NOTES: Value added is amount contributed by country, firm, or other entity to value of good or service and excludes purchases of domestic and imported materials and inputs. Commercial knowledge-intensive services are classified by Organisation for Economic Co-operation and Development and include business, financial, and communications. Internet and data processing is part of communications. Management, scientific, and technicals and computer system design are part of business services.

SOURCE: Bureau of Economic Analysis, International Economic Accounts, U.S. Direct Investment Abroad: Financial and Operating Data for U.S. Multinational Companies 1999–2008, http://www.bea.gov/international/di1usdop.htm, accessed 15 December 2010.

Science and Engineering Indicators 2012

navigational and measuring equipment from 2000 to 2008. The U.S. employment shares in communications equipment fell from 76% in 2000 to 56% in 2008 and in semiconductors fell from to 48% in 2000 to 41% in 2008.

U.S. and Foreign Direct Investment in Knowledge- and Technology-Intensive Industries

Foreign direct investment (FDI) has the potential to generate employment, raise productivity, transfer skills and technology, enhance exports, and contribute to long-term economic development (Kumar 2007). Receipt of FDI may indicate a developing country's emerging capability and integration with countries that have more established industries. FDI in specific industries may suggest the potential for their evolution and the creation of new technologies.

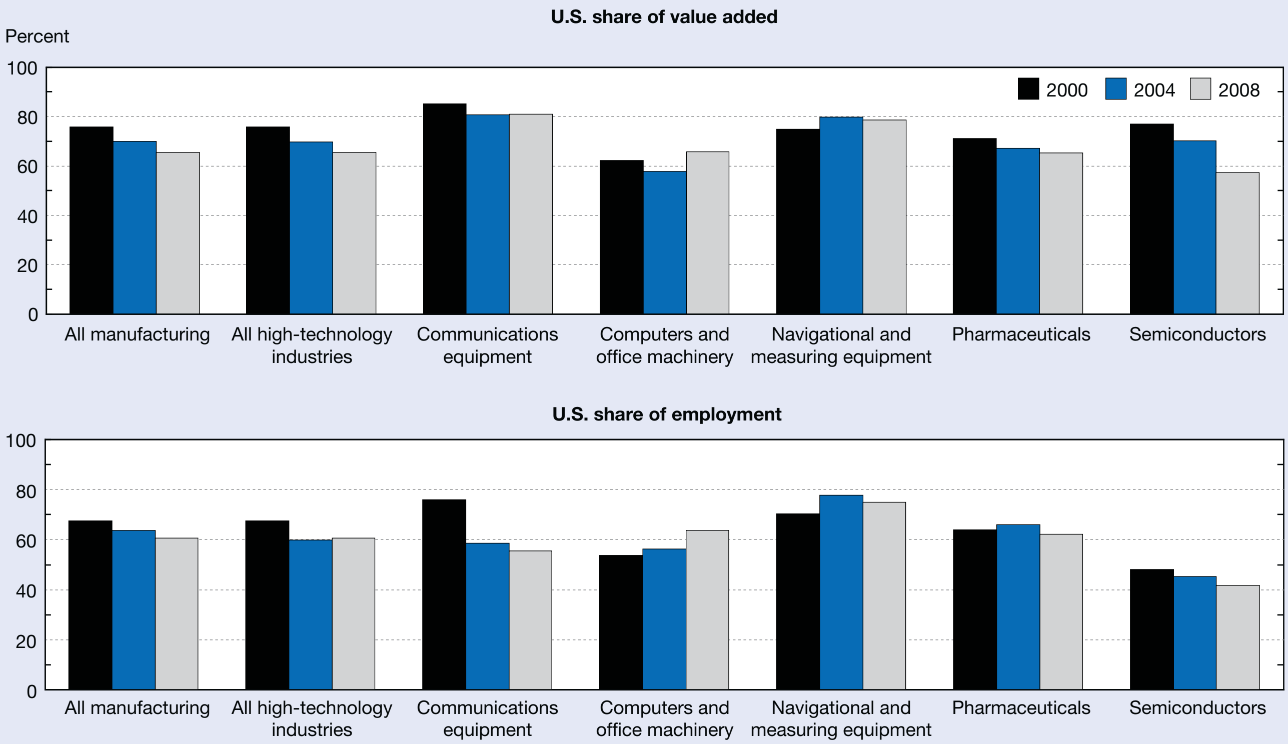
This section uses data from the BEA on U.S. direct investment abroad and foreign investment in the United States in KTI industries. The rising volume of trade by U.S.-based KTI firms has been accompanied by increases in U.S. direct investment abroad and FDI in the United States.

U.S. Direct Investment Abroad

U.S. firms have long invested abroad and have substantial overseas investment positions in both KTI services and manufacturing. The U.S. KI services stock abroad exceeds foreign counterpart investments in the United States; the opposite is the case with HT manufacturing investments (table 6-7). The stock of U.S. direct investment abroad had reached $125 billion in HT manufactures and $1 trillion in commercial KI service industries by 2009.[19] This represented one-quarter of the stock of all U.S. direct overseas investment in all manufacturing industries ($500 billion) and about one-third of U.S. direct overseas investment in all services ($2.8 trillion).

The stock of U.S. direct investment abroad in HT manufacturing industries increased from $87 billion in 2000 to $125 billion in 2009 (table 6-7). Semiconductors and pharmaceuticals have a combined share of 66% of investments in HT industries. The value of pharmaceuticals investments doubled between 2000 and 2009 to reach $51 billion. The investment value in semiconductors rose 25% to reach $31 billion. The stock of investment in the other three HT industries is $10–$13 billion.

Figure 6-36
Globalization indicators of U.S. multinationals in high-technology manufacturing: 2000, 2004, and 2008



NOTES: Value added is amount contributed by country, firm, or other entity to value of good or service and excludes purchases of domestic and imported materials and inputs. High-technology manufacturing industries are classified by Organisation for Economic Co-operation and Development and include communications and semiconductors, computers and office machinery, scientific and measuring instruments, and pharmaceuticals.

SOURCE: Bureau of Economic Analysis, International Economic Accounts, U.S. Direct Investment Abroad: Financial and Operating Data for U.S. Multinational Companies 1999–2006, http://www.bea.gov/international/di1usdop.htm, accessed 15 December 2010.

Science and Engineering Indicators 2012

The stock of U.S. direct investment abroad in commercial KI service industries was $1 trillion in 2009, exceeding one-third of the stock of total U.S. direct investment abroad in all services (table 6-7). Financial services accounted for 86% ($861 billion) of these investments, up from $257 billion in 2000. Business services grew from $61 billion in 2000 to $197 billion in 2009. Within business services, software investments grew from $10 billion to $51 billion, and investment in the professional, scientific, and technical industries more than doubled from $33 billion to $78 billion.

Foreign Direct Investment in the United States

The value of FDI stock in U.S. HT manufacturing industries stood at $222 billion in 2009, up from $133 billion in 2000, larger than the $125 billion FDI stock in U.S. investment abroad (table 6-7). The FDI stock in the U.S. pharmaceuticals industry was $152 billion in 2009, almost 70% of the total. The stock of FDI in pharmaceuticals more than tripled between 2000 and 2009 from $45 billion to $152 billion, coinciding with the acquisition of U.S. drug companies by EU- and India-based firms. The stock of FDI grew rapidly in computers from $3 billion in 2000 to $20 billion in 2009. However, FDI in semiconductors fell from $29 billion to $11 billion during this period, reflecting a relative decline in the U.S. world position in this industry.

FDI stock in U.S. commercial KI service industries was $433 billion in 2009, compared with the $1 trillion in the stock of U.S. investment abroad in these industries (table 6-7). The largest industry was financial services ($292 billion), followed by $84 billion in business services and $56 billion in communications. The stock of FDI in software increased $13 billion to $22 billion over this 9-year period.

Innovation-Related Indicators of the U.S. and Other Major Economies

The OECD defines innovation as the "implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method."[20] Innovation is widely recognized as instrumental

Table 6-7
Stock of U.S. direct investment abroad and foreign direct investment in the United States, by selected industry: 2000, 2005, and 2009
(Billions of dollars)

	U.S. direct investment abroad			Foreign direct investment in the United States		
Industry/service	2000	2005	2009	2000	2005	2009
All knowledge- and technology-intensive industries	420.9	723.7	1,137.2	424.0	455.5	655.2
Commercial KI services	333.6	631.3	1,012.0	291.5	353.9	433.1
Business services	61.0	129.1	196.7	47.0	71.3	83.5
Software	10.4	17.5	50.8	7.4	10.9	21.6
Professional, technical, and scientific services	32.9	57.2	77.5	30.5	51.5	46.1
Architectural and engineering services	3.1	1.9	3.5	2.6	4.2	10.2
Computer system design	15.0	28.5	33.9	13.7	9.1	9.1
Management, scientific, and technical consulting	4.3	11.0	16.5	1.0	9.9	7.9
Communications	55.5	38.1	68.3	77.5	41.0	56.4
Finance	217.1	464.0	747.0	167.0	241.6	293.2
All services	874.6	1,683.7	2,779.6	735.9	1,026.7	1,333.6
High-technology manufacturing	87.3	92.4	125.2	132.5	101.6	222.1
Aerospace products and parts	2.9	4.5	10.9	4.5	8.6	16.6
Communications equipment	16.7	10.6	12.6	33.0	2.0	10.9
Computers and peripheral equipment	14.1	6.3	9.3	2.5	2.2	19.5
Navigational, measuring, and other instruments	3.1	6.4	9.5	19.0	10.9	12.3
Pharmaceuticals	25.3	38.7	51.4	44.7	65.6	151.6
Semiconductors and other electronic components	25.2	26.1	31.4	28.7	12.4	11.2
All manufacturing	343.9	430.7	541.1	480.6	499.9	790.6

KI = knowledge-intensive

NOTES: Knowledge- and technology-intensive industries are commercial knowledge-intensive services and high-technology manufacturing industries. High-technology manufacturing industries and commercial knowledge-intensive services classified by Organisation for Economic Co-operation and Development. High technology manufacturing industries include aerospace, communications and semiconductors, computers and office machinery, navigational, measuring and other instruments, and pharmaceuticals. Knowledge-intensive services include business, financial, communications, education, and health. Commercial knowledge intensive services include business, financial, and communications services. Communications includes broadcasting, telecommunications, and Internet publishing and broadcasting. Finance does not include depository institutions. Detail may not add to total because of rounding.

SOURCE: Bureau of Economic Analysis, International Economic Accounts, U.S. Direct Investment Abroad, Balance of Payments and Direct Investment Position Data, http://www.bea.gov/international/di1usdbal.htm, and Foreign Direct Investment in the U.S.: Balance of Payments and Direct Investment Position Data, http://www.bea.gov/international/di1fdibal.htm, accessed 15 January 2011.

Science and Engineering Indicators 2012

to the realization of commercial value in the marketplace and as a driver of economic growth.[21] ICT technologies, for example, have stimulated the creation of new products, services, and industries that have transformed the world economy over the past several decades.

This section will present data on how innovation activity varies among U.S. industries, using information from the National Science Foundation's (NSF's) Business R&D and Innovation Survey (BRDIS). The section also includes three indicators of activities that are related to innovation, but do not actually constitute innovation. Two of these, patents and trademarks, are indicators of invention—they protect intellectual property in inventions that can have value for commercial innovations. The third indicator concerns early-stage financing for U.S. HT small businesses, which can be an important milestone in the process of bring new products and services to market.

Innovation Activities by U.S. Businesses

The NSF BRDIS survey provides innovation indicators that are representative of all U.S.-located businesses with five or more employees. Survey results indicate which kinds of companies introduced new goods, services, or processes between 2006 and 2008.[22] Preliminary data from a 2008 pilot survey suggest that U.S. KTI industries have a much higher incidence of innovation than other industries.

In the U.S. manufacturing sector, four of the six HT manufacturing industries—computers, communications, scientific and measuring instruments, and pharmaceuticals—reported rates of product and process innovation that were at least double the manufacturing sector average (figure 6-37 and appendix table 6-44). Most of these industries reported significantly higher rates of innovation in both goods and services, suggesting that high rates of innovation by manufacturing companies go hand-in-hand with innovations in services.

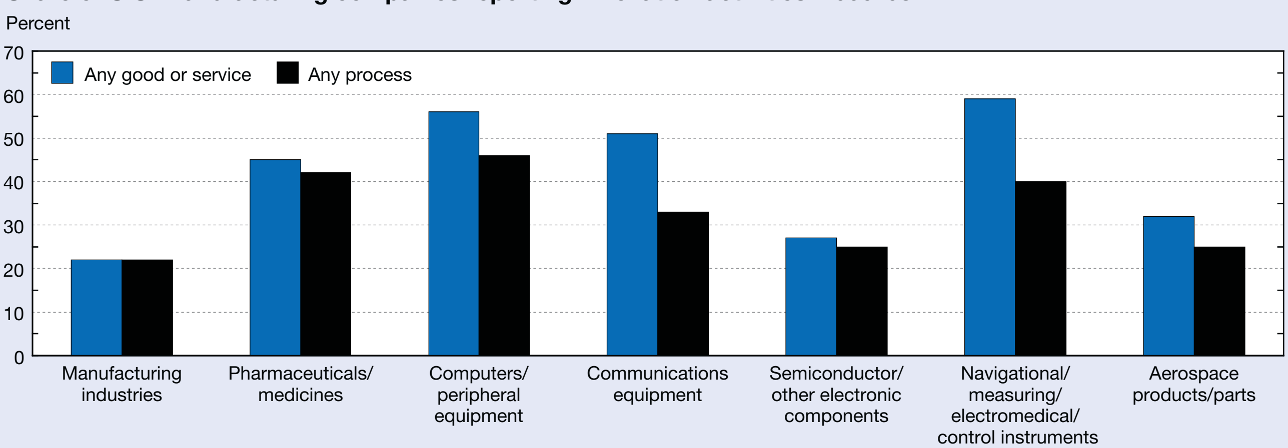
Several of these industries, notably computers, communications, and scientific and measuring instruments, reported significantly higher than average rates of process innovations, particularly in production methods and logistics and delivery methods. Innovation is also higher in several commercial KI service industries in comparison to other service industries (figure 6-38 and appendix table 6-44).[23] Software firms lead in incidence of innovation, with 77% of companies reporting the introduction of a new product or service compared to the 7% average for all nonmanufacturing industries. Innovation is also 2 to 3 times higher than the nonmanufacturing average in the telecommunications/Internet industries. The average rate of innovation in the professional, scientific, and technical industries is close to the nonmanufacturing average, but computer systems design and scientific R&D services reported much higher rates of innovation, comparable to those in the telecommunications/Internet industries.

Global Trends in Patenting and Trademarks

To foster innovation, nations assign property rights to inventors in the form of patents. These rights allow the inventor to exclude others from making, using, or selling the invention for a limited period in exchange for publicly disclosing details and licensing the use of the invention.[24] Inventors obtain patents from government-authorized agencies for inventions judged to be "new…useful…and…nonobvious."[25]

Patenting is an intermediate step toward innovation, and patent data provide indirect and partial indicators of innovation. Not all inventions are patented, and the propensity to

Figure 6-37
Share of U.S. manufacturing companies reporting innovation activities: 2006–08

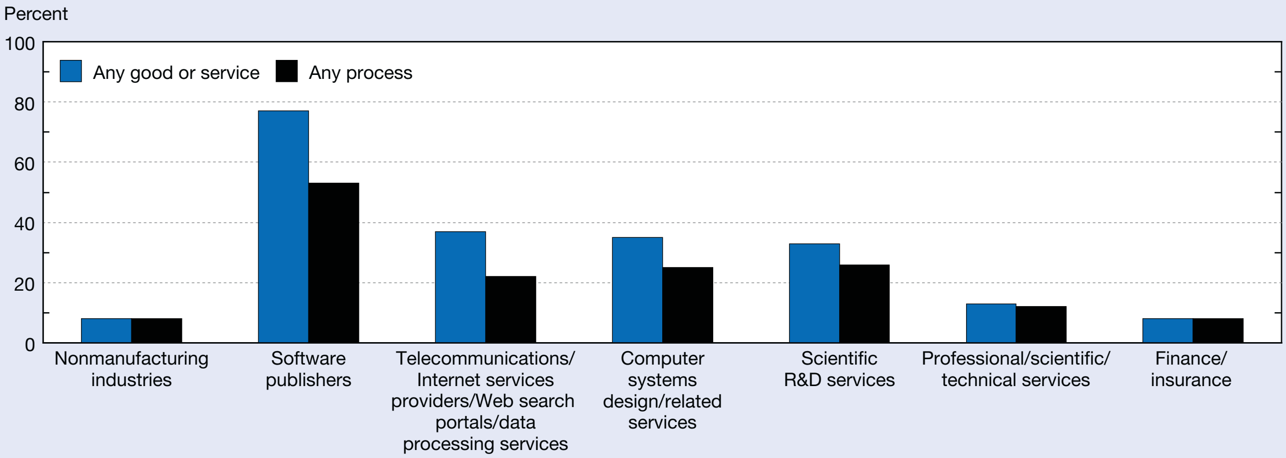


NOTES: Survey asked companies to identify innovations introduced in 2006 to 2008. Sum of yes plus no percentages may not add to 100% due to item nonresponse to some innovation question items. Figures are preliminary and may later be revised. Data may not be internationally comparable.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Business R&D and Innovation Survey (2008). See appendix table 6-44.

Science and Engineering Indicators 2012

Figure 6-38
Share of nonmanufacturing U.S. companies reporting innovation, by selected industry: 2006–08



NOTES: Survey asked companies to identify innovations introduced in 2006 to 2008. Sum of yes plus no percentages may not add to 100% due to item nonresponse to some innovation question items. Figures are preliminary and may later be revised. Data may not be internationally comparable.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Business R&D and Innovation Survey (2008). See appendix table 6-44.

Science and Engineering Indicators 2012

patent differs by industry and technology area. Not all patents are of equal value, and not all foster innovation—patents may be obtained to block rivals, negotiate with competitors, or help in infringement lawsuits (Cohen, Nelson, and Walsh 2000).

Indeed, the vast majority of patents are never commercialized. However, the smaller number of patents that are commercialized result in new or improved products or processes or even entirely new industries. In addition, their licensing may provide an important source of revenue, and patents may provide important information for subsequent inventions and technological advances.

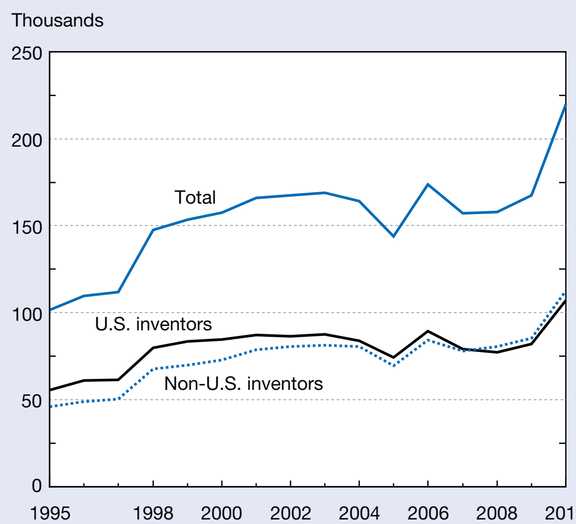
This discussion focuses largely on patent activity at the U.S. Patent and Trademark Office (USPTO). It is one of the largest patent offices in the world and has a significant share of applications and grants from foreign inventors because of the size and openness of the U.S. market.[26] These market attributes make U.S. patent data useful for identifying trends in global inventiveness.

This section also deals with patents filed in all three of the world's largest patenting centers: the United States, the EU, and Japan.[27] Because of the high costs associated with patent filing and maintenance in these three patent offices, inventions covered by these patents are presumed to be valuable.

Applications for USPTO Grants

The USPTO granted inventors 220,000 patents in 2010, 50,000 more than in 2009 (figure 6-39 and appendix table 6-45). The sharp increase in 2010 may reflect recovery from the recession, along with USPTO efforts to decrease its backlog of patent applications. The United States enacted a new patent law in 2011 aimed in part to reduce the backlog of USPTO patent applications (see sidebar, "New U.S. Patent Law"). The number of U.S. patent grants jumped in the late 1990s, coinciding with a strengthening of the patent system, extension of patent protection into new technology areas through policy changes and judicial decisions during the 1980s and 1990s, and administrative changes (NRC 2004).

Figure 6-39
USPTO patents granted, by nationality of inventor: 1995–2010



USPTO = U.S. Patent and Trademark Office

NOTE: Technologies classified by The Patent Board™. Patent grants fractionally allocated between United States and all other countries on basis of proportion of residences of all named inventors.

SOURCE: The Patent Board™, Proprietary Patent database, special tabulations (2011). See appendix tables 6-45 and 6-62.

Science and Engineering Indicators 2012

Inventors residing in the United States were granted 107,000 patents in 2010, a 30% increase over 2009 (figure 6-39 and appendix table 6-45).[28] The U.S. resident share has gradually fallen since the late 1990s, from 54% to 52% in 2002 and to 49% in 2010. The decline in the U.S. share may indicate increased technological capabilities abroad, globalization, and the increasing recognition by developing countries of the potential value of intellectual property protection in the United States.

The overall growth of patent grants, accompanied by a decline in the U.S. share in these grants over the past two decades, reflects a marked increase in patents granted to non-U.S. countries. The USPTO granted 112,000 patents to non-U.S. inventors in 2010 compared to 46,000 in 1995 (figure 6-39 and appendix table 6-45). The EU, Japan, and the Asia-8 are the main recipients, with a collective share of nearly 90% of patents granted to all non-U.S. inventors (figure 6-40).

New U.S. Patent Law

The America Invents Act, Public Law 112-29, 125 Stat. 283, signed into law on September 16, 2011, is the most significant reform of U.S. patent law since 1952. The act aims to foster innovation and improve productivity by making the U.S. patent system more compatible with the systems in other countries. Supporters of the act believe it will reduce a growing backlog of U.S. patent applications, reverse a decline in U.S. patent quality, decrease the number of patents for frivolous inventions, and diminish the amount of expensive and time-consuming patent litigation. Economists and legal scholars who have studied the U.S. patent system have advocated reforms such as those in the new law (see Jaffe and Lerner [2006] and Burk and Lemley [2011])

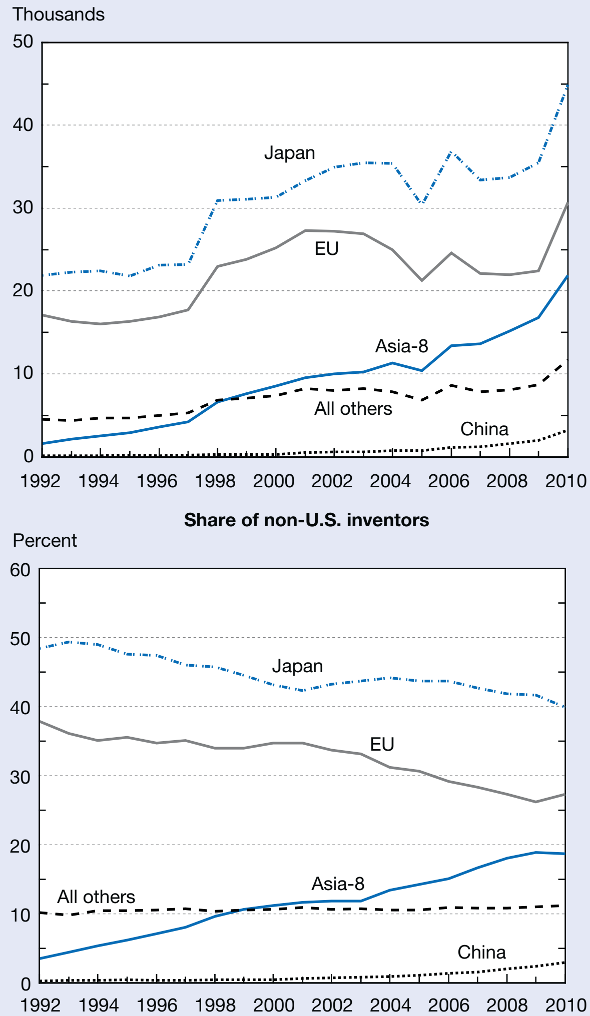
The America Invents Act has three major provisions:

♦ **First-to-file system.** The law changes the primary standard for granting U.S. patent applications from the longstanding "first to invent" doctrine to "first to file." Under the new law, patents would go to the inventor that files an application first, and disputes about who was first to invent would be avoided. The goals of this provision are to harmonize the U.S. patenting system with most other national patent offices and to reduce litigation over disputes about when a product or idea was invented.

♦ **Postgrant review.** The law establishes an administrative postgrant review process similar to opposition proceedings in European patent offices. The process allows a third party to challenge the validity of a patent within 9 months of the patent's issuance. The aims of this provision are to provide an alternative to litigation, improve the quality of patents, and generate better decisions about alleged patent infringements.

♦ **Budget and operations of the U.S. Patent and Trademark Office.** The law gives the U.S. Patent and Trademark Office (USPTO) authority to set its own fees, which had previously been set by Congress. The purpose of this provision is to give USPTO greater budget autonomy and allow it to reduce its application backlog by hiring more examiners and modernizing its IT systems when the need arises.

Figure 6-40
USPTO patents granted to non-U.S. inventors, by selected region/country/economy: 1992–2010



EU = European Union; USPTO = U.S. Patent and Trademark Office

NOTES: Technologies classified by The Patent Board™. Patent grants fractionally allocated among regions/countries on basis of proportion of residences of all named inventors. Asia-8 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. China includes Hong Kong. EU includes current member countries.

SOURCE: The Patent Board™, Proprietary Patent database, special tabulations (2011). See appendix tables 6-45 and 6-62.

Science and Engineering Indicators 2012

Japan has the largest share of foreign patent grants by the USPTO, 40%, down slightly from the early 2000s (figure 6-40 and appendix table 6-45). The EU is second, with a 27% share, a decline of 6 percentage points from 2000. The Asia-8 group was in third place with 20%; its share nearly doubled from 2000 to 2010, largely because of rapid growth by South Korea and Taiwan. Chinese patenting activities in the U.S. remained insubstantial, as did those of Brazil, Russia, and India, in contrast to much higher activity of Chinese and other national patent offices (see sidebar, "Trends in Patents Granted in China, India, and Russia").

USPTO Patenting Activity by U.S. Companies

Patenting by U.S. industry provides an indication of inventive activity, mediated by the relative importance in different industries of patenting as a business strategy.

Trends in Patents Granted in China, India, and Russia

The number of Chinese patent grants grew exponentially during the 2000s. Chinese patents granted to domestic residents rose more than 10-fold from 6,000 in 2002 to 65,000 in 2009 (table 6-C). During this period, the Chinese inventor share of Chinese patent grants increased from 28% to slightly more than 50%, suggesting that patent protection is becoming increasingly important for Chinese companies that sell to the large and growing Chinese consumer market. The bulk of applications by Chinese inventors have been in utility model and industrial designs, which are quicker, cheaper, and have a lower standard than invention patents. Observers have criticized Chinese utility and industrial design patents as low quality but innovation economists note that these types of patents have played an important role in fostering indigenous innovation in Japan, South Korea, and Taiwan.* Chinese patents granted to nonresident inventors have also risen rapidly, coinciding with the growing sales and interest of U.S. and other companies in the Chinese domestic market. The growth of patent grants by residents and nonresidents may also reflect the strengthening of China's patent protection during the 2000s (Zhao 2010).

India and Russia show divergent trends in patenting activity by domestic and foreign inventors. A minority of India's patents are granted to domestic investors, with their share falling from 40% in 2002 to 25% in 2006 (table 6-C). The rising share of patents granted to non-Indian inventors may reflect the strengthening of patent protection for pharmaceuticals and other goods by the Indian patent system during this period. Russian-based inventors dominate patents granted by their country with a share of 76%. This may reflect the orientation of many Russian companies to the domestic market.

*See Ernst (2011) for a discussion on Chinese patenting.

Table 6-C
Patents granted by Brazil, China, India, and Russia, by share of resident and nonresident inventors: Selected years, 1995–2009
Share (percent)

Country	1995	1999	2001	2003	2005	2007	2008	2009
Brazil								
Resident	19.7	13.2	19.1	NA	10.2	NA	9.5	NA
Nonresident	80.3	86.8	80.9	NA	89.8	NA	90.5	NA
Patents (number)	2,659	3,219	3,589	NA	2,439	NA	2,451	NA
China								
Resident	45.1	40.6	33.1	30.7	38.8	47.0	49.7	50.9
Nonresident	54.9	59.4	66.9	69.3	61.2	53.0	50.3	49.1
Patents (number)	3,393	7,637	16,296	37,154	53,305	67,948	93,706	128,489
India								
Resident	25.7	29.3	34.2	40.3	32.3	NA	NA	NA
Nonresident	74.3	70.7	65.8	59.7	67.7	NA	NA	NA
Patents (number)	1,613	2,160	1,549	1,526	4,320	15,318	18,230	NA
Russia								
Resident	81.4	78.7	84.6	83.3	83.1	80.0	77.3	75.5
Nonresident	18.6	21.3	15.4	16.7	16.9	20.0	22.7	24.5
Patents (number)	25,633	19,508	16,292	24,758	23,390	23,028	28,808	34,824

NA = not available

NOTES: Country of origin is based on first named applicant. Year of patent is based on date of patent grant.

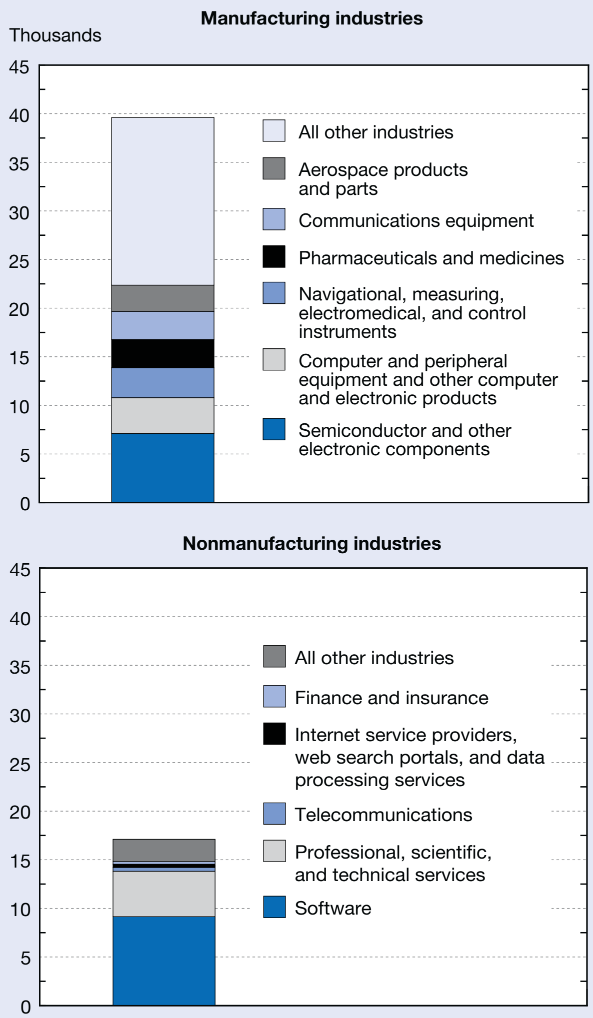
SOURCE: World Intelllectual Property Organization, Intellectual Property Statistics, Patent grants by patent office by resident and nonresident, http://www.wipo.int/ipstats/en/statistics/patents/, accessed 15 June 2011.

Science and Engineering Indicators 2012

According to the NSF BRDIS survey, U.S. KTI industries account for a large share of USPTO patent grants (figure 6-41 and appendix table 6-46). U.S. HT industries were granted 23,000 patents, 57% of the 40,000 patents granted to all U.S. manufacturing industries in 2009. The U.S. semiconductor industry was issued the largest number of patents (7,000) among these HT industries, followed by 3,000 to 4,000 each for aerospace, computers, communications equipment, pharmaceuticals, and scientific and measuring equipment.

U.S. commercial KI services received 86% of the 17,000 patents issued to nonmanufacturing industries (figure 6-41 and appendix table 6-46). The software industry accounted for 9,000 patents, more than half of the patents issued to commercial KI services; professional and technical services were ranked second with 5,000 patents. Two industries in professional and technical services—scientific research and development services and computer systems design—reported significant patenting activity.

Figure 6-41
USPTO patents granted, by selected U.S. industry: 2009



NOTES: Detail may not add to total because of rounding. Industry classification based on dominant business code for domestic R&D performance where available. For companies that did not report business codes, classification used for sampling was assigned. Companies with fewer than five domestic employees not included.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Business R&D and Innovation Survey, 2008. See appendix table 6-46.

Science and Engineering Indicators 2012

USPTO Patents Granted, by Technology Area

This section discusses trends in several technology areas in a new technology classification system that includes broad science and technologically advanced areas that are emerging and technologies closely aligned with HT industries. The largest area is ICT, which consists of networking, information processes, telecommunications, semiconductors, and computer systems (table 6-8 and appendix tables 6-45 and 6-47). It accounts for nearly 40% of all USPTO patents. Health-related technologies consist of biotechnology, pharmaceuticals, medical electronics, and medical equipment. A third broad area includes automation, control, and measuring technologies.

Several of these advanced and emerging technologies were among the fastest growing patent areas during the 2000s (table 6-8). Patents in networking grew at a nearly 20% average annual pace over the decade, information processes grew by 13%, and telecommunications and automation and control grew by 9%, compared to a 3% growth in total patents granted (appendix tables 6-45, 6-48, 6-49, 6-50, and 6-51). Other fast-growing technologies were medical electronics, semiconductors, optics, and measurement techniques and instrumentation (appendix tables 6-52, 6-53, 6-54, and 6-55).

Technologies that lagged behind overall growth in patents included pharmaceuticals, materials, and aerospace and defense (table 6-9 and appendix tables 6-56, 6-57, and 6-58). Weak activity in pharmaceuticals coincides with consolidation of the pharmaceutical industry in the last several years, stronger price and safety regulation of drugs in many developed countries, increased competition from generics, and little growth in Food and Drug Administration approval of new drugs (figure 6-42).

The next section will present patent technology activity indexes for selected regions/countries/economies, which measure the world share of a region, country, or economy in patents in a particular technology relative to its world share in all patents. A ratio greater than 1 signifies that patents by a region/country/economy are concentrated in a particular technology.

ICT: Computer Systems, Information Processes, Networking, Semiconductors, and Telecommunications. U.S. patents are concentrated in three ICT-related technologies: information processes, networking, and telecommunications, with special strength in information processes and networking (table 6-9 and appendix tables 6-45, 6-48, 6-49, and 6-50). U.S. patenting activity, however, is comparatively weak in semiconductors (appendix table 6-53).

EU patenting activity in ICT is comparatively low (table 6-9 and appendix tables 6-45, 6-48, 6-49, 6-50, 6-53, and 6-59). Several studies suggest that the EU has lagged behind the United States in ICT technology, but the pattern may also reflect a preference of EU inventors to patent in the European Patent Office. The United Kingdom is an

Table 6-8
USPTO patents granted, by selected technology area: Selected years, 2000–10

Technology area	2000	2003	2005	2007	2009	2010	Average annual change: 2000–10 (%)
All technologies	157,489	169,020	143,805	157,282	167,350	219,642	3.4
Networking	1,785	2,626	3,321	4,859	6,921	9,861	18.6
Information processing	6,539	7,533	8,141	11,672	15,075	22,038	12.9
Automation and control	1,591	1,843	1,856	2,773	3,225	3,951	9.5
Telecommunications	6,526	7,385	7,125	10,264	11,138	14,727	8.5
Medical electronics	2,066	2,575	2,026	2,439	2,565	3,489	5.4
Semiconductors	10,856	13,108	11,036	11,440	11,974	16,665	4.4
Optics	4,550	6,417	6,696	6,597	6,683	6,875	4.2
Measurement techniques and instrumentation	7,391	9,219	8,406	9,478	9,790	10,918	4.0
Biotechnology	5,606	5,379	4,117	5,940	5,826	8,206	3.9
Computer systems	8,848	9,789	9,711	10,506	11,680	12,654	3.6
Aerospace and defense	1,702	2,110	1,781	1,434	1,679	2,098	2.1
Medical equipment	6,929	7,412	4,913	4,582	4,691	7,424	0.7
Pharmaceuticals	5,388	5,590	3,911	3,835	4,275	5,471	0.2
Materials	5,580	5,793	4,006	3,658	3,582	5,193	–0.7

USPTO = U.S. Patent and Trademark Office

NOTE: Technologies classified by The Patent Board™.

SOURCE: The Patent Board™, Proprietary Patent database, special tabulations (2011). See appendix tables 6-48–6-61.

Science and Engineering Indicators 2012

Table 6-9
Activity in USPTO patent grants in selected technology areas, by selected region/country/economy: 2007–10 average

Technology area	Activity index						
	United States	EU	Japan	South Korea	Taiwan	China	India
All ICT	1.09	0.73	0.90	1.38	1.02	0.95	1.60
Computer systems	0.99	0.53	1.22	1.66	1.15	1.01	1.48
Information processes	1.31	0.75	0.66	0.43	0.37	1.01	2.35
Networking	1.31	0.80	0.50	0.68	0.38	1.03	2.30
Semiconductors	0.83	0.59	1.28	2.47	2.08	0.60	0.69
Telecommunications	1.03	1.03	0.73	1.59	0.94	1.12	1.31
Automation and control	1.10	0.94	0.85	0.72	1.17	1.39	0.92
Measuring and instrumentation	1.01	1.25	0.94	0.56	0.63	1.05	0.78
Optics	0.65	0.72	1.74	2.33	1.52	0.64	0.12
Biotechnology	1.23	1.28	0.42	0.35	0.29	0.86	1.57
Pharmaceuticals	1.03	1.95	0.45	0.26	0.20	0.75	4.64
Medical electronics	1.26	1.18	0.62	0.18	0.11	0.57	0.55
Medical equipment	1.40	1.03	0.33	0.14	0.39	0.38	0.18
Aerospace and defense	1.30	1.60	0.19	0.10	0.26	0.15	0.50
Materials	0.81	1.45	1.32	0.82	0.39	0.80	1.63

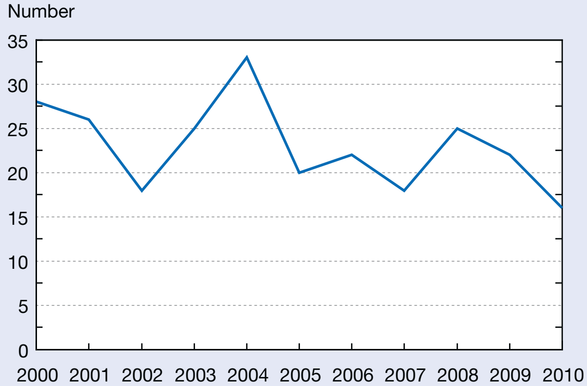
EU = European Union; ICT = information and communications technology; USPTO = U.S. Patent and Trademark Office

NOTES: Activity index consists of ratio of region/country/economy's share of indicated technology to region/country/economy's share of total grants. A ratio of greater than one signifies more active patenting in the selected technology; a ratio of less than one signifies less active patenting. Technologies classified by The Patent Board™. Patent grants fractionally allocated among regions/countries/economies on basis of proportion of residences of all named inventors. China includes Hong Kong.

SOURCE: The Patent Board™, Proprietary Patent database, special tabulations (2011). See appendix tables 6-47–6-56 and 6-58–6-61.

Science and Engineering Indicators 2012

Figure 6-42
New drugs approved by the FDA: 2000–10



FDA = U.S. Food and Drug Administration

NOTE: New drugs consist of FDA-approved new molecular entities, ester, salt, or other noncovalent derivatives.

SOURCE: U.S. Food and Drug Administration, Drugs@FDA, http://www.accessdata.fda.gov/scripts/cder/drugsatfda/index.cfm?fuseaction=Reports.ReportsMenu, accessed 15 May 2011.

Science and Engineering Indicators 2012

exception in the EU with stronger activity in networking, telecommunications, and information processes, similar to the United States.

In Asia, Japan, South Korea, and Taiwan have similar ICT patterns, with strength in computer systems and semiconductors balanced by weaker activity in networking and information processes (table 6-9 and appendix tables 6-45, 6-48, 6-49, 6-50, 6-53, and 6-59). China has an uneven pattern in ICT technologies, with relative strength in telecommunications but average or low activity in other ICT areas. In a pattern that is consistent with an emphasis on developing ICT service industries, India scores high in all ICT areas but semiconductors.

Biotechnology, Medical Electronics, Medical Equipment, and Pharmaceuticals. The United States and the EU have relatively strong patenting activity in these health-related technologies (table 6-9 and appendix tables 6-45, 6-52, 6-56, 6-60, and 6-61). The United States is much weaker in pharmaceuticals, where the EU excels, and stronger in medical equipment.

Four of the Asian economies are very weak in these biomedical technologies (table 6-9 and appendix tables 6-45, 6-52, 6-56, 6-60, and 6-61). The exception is India, which has very strong activity in pharmaceuticals and biotechnology that coincides with its market presence in these industries.

Automation and Control, Measuring and Instrumentation, and Optics. These are areas of generally low patent activity. Relative strengths are automation and control for the United States, measuring techniques and instrumentation for the EU, and optics for Japan, South Korea, and Taiwan (table 6-9, and appendix tables 6-45, 6-51, 6-54, and 6-55). China's relative strength is in automation and control.

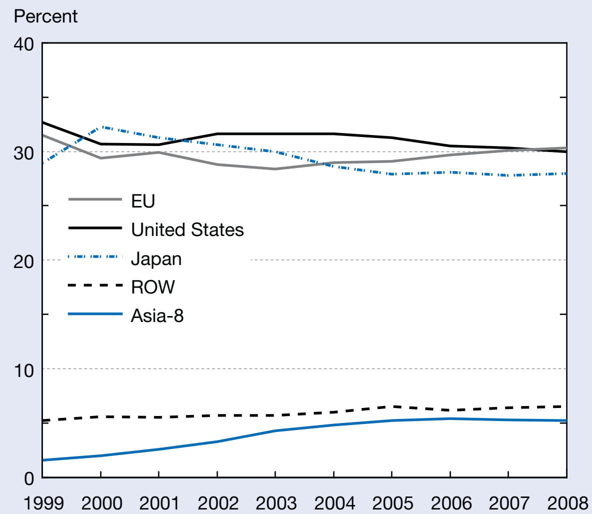
Aerospace and Defense and Materials. The United States and EU have a strong concentration in aerospace and defense, to which the EU adds strength in materials (table 6-9 and appendix tables 6-45, 6-57, and 6-58). This is also a strength for Japan, but the other Asian economies have comparatively low activity levels in these areas.

Patenting Valuable Inventions: "Triadic" Patents

Using patent counts as an indicator of national inventive activity does not differentiate between inventions of minor and substantial economic potential. Inventions for which patent protection is sought in three of the world's largest markets—the United States, the EU, and Japan—are likely to be viewed by their owners as justifying the high costs of filing and maintaining these patents in three markets. These "triadic patents" serve here as an indicator of higher value inventions.

The number of such "triadic" patents was estimated at about 48,000 in 2008 (the last year for which these data are available), up from 45,000 in 1999, and showing little growth after 2004 (figure 6-43 and appendix table 6-63). The United States, the EU, and Japan held basically equal shares and their nearly identical positions in triadic patents contrast with the far greater gap between them in USPTO

Figure 6-43
Global triadic patent families, by share of selected region/country/economy: 1999–2008



EU = European Union; ROW = rest of world

NOTES: Triadic patent families include patents applied for in U.S. Patent and Trademark Office, European Patent Office, and Japan Patent Office. Patent families fractionally allocated among regions/countries/economies based on proportion of residences of all named inventors. Asia-8 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. EU includes current member countries.

SOURCE: Organisation for Economic Co-operation and Development, Patents Statistics, http://stats.oecd.org/WBOS/index.aspx, Patents by Region database, accessed 15 January 2011. See appendix table 6-63.

Science and Engineering Indicators 2012

patent grants.[29] The United States, the EU, and Japan together accounted for more than 93% of triadic patents in 1997, but that share dropped to 88% by 2008, largely reflecting a rapid rise in South Korean filings to 5% of the total.

Trademark Applications

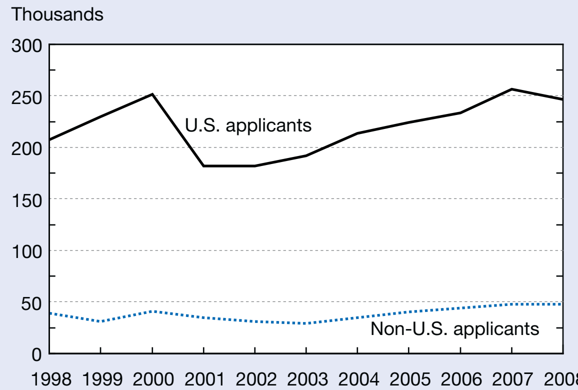
Firms use trademarks to launch new products and services, promote their brand, signal novelty, and appropriate the benefits of their innovation. Trademarks enable companies to establish exclusive identities for their new goods and services and to distinguish their products from those of competitors. Trademarks are considered a downstream indicator of innovation, showing the efforts of firms to build brand equity in new products and services. Because the U.S. market is large and open, this section will use applications for U.S trademarks as a measure of innovation activity for both the United States and other countries.

The total number of U.S. trademark applications was about 300,000 in 2008, with 250,000 applications originating from within the United States (figure 6-44 and appendix table 6-64). The EU, Canada, Switzerland, Japan, and China are the main sources of U.S. trademark applications from outside the United States (figure 6-45). The EU had the largest number of applications from abroad with 22,000, followed by Canada (6,500). Japan and China had the most activity among Asian economies with 3,200 and 2,500, respectively.

The number of U.S. trademark applications rose 20% from 1998 to 2008, although it dropped sharply during the recession of the early 2000s, and again showed signs of slowing during the late-decade recession (figure 6-44 and appendix table 6-64). The U.S. share has fluctuated between 83% and 88%. Among foreign applications, the EU share was consistently just below 50%, and Japan's share was approximately 7%–8% for the period (figure 6-45). China's share grew from 1% in 1998 to 5% in 2008. South Korea and India, although they have growing numbers of patent grants, have little trademark activity.

Patterns in trademark applications by class may indicate innovation activity in related technology or industry areas. Classes related to KTI industries are among those with the most applications in 2008. After advertising, the scientific and measuring category had the second-largest share of applications (10%) (figure 6-46). Several other classes—insurance and finance, science and technology, R&D and computer design, pharmaceuticals, and medical services—had shares of 2%–5% each.

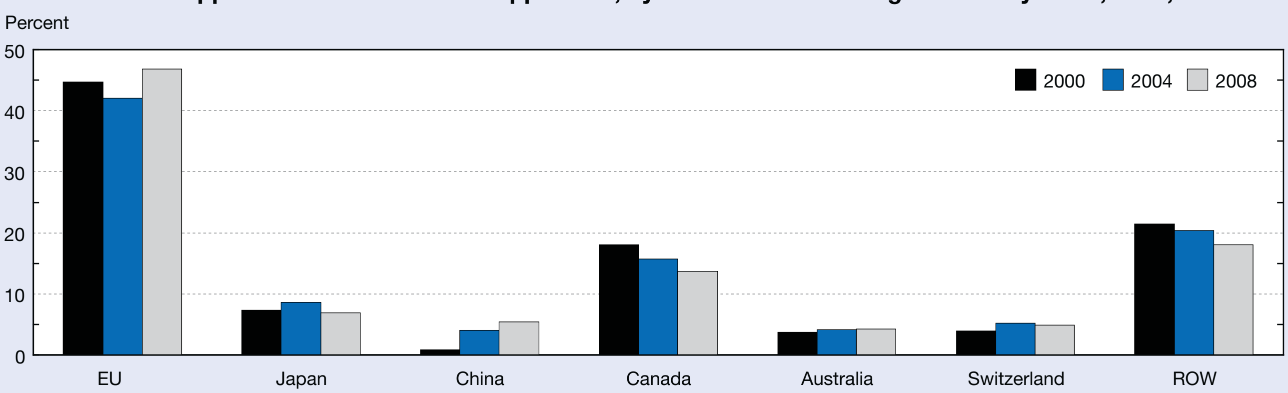
Figure 6-44
U.S. trademark applications by U.S. and non-U.S. applicants: 1998–2008



SOURCE: World Intellectual Property Organisation, Statistics on Trademarks, http://www.wipo.int/ipstats/en/statistics/marks/, accessed 15 February 2011. See appendix table 6-64.

Science and Engineering Indicators 2012

Figure 6-45
U.S. trademark applications from non-U.S. applicants, by share of selected region/country: 2000, 2004, and 2008



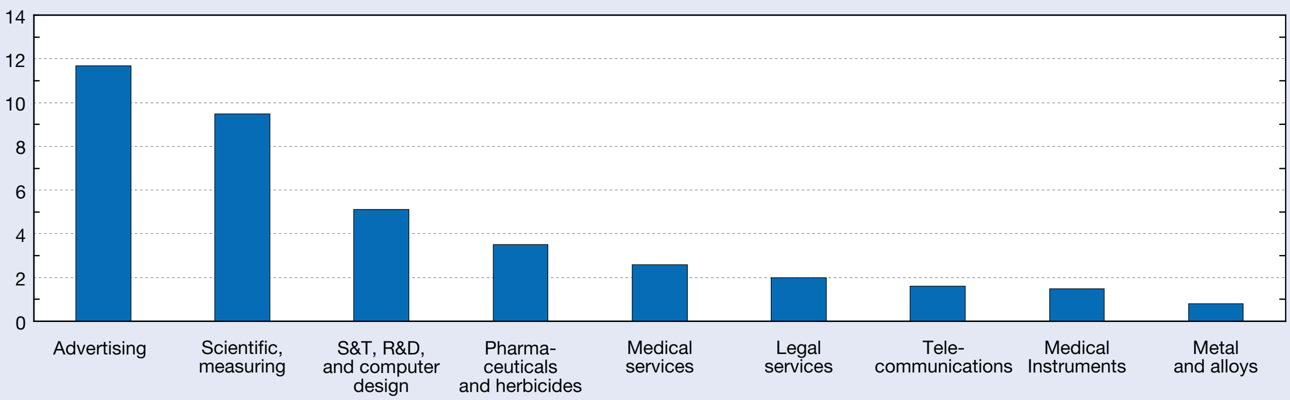
EU = European Union; ROW = rest of world

NOTES: EU includes current member countries. China includes Hong Kong.

SOURCE: World Intellectual Property Organisation, Statistics on Trademarks, http://www.wipo.int/ipstats/en/statistics/marks/, accessed 15 February 2011. See appendix table 6-64.

Science and Engineering Indicators 2012

Figure 6-46
Share of scientific and advanced-technology related classes of U.S. trademark applications: 2008



S&T = science and technology

SOURCE: World Intellectual Property Organisation, Statistics on Trademarks, http://www.wipo.int/ipstats/en/statistics/marks/, accessed 15 February 2011.

Science and Engineering Indicators 2012

U.S. High-Technology Small Businesses

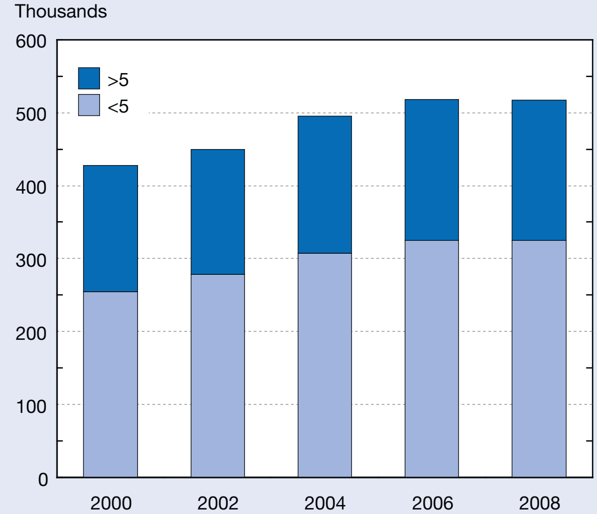
Many of the new technologies and industries seen as critical to U.S. innovation and economic growth are also identified with small businesses. Many large HT businesses invest in and acquire small businesses as part of their efforts to develop and commercialize new technologies. Biotechnology, the Internet, and computer software are examples of industries built around new technologies in whose initial commercialization microbusinesses—those with fewer than five employees—played an important role. Trends in the number of microbusinesses in emerging or established HT sectors may point to innovative industries with future areas of growth. This section covers patterns and trends that characterize microbusinesses operating in HT industries, based on data from the Census Bureau. Two sources of financing for HT small businesses—angel investment and venture capital investment—are also examined using data from the National Venture Capital Association and other sources.

Characteristics of Microbusinesses in U.S. High-Technology Industries

According to U.S. Census data, the number of microbusinesses in industries classified as HT by the Bureau of Labor Statistics (BLS) is about 325,000, more than 60% of all firms operating in these industries (figure 6-47).[30] Services account for more than 90% (300,000) of U.S. HT microbusinesses, 20,000 operate in HT manufacturing, and 5,000 are in other industries. The proportion of services in non-HT microbusinesses is lower at 81%.[31]

The three HT services with the largest number of microbusinesses are management, scientific, and technical consulting; computer systems design; and architectural and engineering. HT manufacturing industries with large numbers of microfirms include navigational, measuring, and electromedical equipment and semiconductors (table 6-10).

Figure 6-47
Number of U.S. high-technology firms, by size: Selected years, 2000–08



NOTES: Firms with less than five employees include those reporting no employees on their payroll. Firm is an entity that is either a single location with no subsidiary or branches or topmost parent of a group of subsidiaries or branches. High-technology industries are defined by Bureau of Labor Statistics on basis of employment intensity of technology-oriented occupations. High-technology small business employment is lower bound estimate because employment not available for a few industries due to data suppression.

SOURCES: U.S. Census Bureau, Statistics of U.S. Businesses, http://www.census.gov/econ/susb/, accessed 15 March 2011; Hecker DE. High-technology employment: A NAICS-based update, *Monthly Labor Review* 128(7):57–72 (2006), http://www. bls.gov/ opub/mlr/2005/07/art6full.pdf, accessed 15 March 2011.

Science and Engineering Indicators 2012

Table 6-10
U.S. high-technology microbusinesses, by number of firms and employment for selected industries: 2008

High-technology Industry	Firms: Number	Firms: Industry share of firms (%)	Employment: Employees	Employment: Industry share of employees (%)
All high-technology microbusinesses	325,447	100.0	465,162	100.0
All high-technology services	300,487	92.3	420,099	90.3
Management, scientific, and technical consulting services	111,965	34.4	138,337	29.7
Computer systems design and related services	80,670	24.8	107,524	23.1
Architectural, engineering, and related services	62,234	19.1	99,932	21.5
Professional and commercial equipment and supplies merchant wholesalers	13,301	4.1	23,786	5.1
Scientific research and development services	7,088	2.2	11,001	2.4
Data processing, hosting, and related services	4,598	1.4	6,883	1.5
Management of companies and enterprises	3,392	1.0	4,365	0.9
Software publishers	2,310	0.7	3,977	0.9
Wired telecommunications carriers	1,521	0.5	2,477	0.5
Wireless telecommunications carriers (except satellite)	717	0.2	1,245	0.3
Facilities support services	642	0.2	1,030	0.2
Satellite telecommunications	388	0.1	583	0.1
All high-technology manufacturing	19,682	6.0	36,515	7.8
Metalworking machinery manufacturing	2,600	0.8	5,306	1.1
Other fabricated metal product manufacturing	2,032	0.6	3,759	0.8
Navigational, measuring, electromedical, and control instruments manufacturing	1,640	0.5	3,036	0.7
Other general purpose machinery manufacturing	1,602	0.5	3,044	0.7
Motor vehicle parts manufacturing	1,555	0.5	2,934	0.6
Industrial machinery manufacturing	1,118	0.3	2,189	0.5
Semiconductor and other electronic component manufacturing	1,098	0.3	1,982	0.4
Electrical equipment manufacturing	648	0.2	1,289	0.3
Computer and peripheral equipment manufacturing	495	0.2	804	0.2
Pharmaceutical and medicine manufacturing	466	0.1	848	0.2
Communications equipment manufacturing	382	0.1	659	0.1
Aerospace product and parts manufacturing	366	0.1	592	0.1
Audio and video equipment manufacturing	207	0.1	387	0.1
Resin, synthetic rubber, and artificial synthetic fibers and filaments manufacturing	154	0.0	263	0.1
All other industries	5,278	1.6	8,548	1.8
Oil and gas extraction	4,545	1.4	7,433	1.6
Electric power generation, transmission, and distribution	342	0.1	547	0.1

NOTES: Microbusinesses are firms with fewer than five employees and include those reporting no employees on their payroll. Firm is an entity that is either a single location with no subsidiary or branches or topmost parent of a group of subsidiaries or branches. High-technology industries defined by Bureau of Labor Statistics on basis of employment intensity of technology-oriented occupations.

SOURCE: U.S. Census Bureau, Statistics of U.S. Businesses, http://www.census.gov/econ/susb/, accessed 15 March 2011; and Hecker DE. High-technology employment: A NAICS-based update, *Monthly Labor Review* 128(7):57–72 (2006), http://www.bls.gov/opub/mlr/2005/07/art6full.pdf, accessed 15 March 2011.

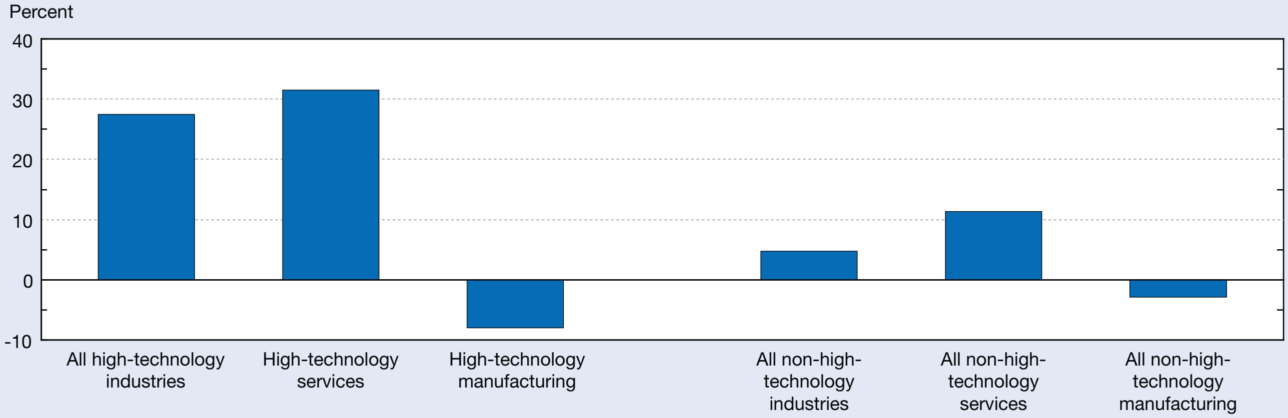
Science and Engineering Indicators 2012

The number of microfirms in BLS-classified HT industries grew much faster than in other industries from 2000 to 2008 (figure 6-48). Growth of microfirms in services classified as HT was three times that in other service industries. However, the number of microfirms in manufacturing classified as HT had a deeper decline than in other manufacturing industries.

Financing of High-Technology Small Businesses

Entrepreneurs seeking to start or expand a small firm with new or unproven technology may not have access to public or credit-oriented institutional funding. Often, they rely on friends and family for financing. However, when they need or can get access to larger amounts of financing, angel capital and venture capital investment are often critical to financing nascent and entrepreneurial HT businesses. (In this section, business denotes anything from an entrepreneur with an idea to a legally established operating company.)

Figure 6-48
Growth in number of U.S. microbusinesses, by selected industry: 2000–08



NOTES: Microbusinesses are firms with less than five employess and those reporting no employees on their payroll. Firm is an entity that is either a single location with no subsidiary or branches or topmost parent of a group of subsidiaries or branches. High-technology industries are defined by Bureau of Labor Statistics on basis of employment intensity of technology-oriented occupations. High-technology small business employment is lower bound estimate because employment not available for a few industries due to data suppression.

SOURCES: U.S. Census Bureau, Statistics of U.S. Businesses, http://www.census.gov/econ/susb/, accessed 15 March 2011; Hecker DE, High-technology employment: A NAICS-based update, *Monthly Labor Review* 128(7):57–72 (2006), http://www.bls.gov/opub/mlr/2005/07/art6full.pdf, accessed 15 March 2011.

Science and Engineering Indicators 2012

An angel investor is a person who provides capital, in the form of debt or equity, from his or her own funds to a private business owned and operated by someone else who is neither friend nor family (Shane 2008). Angel investors may invest on their own as individuals or through an informal network of affiliated investors. Angel funds are more formal organizations where groups of investors pool their resources and jointly invest in businesses.

Venture capitalists pool the investments of others (typically wealthy investors, investment banks, retirement funds, and other financial institutions) in a professionally managed fund. They receive ownership equity in the companies in which they invest, and they almost always participate in managerial decisions.

Angel and venture capital investment are generally categorized into four broad stages of financing:

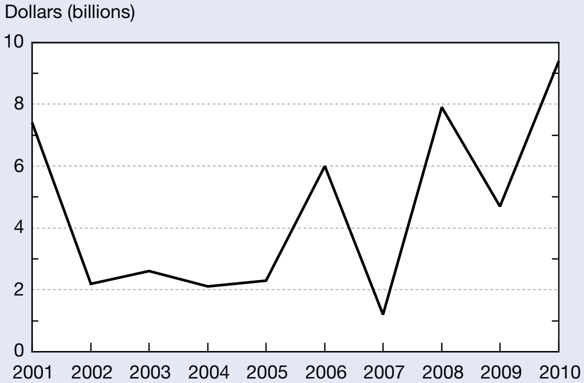
- **Seed and startup** supports proof-of-concept development (seed) and initial product development and marketing (startup or first round).
- **Early stage** supports the initiation of commercial manufacturing and sales.
- **Expansion** provides working capital for company expansion, funds for major growth (including plant expansion, marketing, or development of an improved product), and financing to prepare for an initial public offering (IPO).
- **Later stage** includes acquisition financing and management and leveraged buyouts. Acquisition financing provides resources for the purchase of another company, and a management and leveraged buyout provides funds to enable operating management to acquire a product line or business from either a public or a private company.

This section examines angel capital and venture capital investment patterns in the United States and internationally, focusing on the period from 2001 to 2008. The section examines (1) changes in the overall level of angel and venture capital investment, (2) venture capital investment outside the United States, (3) angel and venture capital investment by stage of financing, and (4) the technology areas that U.S. angel and venture capitalists find attractive.

U.S. angel investment. There are no sources of current, nationally representative data that directly measure U.S. angel investment. Data on U.S. angel investment have largely been restricted to samples that are not nationally representative or that rely disproportionately on angel groups and thereby exclude individual investors. This section will examine two data sources that provide some data on the level and activities of U.S. angel investment, the Global Entrepreneurship Monitor's (GEM's) survey of U.S. informal investment and the Angel Capital Association.

The GEM's U.S. survey is a nationally representative survey that provides a variety of data on patterns of U.S. entrepreneurship, including informal investment. The survey asks respondents who identify themselves as informal investors about their relationship with the person that received their investment, ranging from close family members to strangers. The proportion of strangers provides a crude estimate of the level of U.S. angel investment. By that measure, U.S. angel investment was estimated at $9 billion in 2010 (figure 6-49). Estimated U.S. angel investment has fluctuated widely between 2001 and 2010, from a low of $1 billion in 2007 to a high of $9 billion in 2010.

Figure 6-49
Estimated U.S. angel investment: 2001–10

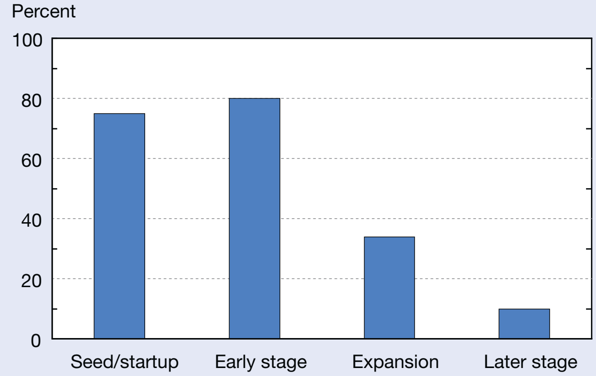


NOTES: U.S. angel investment estimated from the Global Entrepreneurship Monitor's annual survey of the United States. Angel investment is estimated from the proportion of informal investors that lend to strangers multiplied by the average amount of investment per investor and the share of informal investors of the U.S. population of ages 18–99.

SOURCES: Global Entrepreneurship Monitor, http://www.gemconsortium.org/default.aspx; U.S. Census Bureau, Population Estimates, http://www.census.gov/popest/estbygeo.html, accessed 15 May 2011.

Science and Engineering Indicators 2012

Figure 6-50
Investment in financing stages preferred by Angel Capital Association member groups: 2009



NOTES: Percent is share of Angel Capital Association member groups that express preferrence in investing in indicated investment stage. Seed and startup round supports proof-of-concept development (seed) and initial product development and marketing (startup). Early stage supports initiation of commercial manufacturing and sales. Expansion stage provides working capital for company expansion, funds for major growth (including plant expansion, marketing, or development of an improved product), and financing to prepare for an initial public offering. Later-stage funds include acquisition financing and management and leveraged buyouts.

SOURCE: Angel Capital Association Group, Investing through Angel Groups, http://www.angelcapitalassociation.org/, accessed 15 May 2011.

Science and Engineering Indicators 2012

The estimated level of angel investment is significantly lower than that of venture capital investment during this period, and anecdotal evidence suggests that HT areas receive a minority of U.S. angel investment. The returns to angel investors in lower technology industries can be very high, and many individual angel investors make limited or one-time investments, often in lower technology industries (Shane 2008).

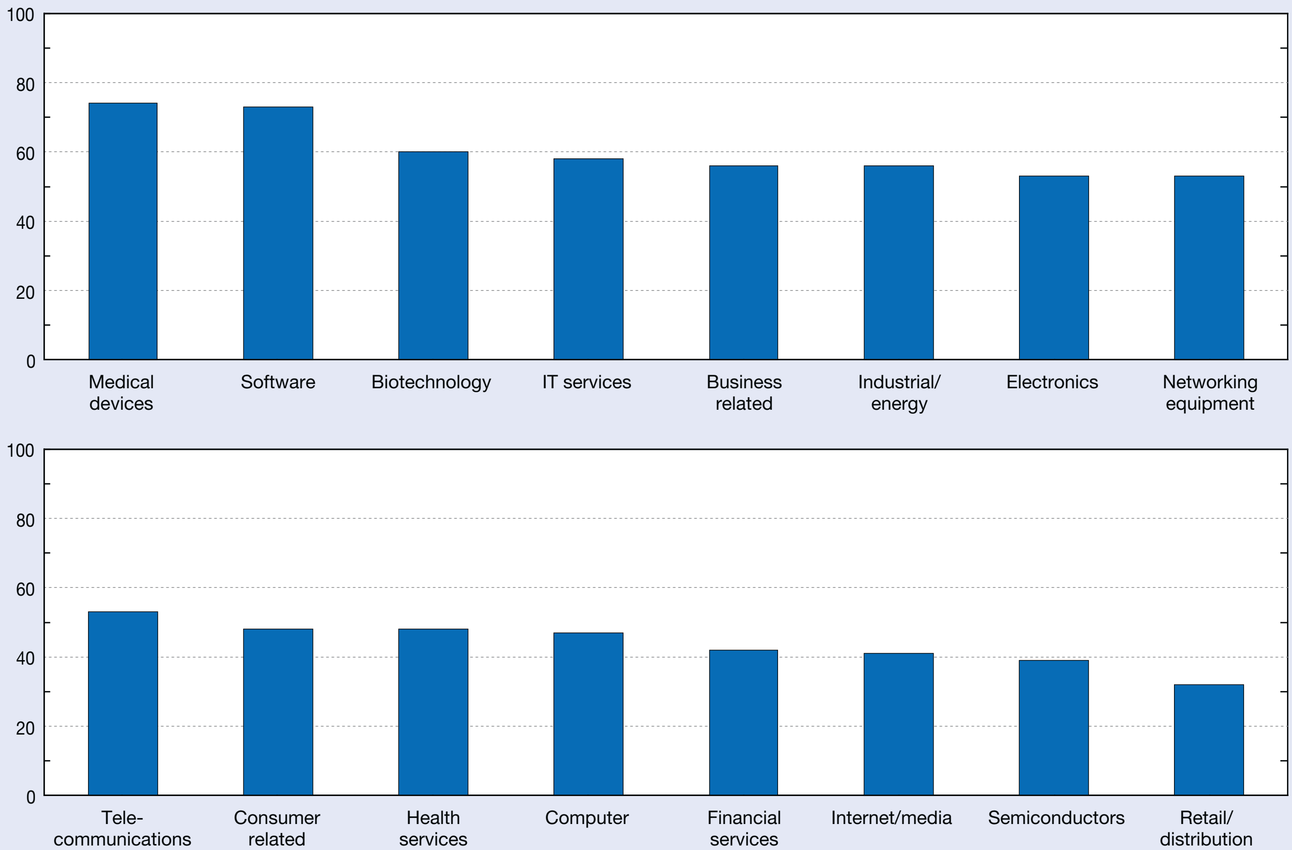
In contrast with individual angel investors, angel networks and groups are more likely to invest a larger share in HT industries. Angel groups allow angels to exchange and analyze information about industries and talk with experts on technologies. Angel groups that pool their investments can invest larger amounts that may be required for HT industries, such as biotechnology or medical devices.

The Angel Capital Association (ACA) is a trade association of 150 leading angel groups in North America. According to ACA's survey of its members, the average investment for an ACA group fell from $1.8–$1.9 million in 2007–08 to $1.4 million in 2009 during the recession. The majority prefer to invest in the earlier stages of financing of companies, with 70%–80% reporting preferences for seed/startup or early-stage financing (figure 6-50). Financing for the later stages of business operations—expansion and later stage—is far less preferred, with 33% preferring the expansion stage and only 10% preferring later stage financing. ACA members expressed strong interest in investing in HT industries (figure 6-51). Software and medical devices have the highest level of interest, with more than 70% of members showing interest, followed by biotechnology with 60%. Half or more of members expressed interest in investing in IT services, industrial/energy, telecommunications, and networking equipment.

Venture capital investment. Data from Dow Jones Venture Capital show that global venture capital investment rose more than 40% from $28 billion in 2005 to $41 billion in 2008 (figure 6-52). It fell sharply to $28 billion in 2009 in the midst of the recession. Investment rebounded in 2010 to reach $34 billion. The United States is the main source of venture capital financing, providing nearly 80% of global investment in 2010. U.S. venture capital investment grew 29%, from $24 billion to $31 billion, during this period. U.S. investment fell sharply in 2009 before growing modestly in 2010 to reach $26 billion. U.S. venture capital investment lagged behind the growth in non-U.S. investment between 2005 and 2010. As a result, the U.S. share of global venture capital investment fell from 85% to 78% during that period.

Venture capital investment originating outside the United States grew rapidly but from a low level, nearly doubling from $4 billion in 2005 to $7 billion in 2010 (figure 6-53). China led the growth in non-U.S. venture capital investment, with its investment tripling from $1.3 billion to $4 billion during the period from 2005 to 2010. China surpassed Europe in 2006 to become the largest source of non-U.S. investment, with its share reaching more than 50% in 2010. The remaining countries and regions—Canada, Europe, Israel, and India—provide small and relatively stable amounts of venture capital, with their shares of non-U.S venture capital investment ranging from 8% to 14%.

Figure 6-51
Investment in technology areas preferred by member groups of the Angel Capital Association: 2009

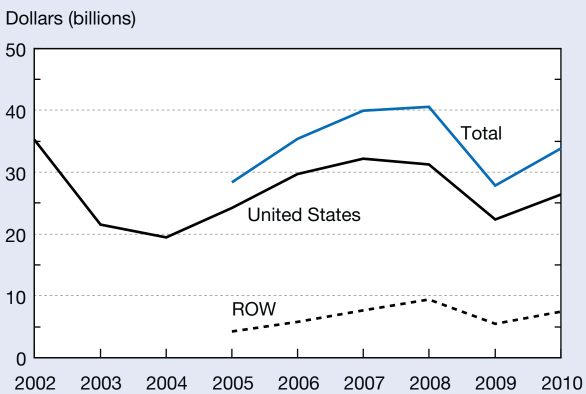


NOTE: Percent is share of Angel Capital Association member groups that express preferrence in indicated technology area.

SOURCE: Angel Capital Association Group, Investing through Angel Groups, http://www.angelcapitalassociation.org/, accessed 15 May 2011.

Science and Engineering Indicators 2012

Figure 6-52
Global and U.S. venture capital investment: 2002–10



ROW = rest of world

NOTE: Data on non-U.S. venture capital investment not available for 2002–04.

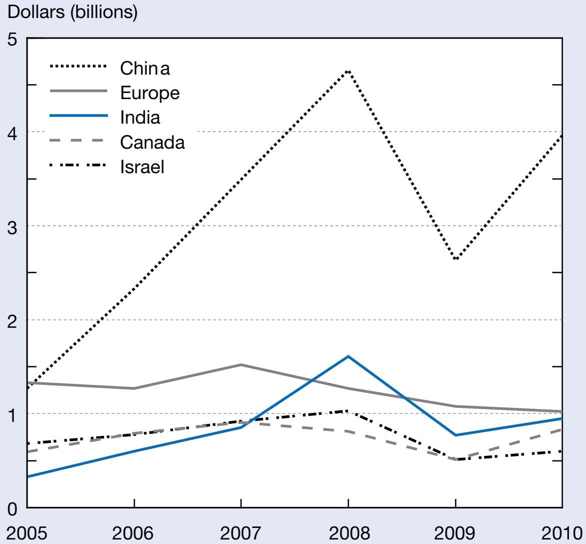
SOURCE: Dow Jones, special tabulations (2011) from VentureSource database, http://www.dowjones.com/info/venture-capital-data.asp. See appendix table 6-65.

Science and Engineering Indicators 2012

U.S. venture capital investment by financing stage. Knowledgeable observers believe that venture capital investment has become generally more conservative during the 2000s.[32] Later stage venture capital investment has both grown in absolute terms and as a share of total investment, from $10.8 billion (50% share of total investment) in 2002 to $17.4 billion (65% share) in 2010 (figure 6-54 and appendix table 6-65). The shift to later stage, more conservative investing has been attributed to a desire for lowered investment risk, higher minimum investment levels, which typically exceed earlier stages, a shorter time horizon for realizing gains, a decline in yields of venture capital investment, and the sharp decline in IPOs and acquisitions of venture capital-backed firms, which has required venture capital investors to provide additional rounds of financing.

In 2010, U.S. venture capital investment in the early stage, consisting of seed, startup, and initiation of commercial activities, was $4.6 billion, slightly higher than its level in 2002 but well below its prerecession peak of $7.9 billion in 2007 (figure 6-54 and appendix table 6-65). The early-stage share of total venture capital investment has declined steadily, from about 33% in the late 1990s to 20%–25% for much of the

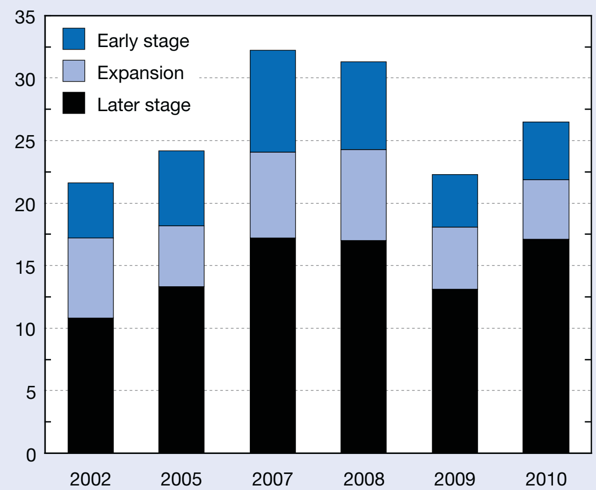
Figure 6-53
Non-U.S. venture capital investment, by region/country: 2005–10



SOURCE: Dow Jones, special tabulations (2011) from VentureSource database, http://www.dowjones.com/info/venture-capital-data.asp.

Science and Engineering Indicators 2012

Figure 6-54
U.S. venture capital investment, by financing stage: Selected years, 2002–10



NOTES: Early stage consists of seed, startup, and initiation of commercial sales. Expansion consists of second round financing that provides working capital for company expansion, and financing to prepare for initial public offering. Later stage includes acquistion financing and management and leverage buyouts.

SOURCE: Dow Jones, special tabulations (2011) from VentureSource database, http://www.dowjones.com/info/venture-capital-data.asp. See appendix table 6-65.

Science and Engineering Indicators 2012

2000s, and down to 17%–19% in 2009–10. The decline in early-stage investment both in absolute terms and as a share of total investment has amplified concerns that there is a growing lack of adequate financing for very young HT firms seeking to grow and successfully commercialize their technologies.

U.S. venture capital financing by technology. Five technologies—software, biopharmaceuticals, medical devices and equipment, consumer information services, and business support services—dominate venture capital financing (table 6-11 and appendix table 6-65). During 2007–10, these five technologies accounted for more than 60% of total and early-stage investment. Software and biopharmaceuticals received the most financing, with each receiving nearly $18 billion in total financing. Total and early-stage investment in software dropped sharply (33%–44%) between 2002 and 2010, reducing software's share of venture capital investment by half. Total investment in biopharmaceuticals remained roughly flat but early-stage financing dropped from $900 million to $600 million during this period.

Medical devices and equipment were second, receiving $13 billion in total financing (table 6-11 and appendix table 6-65). Total investment in this technology increased 27% from $1.8 billion in 2002 to $2.2 billion in 2010. Consumer information services and business support services were third, receiving $10–$11 billion. Consumer information services had the fastest growth among these five technologies, with total investment rising exponentially from less than $200 million in 2002 to $4.5 billion in 2010. Growth in early-stage financing was also rapid, rising from less than $50 million to $600 million. Total investment in business support services rose by 70% from $1.5 billion to $2.7 billion, and early-stage investment more than doubled from $200 million to $500 million.

Investment and Innovation in Clean Energy and Technologies

Clean energy and energy-conservation and related technologies, including biofuels, solar, wind, nuclear, energy efficiency, pollution prevention, smart grid, and carbon sequestration, have become a policy focus in developed and developing nations. These technologies are knowledge and technology intensive and thus are closely linked to scientific R&D. Production, investment, and innovation in these energies and technologies are rapidly growing in many countries. Prompted by concerns over the high cost of fossil fuels and their impact on the climate, governments have directed both stimulus funding and long-term investments into these technologies. Private investors have also shown increased interest.

This section will examine public research, development, and demonstration (RD&D) data from the International Energy Agency (IEA) and venture capital and total private financing data from Bloomberg New Energy Finance, by technology and key region. A sidebar, "Government Stimulus Funding for Clean Energy," will summarize various countries' initiatives related to clean energy as part of their stimulus measures or long-range policies. The IEA data discussed here cover research, development, and

Table 6-11
U.S. venture capital investment, by selected financing stage and industry/technology: Selected years, 2002–10
(Millions of U.S. dollars)

Technology/industry	2002	2005	2007	2008	2009	2010	2007–10 total
	All financing stages						
All technologies/industries	21,509	24,207	32,200	31,243	22,348	26,415	112,206
Software	5,612	5,591	5,669	5,153	3,231	3,762	17,815
Biopharmaceuticals	3,243	4,074	5,822	4,626	4,030	3,246	17,725
Medical devices and equipment	1,776	2,361	3,791	3,615	2,959	2,249	12,614
Consumer information services	152	661	1,740	2,525	1,792	4,552	10,610
Business support services	1,471	1,719	2,989	2,808	2,120	2,516	10,433
	Early-stage financing						
All technologies/industries	4,351	5,958	8,104	6,999	4,242	4,570	23,916
Biopharmaceuticals	932	1,139	1,601	1,345	854	578	4,378
Software	1,299	1,139	1,190	839	788	726	3,543
Consumer information services	43	340	878	870	382	623	2,753
Business support services	217	514	905	841	503	462	2,711
Medical devices and equipment	337	437	722	784	356	333	2,194

NOTES: Technologies classified by Dow Jones. Early-stage financing consists of seed, startup, and initiation of commercial sales.

SOURCE: Dow Jones, special tabulations (2011) of VentureSource database, http://www.dowjones.com/info/venture-capital-data.asp. See appendix table 6-65.

Science and Engineering Indicators 2012

demonstration. They are not comparable to energy RD&D data described in Chapter 4, which focus on research and development.[33]

Commercial Investment

According to Bloomberg New Energy Finance, global commercial investment in clean energy and technology from all sources, including early-stage angel and venture capital investment and later stage financing raised from private equity and public capital markets, has risen rapidly from less than an estimated $20 billion in 2004 to nearly $154 billion in 2010 (figure 6-55).[34] This rise has been spurred by government policies, financial incentives, and funding to foster the development of clean energy production and technologies; falling costs in wind and solar energy; and investor perception that this area is ready for large-scale commercialization. The United States, EU, China, and other countries provided additional support of nearly $200 billion to this sector from stimulus funding to help spur recovery from the global recession (see sidebar, “Government Stimulus Funding for Clean Energy”).

The United States generated an estimated $30 billion (19% global share) in clean energy commercial investment in 2010, placing it behind China and roughly equal to the EU (figure 6-55). After peaking at $34 billion in 2008, U.S. commercial investment declined sharply to $20 billion in 2009 during the global financial crisis before recovering in 2010 to reach nearly its pre-crisis peak.

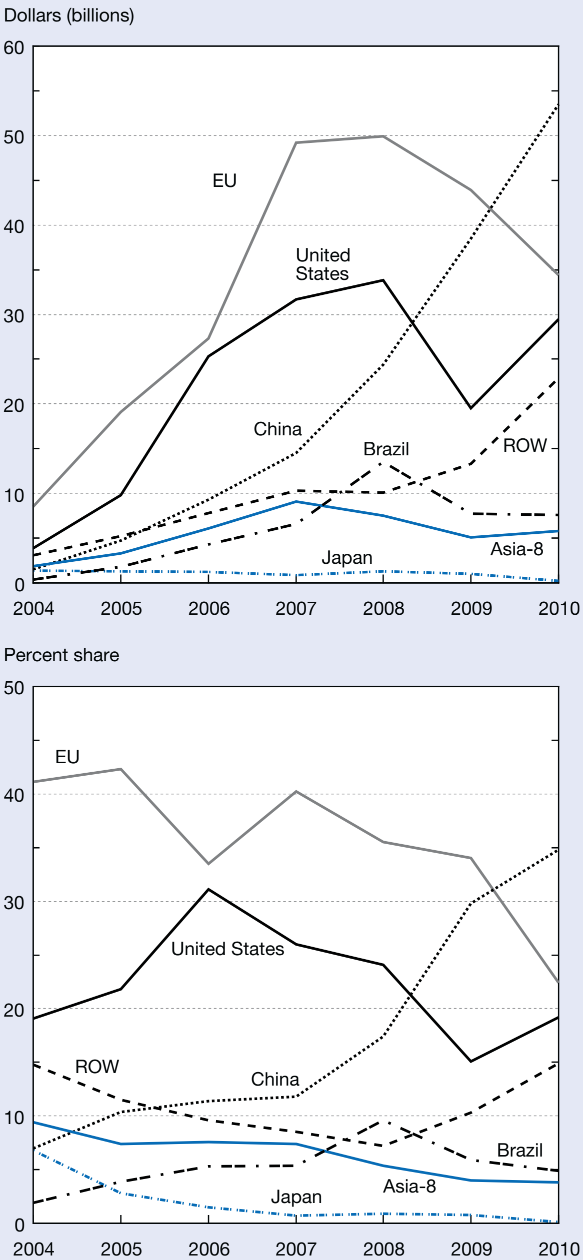
China provided an estimated $54 billion in clean energy financing in 2010, more than any economy in the world (35% share of global investment) (figure 6-55). China’s commercial investment rose exponentially from less than $2 billion in 2004 to $54 billion in 2010, surpassing the United States in 2009 and the EU in 2010. The uninterrupted growth of clean energy investments in China reflects the government’s commitment to reduce China’s reliance on fossil fuels, considerable financing from state development banks (less affected by the financial crisis than other countries/regions), low labor costs, and subsidies to encourage large renewable energy projects, particularly in wind and solar energy.

The EU ties with the United States in clean energy investment, providing an estimated $34 billion in 2010 (22% share of global investment) (figure 6-55). Clean energy investment in the EU has been spurred by government policies such as feed-in tariffs for solar power in Germany and Spain and large-scale investment in offshore wind by the UK. However, EU clean energy investment dropped from $50 billion in 2008 to $23 billion in 2010, reflecting the global recession and sharp cutbacks by Spain, the UK, and other EU countries in their support of solar and other clean energies.

Brazil and the Asia-8 have comparatively low activity in clean energy financing (an estimated $8 and $6 billion, respectively) (figure 6-55). India provides the largest amount of financing ($3.8 billion) from the Asia-8. Investment from both Brazil and the Asia-8 grew rapidly from 2004 to 2010, though from a low base. Japan provided less than $1 billion in clean energy investment in 2010, down sharply from $7 billion in 2004.

Wind technology is the largest recipient of global clean energy financing, with an estimated $99 billion (65% share of total investment) in 2010 (figure 6-56). Wind energy accounted for nearly 60% of total clean energy investment by the EU and the United States and more than 80% by China in 2010 (table 6-12).

Figure 6-55
Financial new investment in clean energy and technologies, by selected region/country/economy: 2004–10



EU = European Union; ROW = rest of world

NOTES: Clean energy and technologies include biomass, geothermal, wind, solar, biofuels, and energy smart and efficiency. Financial new investment includes private and public R&D, venture capital, private equity, and public markets. Mergers and acquisitions are excluded. Asia-8 includes India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand.

SOURCE: Bloomberg New Energy Finance, http://bnef.com/, special tabulations (2011).

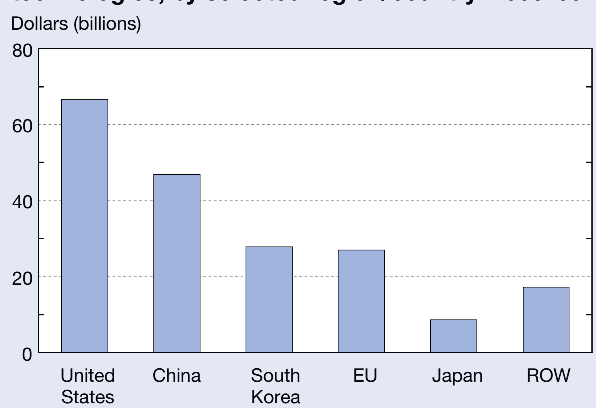
Science and Engineering Indicators 2012

Government Stimulus Funding for Clean Energy

A number of economies pledged an estimated $194 billion in late 2008 and early 2009 for clean energy and low carbon energy projects as part of their stimulus programs undertaken in response to the global economic recession (figure 6-D). Four of these economies, the United States, China, South Korea, and the EU, led stimulus funding of clean energy with a collective $168 billion in spending commitments. The United States had the largest amount with $67 billion in commitments for energy efficiency, renewable energy deployment, transportation, and smart grid technology. China announced $47 billion in funding for energy efficiency, clean vehicles, grid infrastructure, and other energy technologies. The EU and South Korea each committed $27–$28 billion in funding.

Progress was slow in 2009 with governments spending an estimated $20.3 billion (10%) of the total $194 billion in stimulus commitments. The pace accelerated in 2010 with 38% of the stimulus funding commitments (an estimated $74.5 billion) being spent, largely by the United States, China, Germany, and South Korea. Disbursement of stimulus spending commitments in 2009–10 is estimated at $94.8 billion. The majority of this funding has gone to energy efficiency, renewables, smart grid, and R&D. Energy efficiency has received an estimated $35.5 billion (37% share) followed by $20.2 billion (21%) allocated to renewables. R&D and the smart grid have each received $17–$18 billion.

Figure 6-D
Public stimulus funding for clean energy and technologies, by selected region/country: 2008–09



EU = European Union; ROW = rest of world

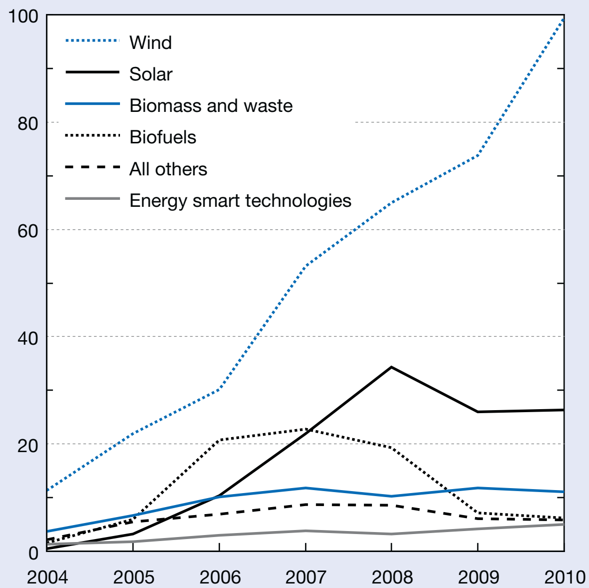
NOTE: Funding amounts are commitments announced by governments in 2008 and 2009.

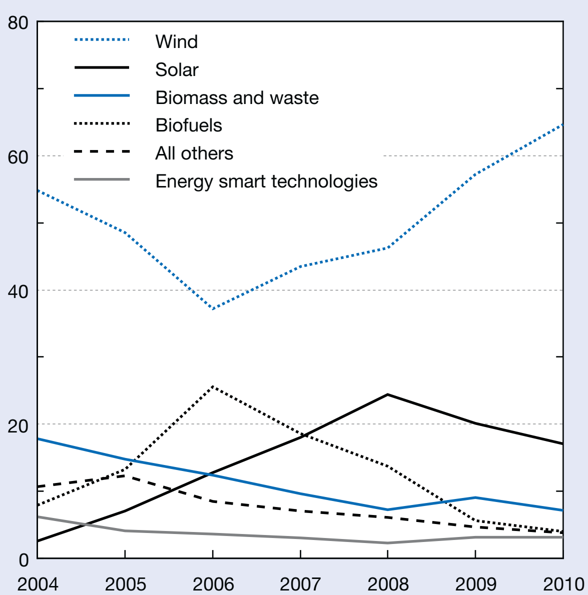
SOURCE: Pew Charitable Trust, "Who's winning the clean energy race," http://www.pewenvironment.org/uploadedFiles/PEG/Publications/Report/G-20Report-LOWRes-FINAL.pdf, accessed 15 May 2011.

Science and Engineering Indicators 2012

China is the world's largest source of investment in wind technology with an estimated $45 billion in 2010, more than twice as much as the EU ($19 billion) and the United States ($17 billion) (table 6-12). China's rapid growth in this field, from less than $1 billion in 2004 to $45 billion in 2010, was spurred by aggressive government policies and comparatively low labor and financing costs. Solar is the second-largest clean energy technology area with an estimated $26 billion of investment in 2010 (17% share of global investment) (figure 6-56). Commercial investment in solar grew rapidly from less than $1 billion in 2004 to a peak of $34 billion in 2008 before falling to $26 billion in 2009–10. The fall in investment may reflect volatility in the price of photovoltaic modules and, in the case of the EU, reductions in government support and incentives in Germany, Spain, and other EU countries. The EU is the world's largest source of financing for solar with an estimated $11 billion in 2010, down sharply from $22 billion in 2008. The marked decline in EU financing reflects the recession and cutbacks by Germany, Spain, and the United Kingdom in government support and incentives for solar power. The United States is the second-largest source of financing in solar with $6 billion in 2010, up from $4 billion in 2009 but below the peak of $8 billion in 2008. China is the third-largest source of solar investment with $4 billion. Chinese investment in this area was negligible in 2004–05 before rising to $2 billion in 2006 and doubling to $4 billion in 2010.

Figure 6-56
Financial new investment in clean energy and technologies, by select energy and technology: 2004–10





NOTES: Clean energy and technologies include biomass, geothermal, wind, solar, biofuels, and energy smart and efficiency. Financial new investment includes private and public R&D, venture capital, private equity, and public markets. Mergers and acquisitions are excluded.

SOURCE: Bloomberg New Energy Finance, http://bnef.com/, special tabulations (2011).

Science and Engineering Indicators 2012

Biomass/waste was the third-largest area of investment, with an estimated $11 billion in 2010 (figure 6-56). After rising rapidly from $4 billion to $10 billion from 2004 to 2006, investment leveled off at $10–11 billion from 2006 to 2010. Biofuels is the fourth-largest area of investment, with $6 billion in 2010. Investment in this sector is down sharply from its $23 billion peak in 2006 due to excess capacity and overinvestment, particularly in the U.S. ethanol sector; volatility in the price of oil; and falls in the prices of corn and other commodities used in biofuels production.[35] U.S. investment slid from $9 billion in 2006 to $1 billion in 2010, and EU investment also fell sharply (table 6-12).

Venture Capital Investment

Venture capital investment is a useful indicator of market assessment of future technology trends. As an important source of financing for new firms, it may indicate nascent areas of clean energy technologies.

Data from Bloomberg New Energy Finance show that global venture capital investment in clean energy rose rapidly, more than quadrupling from an estimated $1 billion in 2004 to $4 billion in 2010, after a sharp recession-induced dip in 2009 (figure 6-57). The United States is the main provider of venture capital financing for clean energy technologies, with more than 90% of global investment in 2010. The EU, China, and other Asian economies have been negligible sources of venture capital.

Two major technology areas, energy smart/efficiency and solar, dominate global venture capital investments in clean energy, receiving an estimated $2 billion and $1.5 billion, respectively (figure 6-58). The energy smart/efficiency category covers a wide range of technologies from digital energy applications to efficient lighting, electric vehicles, and the

Table 6-12
Financial new investment, by selected region/country and energy/technology: 2004–10
(Millions of dollars)

Region/country and technology	2004	2005	2006	2007	2008	2009	2010
EU							
Wind	6,728	12,034	12,413	25,316	22,546	20,660	19,243
Solar	319	1,809	5,359	13,718	22,200	15,222	11,491
Biofuels	477	1,510	4,450	4,694	1,994	1,726	167
United States							
Wind	1,574	3,962	9,210	11,167	17,593	10,479	17,142
Solar	153	1,124	2,389	5,514	7,834	3,666	5,580
Biofuels	989	2,651	10,448	9,136	4,078	935	1,155
China							
Wind	220	1,473	3,678	7,472	17,368	30,764	44,875
Solar	3	90	562	197	1,981	3,967	3,856
Biofuels	17	64	1,117	1,397	187	43	NA

EU = European Union; NA = not available

NOTES: Clean energy technologies include biomass, geothermal, wind, solar, biofuels, and energy smart and efficiency. Financial new investment includes venture capital financing raised from private equity, and public capital markets. Mergers and acquisitions are excluded.

SOURCE: Bloomberg New Energy Finance, http://bnef.com/, special tabulations (2011).

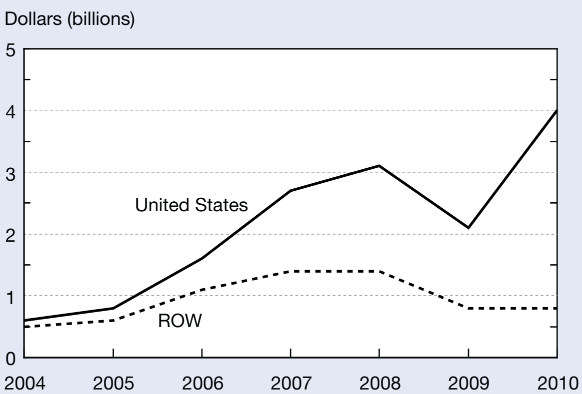
Science and Engineering Indicators 2012

smart grid that maximizes the energy efficiency of existing energy sources and networks.

The attractiveness of these technologies may be enhanced by sizable public R&D funding. In addition, energy efficiency technologies are less capital intensive than other clean energy technologies, have a shorter time horizon than most other energy technologies, can be applied to a wider range of energy products and services, and are less reliant on government incentives or subsidies that may be withdrawn. This sector has also benefited from increased U.S. public research spending. Investor interest has been in electric cars and the smart grid, both of which have received U.S. stimulus funding.

Biofuels is the third-largest technology in terms of venture capital investment, with a share of 10% in 2010 (figure 6-58). Wind energy has received less than 5% of venture capital investment, far less than its dominant share in total commercial investment.

Figure 6-57
Global venture capital investment in clean energy and technologies: 2004–10



ROW = rest of world

NOTE: Clean energy and technologies include biomass, geothermal, wind, solar, biofuels, and energy smart and efficiency.

SOURCE: Bloomberg New Energy Finance, http://bnef.com/, special tabulations (2011).

Science and Engineering Indicators 2012

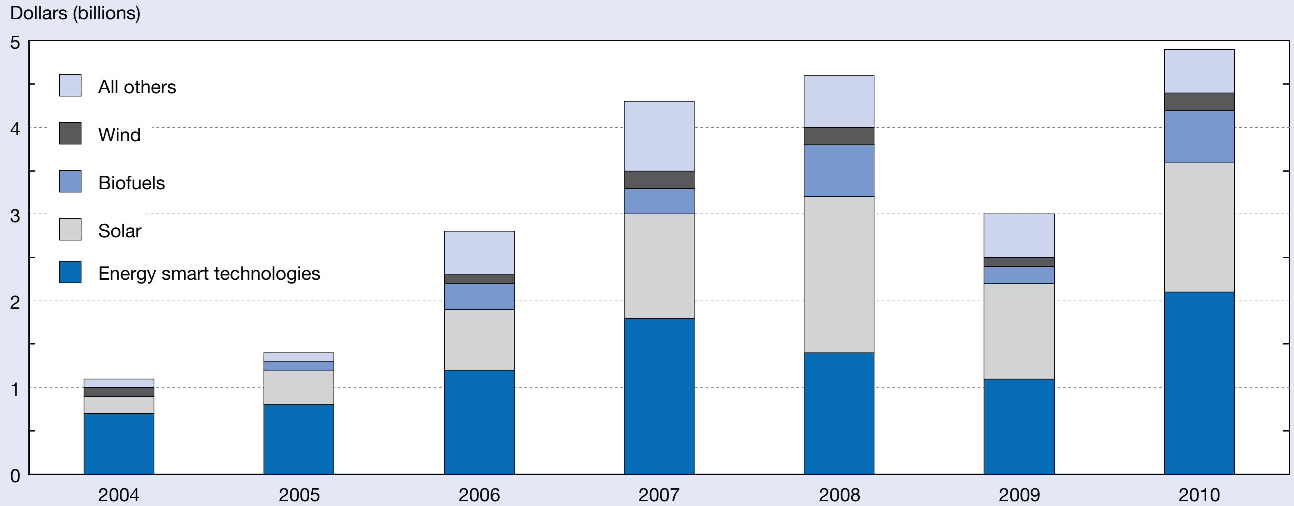
Public Research, Development, and Demonstration Expenditures in Clean Energy and Technologies

According to IEA data, the estimated amount of global public R&D and demonstration (RD&D) investment for clean energy and related technologies was $16.7 billion in 2009 (figure 6-59). Clean energy RD&D includes solar, wind, ocean, nuclear, bioenergy, hydrogen, fuel cells, carbon capture and storage, and energy efficiency.[36]

Nuclear energy was the largest area, receiving $5.3 billion in 2009, one-third of total RD&D (figure 6-59). RD&D funding for nuclear energy has remained relatively flat during the 2000s. The next two largest areas are energy efficiency and renewable energy (solar, wind, ocean, bioenergy), which each received about $4 billion in public RD&D. Other power and storage was third, receiving $1.6 billion (figure 6-59). Renewable energy had the fastest growth between 2000 and 2009, more than quadrupling from $900 million to $3.9 billion. Growth was also rapid in hydrogen and fuel cells, which increased from $32 million in 2002 to $900 million in 2009.

The United States in 2009 had the largest investment in clean energy RD&D; its $7.0 billion accounted for 42% of global RD&D (figure 6-60). However, this figure included one-time funding from the American Recovery and

Figure 6-58
Global venture capital investment in clean energy and technologies: 2004–10

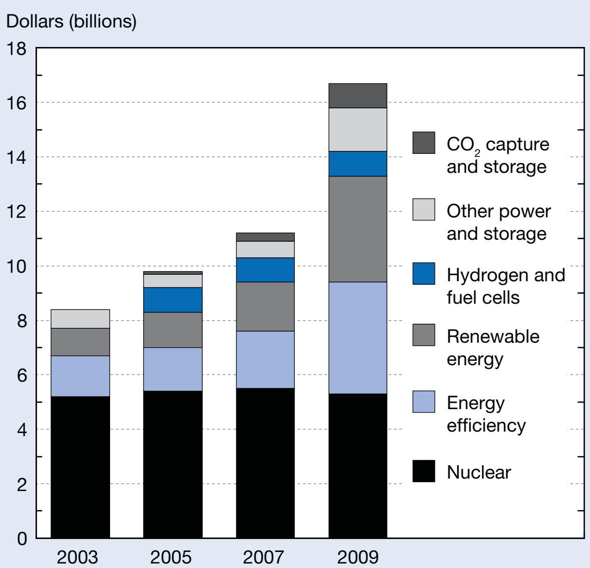


NOTE: Clean energy and technologies include biomass, geothermal, wind, solar, biofuels, and energy smart and efficiency.

SOURCE: Bloomberg New Energy Finance, http://bnef.com/, special tabulations (2011).

Science and Engineering Indicators 2012

Figure 6-59
Global government RD&D in clean energy and technologies, by technology area: 2003, 2005, 2007, and 2009



EU = European Union; RD&D = Research, development, and demonstration

NOTES: RD&D includes research, development, and demonstration projects. Clean energy and technologies include solar, wind, bioenergy, nuclear, fuel cells, hydrogen, CO_2 capture and storage, other power and storage, and energy efficiency. EU consists of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Luxembourg, Netherlands, Poland, Portugal, Slovak Republic, Spain, Sweden, and United Kingdom. Data not available for China.

SOURCE: International Energy Agency, Statistics and Balances, http://www.iea.org/stats/index.asp, accessed 15 March 2011.

Science and Engineering Indicators 2012

Reinvestment Act (ARRA). For much of the 2000s, U.S. public investments had been the third largest behind the EU and Japan, which in 2009 invested about $4.0 billion each, nearly a quarter each of global RD&D.

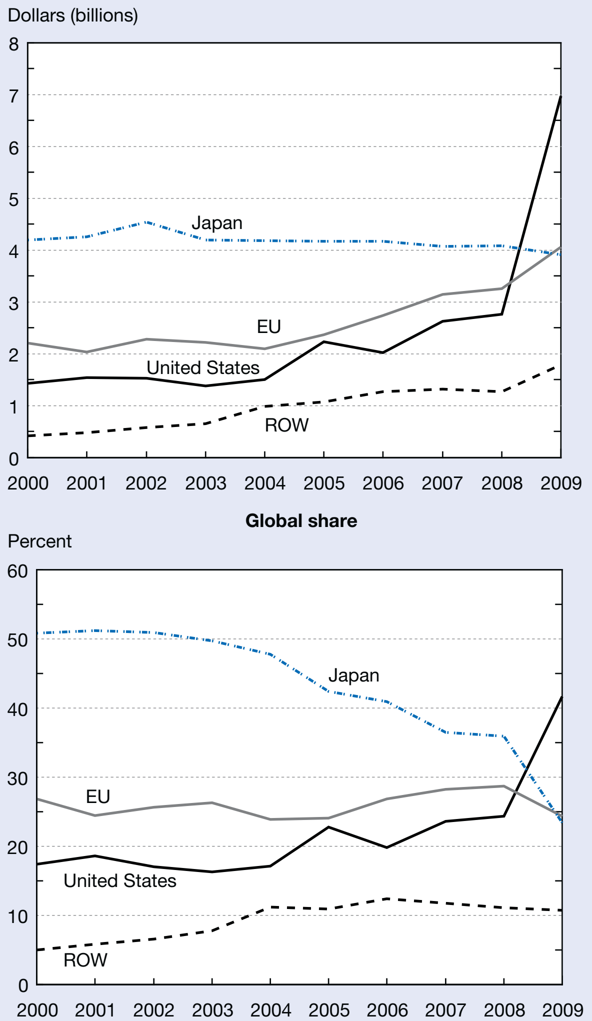
Global public RD&D investment more than doubled between 2000 and 2009 from $8.2 billion to $16.7 billion (figure 6-60). Increases in funding in the United States and the EU propelled growth after 2003; Japan's public RD&D expenditures stayed flat during this period. More recent U.S. data show a sharp decline in U.S. clean energy RD&D investment from $7.0 billion in 2009 to $4.4 billion in 2010, when ARRA funding declined (figure 6-61).

U.S. energy-related RD&D funding across technologies has been volatile (figure 6-62). Energy efficiency, including smart grid, and renewable energy were the two largest areas, each receiving about 30% of funding in 2010. In the renewable energy area, biofuels received the largest share of funding, followed by solar and smaller amounts for wind and ocean energy. The shares of energy efficiency and renewable energy jumped starting in 2009 because most ARRA funding was allocated to these two areas. Nuclear is the third-largest area, receiving 20% of expenditures. Nuclear had been the largest area for much of the 2000s but received scant funding from ARRA, resulting in its share falling from 36% in 2008 to 20% in 2010.

Patenting of Clean Energy and Pollution Control Technologies

USPTO patents granted in clean energy and pollution control technologies can be classified using a new taxonomy developed for this purpose. The taxonomy classifies patents involving bioenergy, nuclear, wind, solar, energy storage, smart grid, and pollution mitigation. The number of patents in these technologies jumped to a record high in 2010, which may mostly reflect USPTO efforts to speed up processing of applications (figure 6-63 and appendix table 6-66).[37] (For a more detailed description of how this taxonomy identifies clean energy and pollution control patents, see the section in Chapter 5, "Identifying clean energy and pollution control patents.") U.S. resident inventors

Figure 6-60
Government RD&D expenditures for clean energy and technologies, by selected region/country: 2000–09



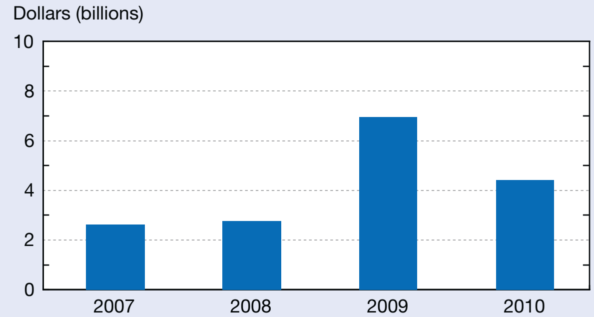
EU = European Union; RD&D = Research, development, and demonstration; ROW = rest of world

NOTES: RD&D includes research, development, and demonstration projects.Clean energy and technologies includes solar, wind, bioenergy, nuclear, fuel cells, hydrogen, CO_2 capture and storage, other power and storage, and energy efficiency. EU includes Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Luxembourg, Netherlands, Poland, Portugal, Slovakia, Spain, Sweden, and United Kingdom. ROW includes Australia, Canada, and South Korea. Data not available for China.

SOURCE: International Energy Agency, Statistics and Balances, http://www.iea.org/stats/index.asp, accessed 15 April 2011.

Science and Engineering Indicators 2012

Figure 6-61
U.S. government RD&D expenditures on clean energy and technologies: 2007–10



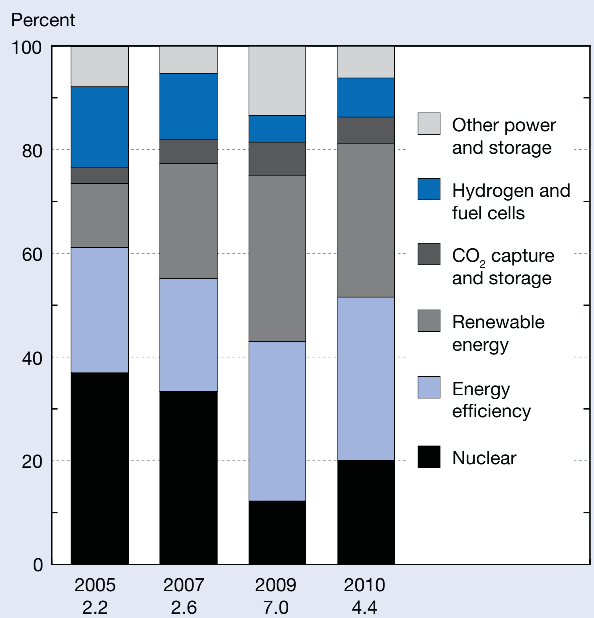
ARRA = American Recovery and Reinvestment Act of 2009; RD&D = Research, development, and demonstration

NOTES: RD&D includes research, development, and demonstration projects. Clean energy and technologies includes solar, wind, bioenergy, nuclear, fuel cells, hydrogen, CO_2 capture and storage, other power and storage, and energy efficiency.

SOURCE: International Energy Agency, Statistics and Balances, http://www.iea.org/stats/index.asp, accessed 15 March 2011.

Science and Engineering Indicators 2012

Figure 6-62
U.S. government RD&D in clean energy and technologies, by share of technology area: 2005, 2007, 2009, and 2010



ARRA = American Recovery and Reinvestment Act of 2009; RD&D = Research, development, and demonstration

NOTES: RD&D includes research, development, and demonstration projects. Amount of R&DD shown in billions of current dollars above each year. Clean energy and technologies include solar, wind, bioenergy, nuclear, fuel cells, hydrogen, CO_2 capture and storage, other power and storage, and energy efficiency.

SOURCE: International Energy Agency, Statistics and Balances, http://www.iea.org/stats/index.asp, accessed 15 March 2011.

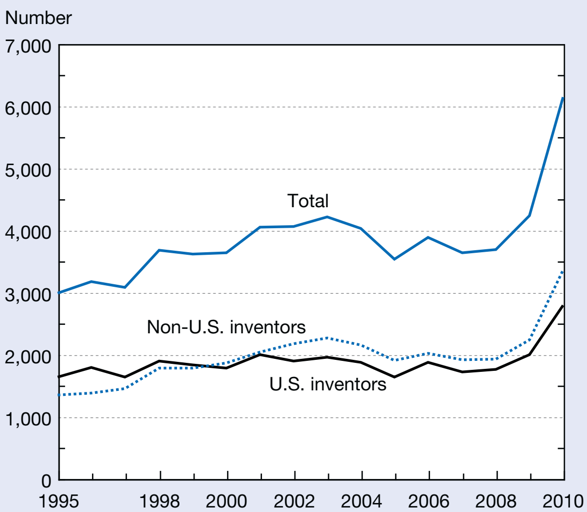
Science and Engineering Indicators 2012

were granted about 45% of the 6,100 clean energy and pollution control technology patents in 2010, continuing the advantage of non-U.S. inventors in these fields since 2000.[38] The decline in the U.S. share of U.S. patent awards since 2000 suggests increased foreign technological capabilities in this area.

Among non-U.S. inventors, Japan, the EU, and South Korea, in that order, are the main recipients of U.S. patents for clean energy and pollution control technologies, with a collective share of 84% of patents granted to all non U.S. inventors (figure 6-64 and appendix table 6-66). Japan received 43% (down from more than 50% in the early 2000s); EU inventors received 30% (down from 36% in 2000). South Korean inventors received 12% of these non-U.S. inventor patents, up steeply from 3% in 2000. No other country has a substantial share of U.S. patents in this area.

Clean energy and pollution control technology patents comprise four broad areas: alternative energy with 3,000 patents granted, energy storage with 1,000 patents, smart grid with 500 patents, and pollution mitigation with 1,900 patents (table 6-13 and appendix tables 6-67, 6-68, 6-69, and 6-70). The proportion of clean energy patents rose from 26% in 1995 to 49% in 2010, with major share gains by fuel cell and losses by nuclear patents (appendix tables 6-71 and 6-72). Energy storage patents advanced from 8% to 16%, and pollution mitigation technologies declined from 58% to 31%, driven by share losses of air quality, water quality, and recycling (appendix tables 6-73, 6-74, and 6-75).

Figure 6-63
USPTO patents in clean energy and pollution control technologies, by U.S. and non-U.S. inventors: 1995–2010



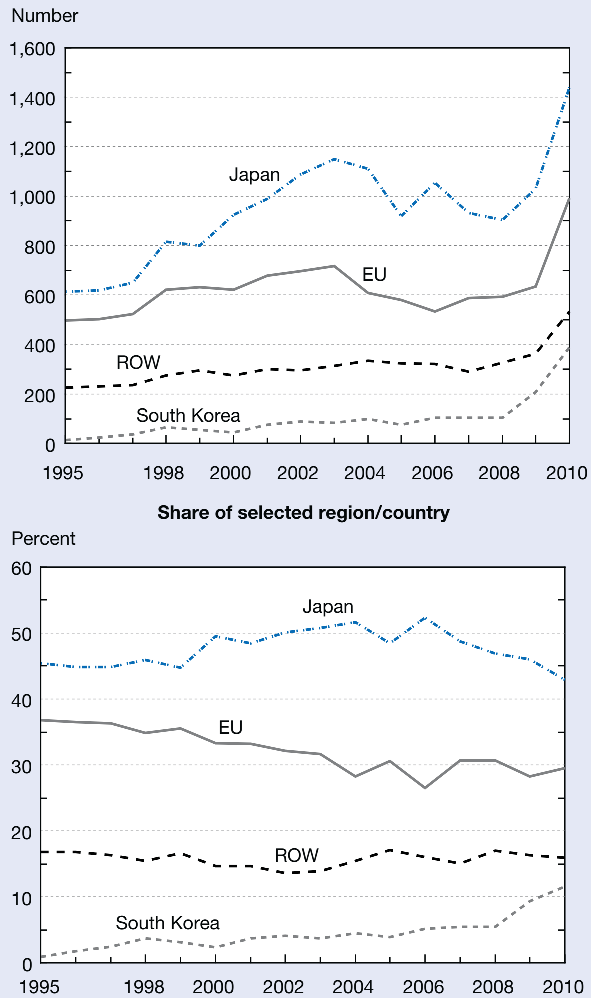
USPTO = U.S. Patent and Trademark Office

NOTES: Clean energy and pollution control technologies include alternative energy, energy storage, smart grid, and pollution mitigation. Alternative energy includes solar, wind, nuclear, hydropower, wave/tidal/ocean, geothermal, and electric/hybrid. Energy storage includes batteries, compressed air, flywheels, superconductivity, magnet energy systems, ultracapacitors, hydrogen production and storage, and thermal energy. Pollution mitigation includes recycling; control of air, water, and solid waste pollution; environmental remediation; cleaner coal; and capture and storage of carbon and other greenhouse gases. Technologies classified by The Patent Board™. Patent grants fractionally allocated among regions/countries on basis of proportion of residences of all named inventors.

SOURCE: The Patent Board™, Proprietary Patent database, special tabulations (2011). See appendix table 6-66.

Science and Engineering Indicators 2012

Figure 6-64
USPTO patents granted to non-U.S. inventors in clean energy and pollution control technologies, by selected region/country: 1995–2010



EU = European Union; ROW = rest of world; USPTO = U.S. Patent and Trademark Office

NOTES: Clean energy and pollution control technologies include alternative energy, energy storage, smart grid, and pollution mitigation. Alternative energy includes solar, wind, nuclear, hydropower, wave/tidal/ocean, geothermal, and electric/hybrid. Energy storage includes batteries, compressed air, flywheels, superconductivity, magnet energy systems, ultracapacitors, hydrogen production and storage, and thermal energy. Pollution mitigation includes recycling; control of air, water, and solid waste pollution; environmental remediation; cleaner coal; and capture and storage of carbon and other greenhouse gases. Technologies classified by The Patent Board™. Patent grants fractionally allocated among regions/countries on basis of proportion of residences of all named inventors. EU includes current member countries.

SOURCE: The Patent Board™, Proprietary Patent database, special tabulations (2011). See appendix table 6-66.

Science and Engineering Indicators 2012

Table 6-13
USPTO patents granted in clean energy and pollution control technologies, by selected area: Selected years, 1995–2010

Technology area	1995	2000	2005	2008	2010
All clean energy and pollution control technologies	2,991	3,641	3,533	3,688	6,145
Alternative energy	825	1,154	1,482	1,606	2,993
Bioenergy	43	71	60	100	222
Electric and hybrid vehicles	129	247	365	377	532
Fuel cells	104	219	518	534	1,031
Geothermal	23	21	19	29	41
Hydropower	24	32	30	43	72
Nuclear	263	144	127	83	120
Solar	210	377	244	238	651
Wind	28	55	137	197	355
Energy storage	227	476	461	526	980
Batteries	124	285	224	235	547
Hydrogen production and storage	54	114	161	193	278
Ultracapacitors	24	52	61	83	131
All others	28	37	34	27	41
Smart grid	295	277	288	385	528
Pollution mitigation	1,717	1,864	1,456	1,321	1,887
Air	701	835	819	719	1,076
Capture and storage of carbon and other greenhouse gases	41	71	72	74	152
Cleaner coal	64	72	60	54	158
Environmental remediation	160	140	76	78	89
Recycling	327	322	170	120	186
Solid waste	304	235	137	116	129
Water	301	385	274	281	319

USPTO = U.S. Patent and Trademark Office

NOTES: Clean energy and pollution control technologies include alternative energy, energy storage, smart grid, and pollution mitigation. Alternative energy includes solar, wind, nuclear, bioenergy, hydropower, wave/tidal/ocean, geothermal, and electric/hybrid. Pollution mitigation includes recycling; control of air, water, and solid waste pollution; environmental remediation; cleaner coal; and capture and storage of carbon and other greenhouse gasses. Energy storage includes batteries, compressed air, flywheels, superconductivity, magnet energy systems, ultracapacitors, hydrogen production and storage, and thermal energy. Technologies classified by The Patent Board™. Sum of individual technologies may exceed broad areas and sum of broad categories may exceed total because some patents are assigned to multiple individual technologies or broad areas.

SOURCE: The Patent Board™, special tabulations (2011) of Proprietary Patent database. See appendix tables 6-66–6-84.

Science and Engineering Indicators 2012

Patent technology activity indexes measure the world share of a region, country, or economy in clean energy and clean technologies relative to its world share in patents in all technologies. A ratio greater than 1 signifies that patents by a region/country/economy are concentrated in a particular technology (table 6-14).

In clean energy patents, the U.S. has a high concentration in bioenergy and solar technologies and relatively low patent activity in fuel cells, hybrid vehicles, and wind energy (table 6-14 and appendix tables 6-45, 6-71, 6-76, 6-77, 6-78, and 6-79). The EU has relatively high concentrations in bioenergy, wind, and nuclear and relatively low concentration in electric hybrid technologies (appendix table 6-72). Japan has a high concentration of patents in electric hybrid technologies and fuel calls, but relatively low activity in bioenergy, nuclear, and solar. South Korea's concentration of patent activity is low across the range of clean energy.

The United States and EU have relatively low concentrations of patents in energy storage because of their low activity in battery technology, but this is an area of high concentration for Japan and South Korea (table 6-14 and appendix tables 6-45, 6-68, and 6-80). Despite its overall low concentration of patents in energy storage, the United States has a high concentration of patents in hydrogen power and storage (appendix table 6-81).

In smart grid, the United States has a high concentration of patents, the EU has a slightly above average concentration and Japan and South Korea have relatively low concentrations (appendix tables 6-45 and 6-69).

In pollution mitigation technologies, the United States has a slightly above average concentration of patents, with very high concentration in clean coal and slightly higher concentration in carbon capture and storage (table 6-14 and appendix tables 6-45, 6-82, and 6-83). The EU has a particularly high concentration of patents in air pollution, carbon capture and storage, and solid waste (appendix tables 6-73 and 6-84). Japan has a relatively low concentration in this area, with the exception of air pollution. South Korea has relatively low concentrations in all pollution mitigation technologies.

Table 6-14
Patenting activity in selected clean energy and pollution control technologies, by selected region/country: 2007–10
(Activity index)

Technology	United States	EU	Japan	South Korea
All clean energy and pollution control technologies	0.95	1.14	1.16	0.94
Alternative energy	0.92	1.24	1.22	0.87
Bioenergy	1.32	1.26	0.23	0.11
Fuel cells	0.79	0.92	1.65	1.46
Hybrid electric	0.76	0.89	2.02	0.78
Nuclear	0.96	1.94	0.79	1.26
Solar	1.13	1.01	0.80	0.50
Wind	0.86	2.92	0.31	0.19
Energy storage	0.73	0.54	1.71	2.58
Batteries	0.42	0.35	2.09	4.74
Hydrogen power and storage	1.16	0.86	0.95	0.62
Smart grid	1.23	1.02	0.50	0.48
Pollution mitigation	1.03	1.33	0.96	0.40
Air	0.92	1.50	1.30	0.38
Capture and storage of carbon and other greenhouse gases	1.18	1.55	0.48	0.36
Cleaner coal	1.43	0.89	0.34	0.33
Solid waste	1.10	1.39	0.41	0.56
Water	1.20	0.98	0.53	0.56

EU = European Union; USPTO = U.S. Patent and Trademark Office

NOTES: Clean energy and pollution control technologies include alternative energy, energy storage, smart grid, and pollution mitigation. Alternative energy includes solar, wind, nuclear, bioenergy, hydropower, wave/tidal/ocean, geothermal, and electric/hybrid. Energy storage includes batteries, compressed air, flywheels, superconductivity, magnet energy systems, ultracapacitors, hydrogen production and storage, and thermal energy. Pollution mitigation includes recycling; control of air, water, and solid waste pollution; environmental remediation; cleaner coal; and capture and storage of carbon and other greenhouse gases. Technologies classified by The Patent Board™. Patent grants fractionally allocated among regions/countries on basis of proportion of residences of all named inventors. EU includes current member countries. Activity index consists of ratio of region/country's share of indicated technology to region/country's share of total grants. A ratio of greater than one signifies more active patenting in the selected technology; a ratio of less than one signifies less active patenting.

SOURCE: The Patent Board™, special tabulations (2011) of Proprietary Patent database. See appendix tables 6-66–6-84.

Science and Engineering Indicators 2012

Conclusion

The U.S. economy continues to be the leading global economy in technology-based industries as measured by its overall performance, market position in KTI industries, and position in patenting and other measures of innovation-related activities.

The strong competitive position of the U.S. economy is tied to continued U.S. global leadership in many KTI industries. The United States continues to hold the dominant market position in commercial KI service industries, which account for nearly one-fifth of global economic activity. The U.S. trading position in technology-oriented services remains strong, as evidenced by the continued U.S. surplus in commercial KI services and licensing of patents and trade secrets. The United States is the leading source of RD&D and venture capital financing of clean energy and technologies.

The overall U.S. ranking notwithstanding, its market position in most of these industries has either flattened or slipped. Productivity growth of the U.S. economy has slowed in the 2000s relative to the 1990s. The historically strong U.S. trade position in advanced technology products has shifted to deficit because of the faster growth of imports than exports. This shift is due in part to U.S. companies moving assembly and other activities to China, other East Asian countries, and elsewhere. However, the U.S. deficit also reflects the development of indigenous capability by China and other East Asian countries in HT manufacturing industries.

China and other emerging Asian economies are showing rapid progress in their overall economic growth and technological capabilities. Productivity growth has accelerated, coinciding with an increase in the concentration of KTI industries in many of their economies. Their market positions in KTI industries—particularly HT manufacturing industries—have strengthened, and their shares of U.S. and economically valuable patents have risen, led by South Korea and Taiwan. The number of Chinese patents has soared, with Chinese and non-Chinese inventors each having a 50% share, suggesting the expansion of technological activity by domestic and foreign companies in China's rapidly growing economy.

Among individual large countries, China's progress clearly stands out. China has become a leading global producer and exporter of HT manufacturing goods. It has become a major global assembly center, supplied by components and inputs from East Asian economies. However, China's rapid progress in other indicators of technological capability and the nascent rise of globally competitive Chinese companies suggest that China is moving to more technologically challenging and higher end manufacturing activities. China has become the world's largest source of commercial financing for clean energy and is home to rapidly growing wind and solar industries.

The EU's position has been similar to that of the United States for much of the 2000s—relatively strong overall economic performance with a slowdown in productivity and flat or slight declines in its market position in KTI industries. However, the EU has suffered more severe losses in its market position in KTI industries than the United States during the worldwide recession in part because of the EU's debt and fiscal problems. Japan's economy has shown less dynamism compared with the United States and the EU, and its market position has declined steeply in many KTI industries. Japan's loss of market position in HT manufacturing industries is due, in part, to Japanese companies shifting production to China and other Asian economies.

The global recession had a disproportionately severe impact on the United States, the EU, and other developed economies, with production of their technology-intensive industries declining in 2009. In contrast, technology-intensive industries of developing economies, led by China, continued to grow during the global recession and increased their market positions relative to developed economies. Worldwide output of technology-intensive industries recovered in 2010, with much faster growth by China and other developing economies. Recovery of technology-intensive industries in the developed economies in 2010 was more evident in the United States and Japan than in the EU. Whether the global downturn will lead to fundamental changes in the market positions of the United States and other developed economies in the production and trade of KTI industries remains uncertain.

Notes

1. See Mudambi (2008) and Reynolds (2010) for a discussion on the shift to knowledge-based production and geographical dispersion of economic activity.

2. See OECD (2001) for a discussion of classifying economic activities according to degree of "knowledge intensity." Part of the discussion on trade uses a different, product-based classification of the U.S. Census Bureau under the terminology *advanced technology products.*

3. Like all classification schemes, the OECD classification has shortcomings. For example, KTI industries produce some goods or services that are neither knowledge intensive nor technologically advanced. In addition, multiproduct companies that produce a mix of goods and services, only some of which are KTI, are assigned to their largest business segment. Nevertheless, data based on the OECD classification allow researchers and analysts to trace, in broad outline, the worldwide trends towards greater interdependence in science and technology and the development of KTI sectors in many of the world's economies.

4. In designating these HT manufacturing industries, OECD took into account both the R&D expenditures made directly by firms and R&D embedded in purchased inputs (indirect R&D) for 13 countries: the United States, Japan, Germany, France, the United Kingdom, Canada, Italy, Spain, Sweden, Denmark, Finland, Norway, and Ireland. Direct R&D intensities were calculated as the ratio of total R&D expenditure to output (production) in 22 industrial sectors. Each sector was weighted according to its share of the total output among the 13 countries, using purchasing power parities as exchange rates. Indirect intensities were calculated using the technical coefficients of industries on the basis of input-output matrices. OECD then assumed that, for a given type of input and for all groups of products, the proportions of R&D expenditure embodied in value added remained constant. The input-output coefficients were then multiplied by the direct R&D intensities. For further details concerning the methodology used, see OECD (2001). It should be noted that several nonmanufacturing industries have R&D intensities equal to or greater than those of industries designated by the OECD as HT manufacturing. For additional perspectives on OECD's methodology, see Godin (2004).

5. See Atkinson and McKay (2007: 16–17) for a discussion of and references to the impact of IT on economic growth and productivity.

6. The sum of the value added attributable to individual commercial KI services does not add to the total because of rounding.

7. Data on the health sector includes social services.

8 See Bresnahan and Trajtenberg (1995) and DeLong and Summers (2001) for a discussion of ICT and general-purpose technologies.

9. These ICT infrastructure indexes originate from the Connectivity Scorecard, which has developed a variety of ICT indexes for developed and developing countries. The ICT infrastructure indexes are benchmarked against the best-in-class country in developed and developing countries. The business ICT infrastructure index is composed of metrics on business hardware and software and penetration of business lines. The consumer infrastructure index is composed of indicators on penetration of telephone line and broadband. The government infrastructure index is composed of metrics related to e-government capacity and the share of schools connected to the Internet. More information on the methodology can be found at http://www.connectivityscorecard.org/methodology/

10. See Williamson and Raman (2011) for a discussion of China's acquisition of foreign companies.

11. Commercial KTI services and goods trade does not correspond to commercial KTI industries because industry and trade data are collected on different bases. Industry production data are classified by primary industry and trade data are classified by product or service.

12. Data on commercial KI trade between China and Hong Kong are not available.

13. The sums of the categories do not add to the total, which also includes a small amount of trade in noncommercial KI services, including construction services.

14. IHS Global Insight data as of July 2009.

15. The U.S. trade balance is affected by many other factors, including currency fluctuations, differing fiscal and monetary policies, and export subsidies between the United States and its trading partners.

16. China is the single largest trading partner for the United States in goods trade according to recent data from the U.S. Census. For more information, see http://www.census.gov/foreign-trade/index.html.

17. The discrepancy in the trade figures is because of rounding.

18. U.S. multinational financial services data for 1999 and 2006 do not include banks and depository institutions, which are included in the global industry data on financial services.

19. U.S. direct investment abroad by industry and country is a lower bound estimate because an increasing share of U.S. direct investment (36% in 2008) is through holding companies that invest in other industries that may be in a different country. For more information, see Ibarra and Koncz (2008).

20. OECD (2005).

21. Definitions of innovation differ widely, but a common element is the commercialization of something that did not previously exist.

22. The NSF BRDIS survey's definition of innovation is very similar to the OECD definition. For more information, see NSF, Business R&D and Innovation Survey, http://www.nsf.gov/statistics/srvyindustry/about/brdis/.

23. BRDIS data are not available for the entire U.S. service sector.

24. Rather than granting property rights to the inventor, as is the practice in the United States and many other countries, some countries grant property rights to the applicant, which may be a corporation or other organization.

25. U.S. patent law states that any person who "invents or discovers any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof, may obtain a patent." The law defines *nonobvious* as "sufficiently different from what has been used or described before that it may be said to be nonobvious to a person having ordinary skill in the area of technology related to the invention." These terms are part of the criteria in U.S. patent law. For more information, see USPTO, "What Is a Patent?" Available at http://www.uspto.gov/web/offices/pac/doc/general/index.html#patent. Accessed 19 June 2009.

26. The Japan Patent Office is also a major patent office but has a much smaller share of foreign patents than the USPTO and the European Patent Office.

27. Although the USPTO grants several types of patents, this discussion is limited to utility patents, commonly known as patents for inventions. They include any new, useful, or improved-on method, process, machine, device, manufactured item, or chemical compound.

28. Unless otherwise noted, USPTO assigns patents to countries on the basis of the residence of the first-named inventor.

29. Triadic patent families with co-inventors residing in different countries are assigned to their respective countries/economies on a fractional-count basis (i.e., each country/economy receives fractional credit on the basis of the proportion of its inventors listed on the patent). Patents are listed by priority year, which is the year of the first patent filing. Data for 1998–2003 are estimated by the OECD.

30. The high-technology definition used here is from the Bureau of Labor Statistics and differs from that used in earlier sections. See Hecker (2005) for a definition and the methodology for determining HT industries.

31. According to U.S. Census data, the number of U.S. microbusinesses in non-HT industries in 2008 was 3.3 million, with 2.7 million operating in service industries.

32. Another possibility is that venture capital investor behavior changed because fewer opportunities for attractive risky investments were available in the 2000s than in the 1990s.

33. The IEA manual states: "The IEA concept of Energy RD&D differs from the Frascati concept of R&D, in that (i) it focuses on energy related programmes only; (ii) it includes "demonstration projects"; and (iii) it includes state owned companies. …The energy RD&D data collected by the IEA should not be confused with the data on government budget appropriations or outlays on R&D (GBAORD) collected by the OECD Directorate for Science, Technology, and Industry for the socio-economic objective 'Production, distribution and rational utilisation of energy'…" See IEA (2011), http://www.iea.org/stats/RDD%20Manual.pdf, pp. 16–17.

34. Bloomberg's data include investment in renewable energy, biofuels, energy efficiency, smart grid and other energy technologies, carbon capture and storage and infrastructure investments targeted purely at integrating clean energy. Investment in solar hot water, combined heat and power, renewable heat, and nuclear are excluded, as are the proceeds of mergers and acquisitions (which do not contribute to new investment).

35. See UNEP 2009, p. 18, for a discussion of the biofuels sector.

36. The IEA has no official definition of clean energy. This discussion includes public RD&D in energy efficiency, renewable energy, nuclear, hydrogen and fuel cells, CO_2 capture and storage, and other power and storage technologies.

37. The USPTO initiated a green technology pilot program on December 7, 2009, that expedites processing of some applications related to green technologies. For more information, see http://www.uspto.gov/patents/init_events/green_tech.jsp.

38. See note 28.

Glossary

Affiliate: A company or business enterprise located in one country but owned or controlled (10% or more of voting securities or equivalent) by a parent company in another country; may be either incorporated or unincorporated.

Angel investment: Financing from affluent individuals for business startups, usually in exchange for ownership equity. Angel investors typically invest their own funds or organize themselves into networks or groups to share research and pool investment capital.

Asia-8: India, Indonesia, Malaysia, the Philippines, Singapore, South Korea, Taiwan, and Thailand.

Commercial knowledge-intensive services: Knowledge-intensive services that are generally privately owned and compete in the marketplace without public support. These services are business, communications, and financial services.

Company or firm: A business entity that is either a single location with no subsidiary or branches or the topmost parent of a group of subsidiaries or branches.

EU (European Union): The 27 member states of the European Union since 2007 include Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, and the United Kingdom.

Foreign direct investment: Financial investment by which a person or an entity acquires a lasting interest in and a degree of influence over the management of a business enterprise in a foreign country.

Gross domestic product (GDP): The market value of all final goods and services produced within a country within a given period of time.

High-technology manufacturing industries: Those that spend a relatively high proportion of their revenue on R&D, consisting of aerospace, pharmaceuticals, computers and office machinery, communications equipment, and scientific (medical, precision, and optical) instruments.

Information and communications technology industries: A subset of knowledge- and technology-intensive industries, consisting of two high-technology manufacturing industries, computers and office machinery and communications equipment and semiconductors, and two knowledge-intensive service industries, communications and computer services, which is a subset of business services.

Intellectual property: Intangible property resulting from creativity that is protected in the form of patents, copyrights, trademarks, and trade secrets.

Intra-EU exports: Exports from EU countries to other EU countries.

Knowledge-intensive industries: Those that incorporate science, engineering, and technology into their services or the delivery of their services, consisting of business, communications, education, financial, and health services.

Knowledge- and technology-intensive industries: Those that have a particularly strong link to science and technology. These industries are five service industries, financial, business, communications, education, and health, and five manufacturing industries, aerospace, pharmaceuticals, computers and office machinery, communications equipment, and scientific (medical, precision, and optical) instruments.

Normalizing: To adjust to a norm or standard.

Not obvious: One criterion (along with "new" and "useful") by which an invention is judged to determine its patentability.

Productivity: The efficiency with which resources are employed within an economy or industry, measured as labor or multifactor productivity. Labor productivity is measured by GDP or output per unit of labor. Multifactor productivity is measured by GDP or output per combined unit of labor and capital.

Purchasing power parity (PPP): The exchange rate required to purchase an equivalent market basket of goods.

R&D intensity: The proportion of R&D expenditures to the number of technical people employed (e.g., scientists, engineers, and technicians) or the value of revenues.

Triadic patent: A patent for which patent protection has been applied within the three major world markets: the United States, Europe, and Japan.

Utility patent: A type of patent issued by the U.S. Patent and Trademark office for inventions, including new and useful processes, machines, manufactured goods, or composition of matter.

Value added: A measure of industry production that is the amount contributed by the country, firm, or other entity to the value of the good or service. It excludes the country, industry, firm, or other entity's purchases of domestic and imported supplies and inputs from other countries, industries, firms, and other entities.

Value chain: A chain of activities to produce goods and services that may extend across firms or countries. These activities include design, production, marketing and sales, logistics, and maintenance.

Venture capitalist: Venture capitalists manage the pooled investments of others (typically wealthy investors, investment banks, and other financial institutions) in a professionally managed fund. In return, venture capitalists receive ownership equity and almost always participate in managerial decisions.

References

Atkinson RD, McKay AS. 2007. *Digital Prosperity: Understanding the Economic Benefits of the Information Technology Revolution.* Special Report. Washington, DC: The Information Technology & Innovation Foundation. http://www.itif.org/index.php?id=34. Accessed 24 September 2009.

Athukorala P-C, Yamashita N. 2006. Production fragmentation and trade integration: East Asia in a global context. *North American Journal of Economics and Finance* 17:233–56.

Bresnahan T, Trajtenberg M. 1995. General purpose technologies: "Engines of growth"? *Journal of Econometrics* 65:83–108.

Burk D, Lemley M. 2011. *The Patent Crisis and How the Courts Can Solve It*. Chicago, IL: University of Chicago Press.

Cohen W, Nelson R, Walsh J. 2000. Protecting their intellectual assets: Appropriability conditions and why U.S. manufacturing firms patent (or not). National Bureau of Economic Research (NBER) Working Paper No. 7552. Available at http://www.nber.org/papers/w7552. Accessed 15 June 2009.

DeLong JB, Summers LH. 2001. How important will the information economy be? Some simple analytics. University of California, Berkeley, and National Bureau of Economic Research. http://econ161.berkeley.edu/Econ_Articles/summers_jh_2001/jh_analytics.pdf. Accessed 19 October 2009.

Ernst D. 2011. *China's Innovation Policy Is a Wake-Up Call for America.* AsiaPacific Issues, No. 100. Honolulu, HI: Honolulu East-West Center. http://www.eastwestcenter.org/fileadmin/stored/pdfs/api100.pdf. Accessed 15 June 2011.

Godin B. 2004. The new economy: What the concept owes to the OECD. *Research Policy* 33:679–90.

Hecker D. 2005. High-technology employment: A NAICS-based update. *Monthly Labor Review* (July):57–72. http://www.bls.gov/opub/mlr/2005/07/art6full.pdf. Accessed 15 June 2009.

Ibarra M, Koncz J. 2008. Direct investment positions for 2008: Country and industry detail. *Survey of Current Business* 89(7):20–34. http://www.bea.gov/scb/pdf/2009/07%20July/0709_dip.pdf. Accessed 27 August 2009.

International Energy Agency. 2011. *IEA Guide to Reporting Energy RD&D Budget/Expenditure Statistics.* Paris, France: Organisation for Economic Co-operation and Development/International Energy Agency. http://www.iea.org/stats/RDD%20Manual.pdf. Accessed 14 October 2011.

Jaffe A, Lerner J. 2006. *Innovation and its Discontents*. Princeton, NJ: Princeton University Press.

Koopman R, Wang Z, Wei S-J. 2008. How much of Chinese exports is really made in China? Assessing domestic value added when processing trade is pervasive. National Bureau of Economic Research (NBER) Working Paper No. 14109. http://www.nber.org/papers/w14109. Accessed 15 June 2009.

Kumar A. 2007. Does foreign direct investment help emerging economies? *Economic Letter* 2(1), January. Federal Reserve Bank of Dallas. http://dallasfed.org/research/eclett/2007/el0701.html. Accessed 20 October 2009.

Mudambi R. 2008. Location, control, and innovation in knowledge-intensive industries. *Journal of Economic Geography* 8(5)(September):699–725.

National Research Council (NRC). 2004. A Patent System for the 21st Century. Merrill SA, Levin RC, Myers MB, editors. Committee on Intellectual Property Rights in the Knowledge-Based Economy. Washington, DC: National Academies Press.

Ng F, Yeats A. 2003. Major trade trends in East Asia: What are their implications for regional cooperation and growth? Policy Research Working Paper No. 3084. The World Bank. http://econ.worldbank.org/external/default/main?pagePK=64165259&piPK=64165421&theSitePK=469372&menuPK=64216926&entityID=000094946_03071704242197. Accessed 4 August 2009.

Organisation for Economic Co-operation and Development (OECD). 2001. *Knowledge-Based Industries*. Paris: Directorate for Science, Technology, and Industry/Economic Analysis Statistics.

Organisation for Economic Co-operation and Development (OECD) Statistical Office of the European Communities. 2005. *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data,* 3rd edition. Paris: OECD Publishing. http://www.oecdbookshop.org/oecd/display.asp?sf1=identifiers&st1=922005111P1. Accessed 15 May 2011.

Organisation for Economic Co-operation and Development (OECD). 2007. *Science, Technology and Industry Scoreboard 2007, Annex 1.* Paris: Directorate for Science, Technology, and Industry. http://masetto.sourceoecd.org/pdf/sti2007/922007081e1-annex1.pdf. Accessed 26 June 2009.

Reynolds E. 2010. Institutions, Public Policy and the Product Life Cycle: The Globalization of Biomanufacturing and Implications for Massachusetts. Working Paper Series for Industrial Performance Center, Massachusetts Institute of Technology. http://web.mit.edu/ipc/publications/pdf/IPC10-001.pdf. Accessed 15 January 2011.

Rosen DH, Wing HP. 2005. China and the changing economic geography of Asia? Seminar Series 5. Washington, DC: National Defense University, Institute for National Strategic Studies, and American Enterprise Institute for Public Policy Research. http://www.aei.org/event/1109. Accessed 15 June 2009.

Shane S. 2008. The importance of angel investing in financing the growth of entrepreneurial ventures. Working paper for Small Business Administration, Office of Advocacy. http://archive.sba.gov/advo/research/rs331tot.pdf. Accessed 10 June 2011.

United Nations Environmental Programme (UNEP). 2009. *Global Trends in Sustainable EnergyInvestment 2009: Analysis of Trends and Issues in the Financing of Renewable Energy and Energy Efficiency.* New York: United Nations Environmental Programme. http://www.unep.org/pdf/Global_trends_report_2009.pdf. Accessed 10 June 2011

Williamson PJ, Raman AP. 2011. The globe: How China reset its global acquisition agenda. *Harvard Business Review* (April). Available at http://hbr.org/2011/04/the-globe-how-china-reset-its-global-acquisition-agenda/ar/6. Accessed 15 June 2011.

Xing, Y. 2010. How the iPhone widens the United States' trade deficit with the People's Republic of China. Asian Development Bank Institute. http://www.adbi.org/working-paper/2010/12/14/4236.iphone.widens.us.trade.deficit.prc/how.iphones.are.produced/. Accessed 15 June 2011.

Zhao, M. 2010. Policy complements to the strengthening of IPRS in developing countries—China's intellectual property environment: A firm-level perspective," OECD Trade Policy Working Papers No. 105, OECD Publishing. http://dx.doi.org/10.1787/5km7fmtw4qmv-en

Chapter 7
Science and Technology: Public Attitudes and Understanding

List of Sidebars

List of Tables

List of Figures

Highlights

Information Sources, Interest, and Involvement

The Internet is the main source of information for learning about specific scientific issues such as global climate change and biotechnology.

- Americans are now about equally likely to rely on the Internet as on television as their primary source of general science and technology (S&T) information.

Americans have consistently expressed interest in S&T, with 41% reporting they were "very interested" and 50% reporting they were "moderately interested" in new scientific discoveries.

- However, Americans also express similar or higher levels of interest in a range of other news topics.
- On average, Europeans appear to express lower levels of public interest in "new scientific discoveries and technological developments" relative to Americans, although there is considerable variation among different European countries.

In 2008, a majority of Americans said they had visited an informal science institution such as a zoo or natural history museum within the past year. This proportion is generally consistent with results from surveys conducted since the 1980s.

- Americans with more formal education are more likely to visit informal science institutions.
- Visits to informal science institutions tend to be less common in Europe, Japan, and Brazil. Visits to a zoo are about equally common in China and the United States.

Public Knowledge About S&T

Many Americans continue to give multiple incorrect answers to questions about basic factual knowledge of science or the scientific inquiry process. In the United States, levels of factual knowledge of science have been stable for more than a decade.

- Americans' factual knowledge of science is positively related to their formal education level and the number of science and math courses they have taken. Younger generations also exhibit higher levels of factual knowledge about science than older generations.
- Men tend to score higher than women on factual knowledge questions in the physical sciences; women score equally well as men on questions in the biological sciences.
- People who score well on factual knowledge measures also tend to know more about emerging science topics such as nanotechnology.

Levels of factual knowledge of science in the United States are comparable to those in Europe and appear to be higher than those in Japan, China, or Russia.

- In Europe, China, and South Korea, demographic variations in factual knowledge are similar to those in the United States.

Americans' understanding of the process of scientific inquiry is stable, after modest improvements since the mid-1990s. Understanding of what constitutes an experiment is greater in 2010 than in previous years.

- Americans' understanding of scientific inquiry is strongly associated with their factual knowledge of science, their level of formal education, and the number of science and mathematics courses they have completed.
- Men and women obtain similar scores on understanding of scientific inquiry.

Public Attitudes About S&T in General

Americans in all demographic groups consistently endorse the past achievements and future promise of S&T.

- In 2010, 69% of Americans said that the benefits of scientific research have strongly or slightly outweighed the harmful results; 9% said the harmful results outweighed the benefits.
- Americans tend to have more favorable attitudes about the promise of S&T than Europeans, the Japanese, Malaysians, Indians, and the Chinese. Attitudes in South Korea tend to be more favorable than those in the United States.
- Reservations about science accompany these favorable attitudes. Nearly half of Americans agree that "science makes our way of life change too fast," and large proportions of Chinese and South Korean residents voice the same sentiment.

Support for government funding of scientific research remains strong.

- In 2010, 82% of Americans expressed support for government funding of basic research.
- In 2009, 73% of Americans said spending on basic scientific research "usually pays off in the long run"; fewer than two in ten said such spending was "not worth it." About the same percentage (74%) said spending on engineering and technology "usually pays off in the long run."

The public continues to expresses confidence in science leaders.

- In 2010, roughly equal percentages of Americans expressed "a great deal" of confidence in medical leaders and scientific leaders; military leaders were the only group in whom more Americans expressed a great deal of confidence.

- On science-related public policy issues (global climate change, stem cell research, nuclear power, and genetically modified foods), Americans regard science and engineering leaders as both knowledgeable and impartial—relative to other leaders—and believe they should be influential in decisions about these topics.
- However, Americans also perceive a considerable lack of consensus among scientists on these issues.

A majority of Americans accord scientists "very great prestige." Ratings for engineers are lower but nonetheless better than those of most other occupations.

- In 2009, more Americans rated scientists as having "very great prestige" than did so for almost any other occupation surveyed, second only to firefighters.
- Nearly four in ten (39%) Americans rated engineers as having "very high prestige"—well above most other occupations considered on the survey.

Public Attitudes About Specific S&T Issues

Americans' support for the development of alternative sources of energy increased in the 2000s. Assessments of environmental hazards from pollution, nuclear power, and climate change were largely stable between 1993 and 2010.

- A majority of Americans said the government spends too little on developing alternative energy sources, and most favor providing incentives for using solar and other alternative energy sources.
- In 2010 and 2011, about one-third of Americans (34%) said they worry about environmental quality "a great deal," following an increase from 2006 to 2008. More Americans considered water pollution as "very" or "extremely dangerous" to the environment than they did several other potential problems.
- Climate change continues to divide opinion. In a 22-nation survey, respondents from the United States, China, and the UK were less likely to consider climate change a "very serious problem" than those in a number of other countries. Respondents from only two nations (Poland and Pakistan) were less likely than Americans to consider climate change a "very serious problem."
- Support for the use of nuclear power to generate electricity increased from 53% in 2007 to 62% in 2010. However, a substantial minority says that nuclear power plants are not safe—a proportion that may increase after the 2011 earthquake and tsunami in Japan.

A majority of Americans favor medical research that uses human embryonic stem cells. However, Americans are overwhelmingly opposed to reproductive cloning and wary of innovations using "cloning technology."

- Support for embryonic stem cell research has increased since 2004, with 62% in favor of embryonic stem cell research in 2010. A higher proportion (71%) favors stem cell research when it does not involve human embryos.
- More than three-quarters of Americans oppose human cloning.

Americans remain largely unfamiliar with nanotechnology, despite increased funding and a growing numbers of products on the market that use nanotechnology.

- Public awareness of nanotechnology remains limited. Even among respondents who had heard of nanotechnology, knowledge levels are not high.
- Those who have heard "a lot" or "some" about nanotechnology are more likely to say the benefits of such technology will outweigh any harms than to say the harmful results will outweigh the benefits.
- Europeans are split, on average, over whether nanotechnology use in consumer products should be encouraged or not (44% to 35%, respectively, with 22% holding no opinion).

Introduction

Chapter Overview

Science and technology (S&T) affect all aspects of American life, including work, leisure, family, and civic activities. In the workforce, Americans use technology to improve productivity in ways that could not have been imagined a generation ago, applying recently invented tools and applications. In their leisure time, they entertain themselves with high technology electronic products and make friends, communicate, and stay informed about the world through the Internet and social media. As citizens, they may engage in discussions on climate change, stem cell research, and nuclear power—issues about which atmospheric scientists, microbiologists, and nuclear engineers have formal training and expertise—or benefit from advances in new technologies.

It is increasingly difficult for Americans to be competent workers, consumers, and citizens without some degree of competency in S&T. How the American public collectively deal with S&T-related issues may, in turn, affect what kinds of S&T development the United States will support. Therefore, this chapter presents not only indicators about media sources, information, and knowledge of S&T, but indicators of people's attitudes about S&T-related issues as well. To put U.S. data in context, this chapter examines trend indicators for past years and comparative indicators for other countries.

Chapter Organization

This chapter is divided into four main sections. The first section includes indicators of the public's sources of information about, level of interest in, and active involvement with S&T. The second section reports indicators of public knowledge, including measures of factual knowledge of science and engineering and people's understanding of the scientific process. When possible, American adults' understanding of science is compared to that of American students. The third and fourth sections of the chapter describe public attitudes toward S&T. The third section presents data on attitudes about S&T in general, including support for government funding of basic research, confidence in the leadership of the scientific community, perceptions of the prestige of S&E occupations, and opinions about how much influence science and scientists should have on public affairs. The fourth section addresses public attitudes on issues in which S&T plays an important role, such as the environment, climate change, nuclear power, the quality of science and math education, and the use of animals in scientific research. It also includes indicators of public opinion about several emerging lines of research and new technologies, including stem cell research, cloning, genetically modified (GM) food, nanotechnology, and synthetic biology.

A Note About Data and Terminology

This chapter emphasizes trends over time, patterns of variation within the U.S. population, and international patterns. It reviews survey data from national samples with sound representative sampling designs. The emphasis in the text is on the trends and patterns presented in the data. All survey data are subject to numerous sources of error; interpretation of the data should be mindful of the limits of survey data. Caution is especially warranted for data from surveys that omit significant portions of the target population, have low response rates, or have topics that are particularly sensitive to subtle differences in question wording. (See sidebars, "U.S. Survey Data Sources" and "International Survey Data Sources.") Most of the international comparisons involve identical questions asked in different countries. However, language and cultural differences can affect how respondents interpret questions and can introduce numerous complexities, so international comparisons require careful consideration.

Throughout this chapter, the terminology used in the text reflects the wording in the corresponding survey question. In general, survey questions asking respondents about their primary sources of information, interest in issues in the news, and general attitudes use the phrase "science and technology." Thus, "S&T" is used when discussing these data. Survey questions asking respondents about their confidence in institutional leaders, the prestige of occupations, and their views on different disciplines use terms such as "scientific community," "scientists," "researchers," and "engineers," so "S&E" is used when examining issues related to occupations, careers, and fields of research. Although science and engineering are distinct fields, national survey data that make this distinction are scarce.

Information Sources, Interest, and Involvement

Americans' awareness and understanding of S&T are dependent, in part, on how much they monitor new S&T developments throughout their adult life. Because S&T are relevant to so many aspects of daily life and are often changing and evolving, information about S&T can help Americans make informed decisions and more easily navigate the world around them. Interest in and involvement with S&T can lead Americans to acquire more information and achieve greater understanding.

This section reviews the sources of information about S&T that are available to and used by the public, interest in and attention to media reports about S&T, and the amount of S&T news available from traditional and new media sources. It concludes with indicators of behavioral involvement in S&T through visits to museums and other cultural institutions.

U.S. Survey Data Sources

Sponsoring Organization	Title	Years Used	Information Used	Data Collection Method	Respondents *(n)*; Margin of Error of General Population Estimates
National Science Foundation (NSF)	Public Attitudes Toward and Understanding of Science and Technology (1979–2001); University of Michigan Survey of Consumer Attitudes 2004	1979–2001, 2004	Information sources, interest, informal science institution visits, general attitudes, government spending attitudes, science/math education attitudes, animal research attitudes	Telephone interviews	*n* = 1,574–2,041; ± 2.47%–3.03%
NORC at the University of Chicago	General Social Survey (GSS)	1973–2010	Government spending attitudes, confidence in institutional leaders	Face-to-face interviews	Government spending (2000–10): *n* = 1,358–4,901; ± 2.7%–3.9% Confidence in institutional leaders, (1973–2010): *n* = 876–3,278; ± 1.3%–3.3%
NORC at the University of Chicago	GSS environment module	1993–94, 2000, 2010	Environmental dangers attitudes	Face-to-face interviews	*n* = 1,276–1,557; ± 2.5%–3.3%
NORC at the University of Chicago	GSS S&T module	2006, 2008, 2010	Information sources, interest, informal science institution visits, general attitudes, government spending attitudes, science/math education attitudes, animal research attitudes, nanotechnology awareness and attitudes, science knowledge	Face-to-face interviews	*n* = 1,864–2,021; ± 2.5%–3.3%
ABC News/Planet Green/Stanford University	ABC News/Planet Green/ Stanford University Poll	2008	Environmental problem attitudes	Telephone interviews	*n* = 1,000; ± 3.0%
CBS News/*New York Times*	CBS News/*New York Times* Poll	2008	Genetically modified food awareness and attitudes	Telephone interviews	*n* = 1,065; ± 3.0%
American Association for the Advancement of Science (AAAS)	AAAS Project 2061 (unpublished results, 2008)	2007 (middle school students)	Science knowledge	Paper questionnaires	*n* = 2,047 middle school students; *n* = 1,597 (follow-up question)
Department of Education, National Center for Education Statistics (NCES)	National Assessment of Education Progress (NAEP)	2000 (grade 8), 2005 (grades 4 and 8)	Science knowledge	Paper questionnaires	2000 (independent national sample): *n* = 15,955 8th graders; ± 2.2% (one question used) 2005 (combined national/ state sample): *n* = 147,700 4th graders; ± 1.0% (one question used) *n* = 143,400 8th graders; ± 0.8%–1.2% (three questions used)
The Gallup Organization	Various ongoing surveys	2001–11	Federal priorities, environmental protection, climate change, global warming, nuclear power, alternative energy, animal research, stem cell research, quality of science/math education in U.S. public schools attitudes	Telephone interviews	*n* = ~1,000; ± 3.0–4.0%
Harris Interactive	The Harris Poll	1977–2009	Occupational prestige attitudes	Telephone interviews	*n* = ~1,000 (~500 asked about each occupation)
Pew Initiative on Food and Biotechnology, The Pew Charitable Trusts	Poll on consumer attitudes toward genetically modified foods and genetic engineering	2001–06	Genetically modified foods attitudes	Telephone interviews	*n* = 1,000; ± 3.1%
Pew Internet & American Life Project, Pew Research Center	Pew Internet & American Life Survey	2006, 2010	Information sources, interest, involvement, Internet use	Telephone interviews	2006: *n* = 2,000; ± 3.0% 2010: *n* = 2,252; ± 2.4%
Pew Research Center for the People and the Press	Biennial News Consumption Survey	2008, 2010	Information sources, interest, credibility of information sources, top stories, time spent following the news	Telephone interviews	2008: *n* = 3,615; ± 2.0% 2010: *n* = 3,006; ± 2.5%
Pew Research Center for the People and the Press	General Public Science Survey, separate survey of AAAS scientists	2009	Public's and scientists' beliefs about S&T-related issues, benefits of science to well-being of society, animal research attitudes	Telephone interviews (survey of general public) Internet (survey of scientists)	Public: *n* = 2,001; ± 2.5% Scientists: *n* = 2,533; ± 2.5%
Pew Research Center for the People and the Press	News Interest Index Survey	2010–11	Top stories, nuclear power and offshore oil drilling attitudes	Telephone interviews	*n* = ~1,000; ± 4.0%

U.S. Survey Data Sources—continued

Sponsoring Organization	Title	Years Used	Information Used	Data Collection Method	Respondents *(n);* Margin of Error of General Population Estimates
Pew Research Center for the People and the Press	Political Survey (various)	2008–11	Information sources, Internet use, national policy attitudes (environment, global warming, energy, stem cell research), government spending for scientific research attitudes	Telephone interviews	*n* = ~1,300–2,250; ± 2.5%–3.5%
Virginia Commonwealth University (VCU)	VCU Life Sciences Survey	2001–08, 2010	Interest, science and government spending for scientific research attitudes, energy sources, animal research, stem cell research, cloning technology attitudes	Telephone interviews	*n* = ~1,000; ± 3.0%–3.8%
The Woodrow Wilson International Center for Scholars, conducted by Peter D. Hart Research Associates	Synthetic Biology Project	2010	Synthetic biology awareness and attitudes	Telephone interviews	*n* = 1,000; ± 3.1%

International Survey Data Sources

Sponsoring Organization	Title	Years Used	Information Used	Data Collection Method	Respondents *(n);* Margin of Error of General Population Estimates
BBVA Foundation (Fundacion BBVA)	BBVA Foundation International Study on Attitudes To Stem Cell Research and Hybrid Embryos	2007/2008 combined	Stem cell research knowledge, awareness, and attitudes	Face-to-face interviews	*n* = 1,500 for each of 15 countries; ± 2.6%
British Council, Russia	Survey of Public Attitudes Toward Science and Technology in Russia	2003	Various knowledge and attitude items	Paper questionnaires	*n* = 2,107
Canadian Biotechnology Secretariat	Canada–U.S. Survey on Biotechnology	2005	Biotechnology, nanotechnology, genetically modified foods, and other technology attitudes (includes U.S. data on specific issues)	Telephone interviews	(Canada): *n* = 2,000; ± 2.19% (United States): *n* = 1,200; ± 2.81%
Chinese Association for Science and Technology (CAST), China Research Institute for Science Popularization (CRISP)	Chinese National Survey of Public Scientific Literacy	2001, 2007	Various knowledge and attitude items, interest, occupational prestige, informal science institution visits	Face-to-face interviews	2001: *n* = 8,350 2007: *n* = 10,059; ± 3.0%
European Commission	Special Eurobarometer 224/ Wave 63.1: *Europeans, Science and Technology* (2005)	2005	Knowledge, trust in scientists, public support for basic research, other attitudes, informal science institution visits	Face-to-face interviews	(EU total) *n* = 26,403; (Germany) 1,507; (UK) 1,307; (Slovakia) 1,241; (19 other countries) ~1,000; (3 other countries) ~500
	Special Eurobarometer 224/ Wave 64.3: *Europeans and Biotechnology in 2005: Patterns and Trends* (2006)	2005	Biotechnology attitudes		(EU total) *n* = ~25,000; (each member country/state) ~1,000
	Special Eurobarometer 300/ Wave 69.2: *Europeans' Attitudes Towards Climate Change* (2008)	2008	Climate change attitudes		(EU total) *n* = ~26,661; (Germany) 1,534; (UK) 1,306; (22 other countries) ~1,000; (3 other countries) ~500
	Special Eurobarometer 340/ Wave 73.1: *Science and Technology Report* (2010)	2010	S&T attitudes and interest, support for basic research, animal research attitudes		(EU total) *n* = ~26,671; (Germany) 1,531; (UK) 1,311; (22 other countries) ~1,000; (3 other countries) ~500
	Special Eurobarometer 341/ Wave 73.1: *Europeans and Biotechnology in 2010: Winds of change?* (2010)	2010	Nuclear energy, nanotechnology, emerging biotechnologies, synthetic biology, and genetically modified foods attitudes		(EU total) *n* = ~26,676; (Germany) 1,531; (UK) 1,316; (22 other countries) ~1,000; (3 other countries) ~500

International Survey Data Sources—continued

Sponsoring Organization	Title	Years Used	Information Used	Data Collection Method	Respondents *(n)*; Margin of Error of General Population Estimates
India National Council of Applied Economic Research	National Science Survey	2004	Various knowledge and attitude items, informal science institution visits	Face-to-face interviews	*n* = 30,255
Japan National Institute of Science and Technology Policy, Ministry of Education, Culture, Sports, Science and Technology	Survey of Public Attitudes Toward and Understanding of Science & Technology in Japan	2001	Various knowledge and attitude items, informal science institution visits	Face-to-face interviews	*n* = 2,146
Korea Foundation for the Advancement of Science and Creativity (KOFAC, formerly Korea Science Foundation)	Survey of Public Attitudes Toward and Understanding of Science and Technology	2004, 2006, 2008	Interest, various knowledge and attitude items, informal science institution visits	Face-to-face interviews	*n* = 1,000; ± 3.1%
Malaysian Science and Technology Information Center (MASTIC), Ministry of Science, Technology and Innovation	Survey of the Public's Awareness of Science and Technology: Malaysia	2008	Interest, awareness, various knowledge and attitude items, informal science institution visits	Face-to-face interviews	*n* = 18,447; ± 1.0%
Ministry of Science and Technology (MCT) of Brazil	Public Perceptions of Science and Technology	2006, 2010	Interest, informal science institution visits	Face-to-face interviews	*n* = ~ 2,000; ± 2.2%
Pew Global Attitudes Project, Pew Research Center	Global Attitudes Survey	2010	Climate change concerns	(Varies by country) Face-to-face interviews Telephone interviews	(United States) *n* = 1,002; ± 4.0%; (21 other countries) *n* = 700–3,262; ± 2.5%–5.0%
Samuel Neaman Institute for Advanced Studies in Science and Technology (Israel)	Survey of attitudes of Israeli public toward science and technology	2006	Prestige of science careers	Telephone interviews	*n* = 490
U.S. Department of Education, NCES	Trends in International Mathematics and Science Study (TIMSS)	2003 (grade 8)	Science knowledge	Paper questionnaires	(United States) *n* = 8,912; ± 1.4% (for all TIMSS questions); (44 other countries) *n* = 2,943–8,952; ± 1.0%–2.4% (for all TIMSS questions)
WorldPublicOpinion.org/ The World Bank, managed by Program on International Policy Attitudes at University of Maryland	WorldPublicOpinion.org Poll	2009	Attitudes toward climate change as government priority	(Varies by country) Face-to-face interviews Telephone interviews	*n* = 18,578 in 19 nations comprising 60% of world's population; ± 3.0%–4.0%

EU = European Union; UK = United Kingdom

NOTES: All surveys are national in scope and based on probability sampling methods. Statistics on number of respondents and margin of error are as reported by the sponsoring organization. When a margin of error was not cited, none was given by the sponsor.

S&T Information Sources

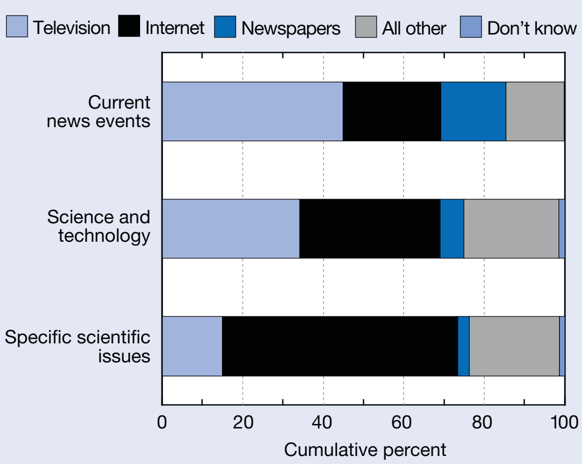
U.S. Patterns and Trends

The media environment has been changing over the past decade. Although a plurality of Americans say that television is their primary source of news about current events, fewer said that they relied on television news for S&T information in 2010 than in previous years. Also, a majority turn to the Internet as their primary source of information on specific scientific issues such as global climate change, stem cell research, GM foods, and nuclear power.

For news about current events, television is the primary source of information for 45% of Americans. Substantial percentages report that most of their current event news comes from the Internet (24%) or newspapers (16%) (figure 7-1; appendix table 7-1). The proportion of Americans getting information about current events from the Internet has increased considerably since the 1990s, and the proportion using newspapers for current events has declined (figure 7-2). Newspaper readership has strongly declined over the past decade (Project for Excellence in Journalism, PEJ 2010e). Patterns of reported media use over time are complicated by the fact that some of the readership for newspapers has shifted to online news sources by the same organizations that produce print newspapers.[1] Thus, the separation between print and online news sources is often blurred. (Also see sidebar, "The Blending of Print and Online Sources of Science News.")

For news about S&T, Americans are about equally likely to rely on the Internet as on television. According to the 2010 General Social Survey (GSS), 35% of Americans cite the Internet as their primary source of S&T information, up from 29% in 2008. The proportion citing the Internet as their primary source of S&T information has grown steadily since

Figure 7-1
Primary source of information about current news events, science and technology, and specific scientific issues: 2010

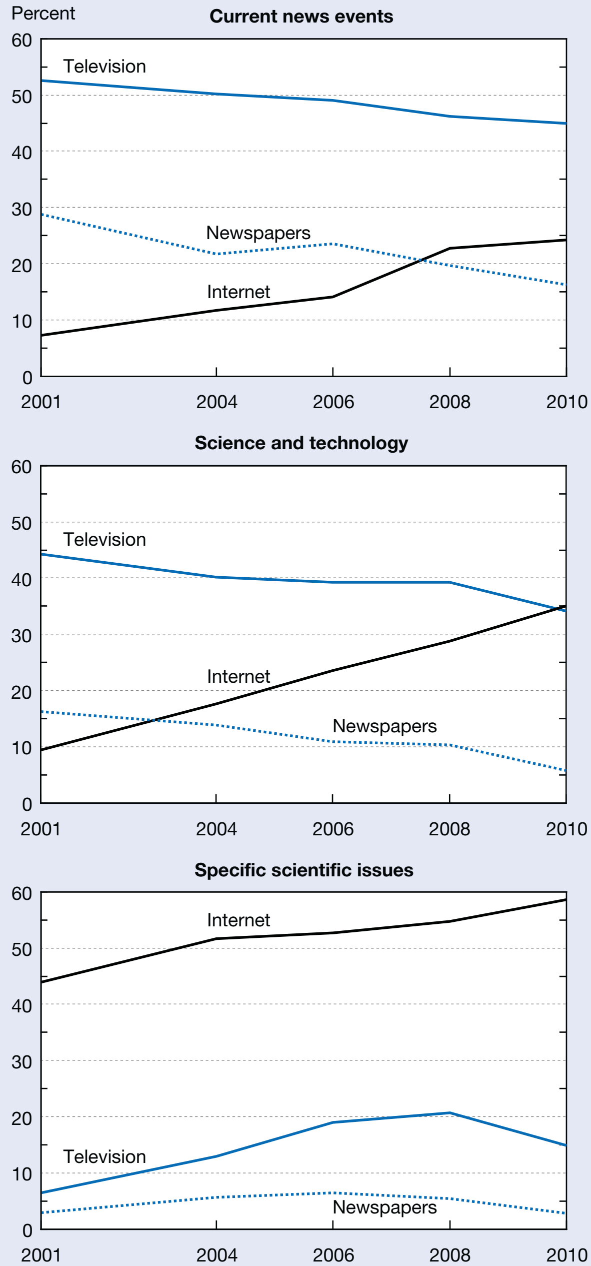


NOTE: "All other" includes radio, magazines, books, government agencies, family, and friends/colleagues.

SOURCE: University of Chicago, National Opinion Research Center, General Social Survey (2010). See appendix tables 7-1, 7-2, and 7-3.

Science and Engineering Indicators 2012

Figure 7-2
Primary source of information about current news events, science and technology, and specific scientific issues: 2001–10



SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Public Attitudes Toward and Understanding of Science and Technology (2001); University of Michigan, Survey of Consumer Attitudes (2004); University of Chicago, National Opinion Research Center, General Social Survey (2006, 2008, 2010). See appendix tables 7-1, 7-2, and 7-3.

Science and Engineering Indicators 2012

The Blending of Print and Online Sources of Science News

Internet news sites sometimes represent new providers of news and other times represent an alternative outlet for reporting done by print or broadcast media organizations. The 2010 General Social Survey asked half the sample a question with response options that distinguish between online and print-format sources for newspapers and magazines.

Print media organizations are more likely to serve as a primary source of Americans' information about current news events than they are about either S&T or specific scientific issues. When it comes to news about current events, a roughly equal proportion of Americans who primarily rely on the Internet do so via online venues of print media organizations and other online sources (12% and 11% of adults, respectively). Print media organizations are less dominant as sources of news about general S&T. Eleven percent of Americans rely on Internet sources for S&T news provided by print media organizations; nearly twice as many use other online sources (20%). A majority of Americans seeking information about specific scientific issues say the Internet would be their primary source, 12% would rely on online information from print media organizations, and 48% would rely on other online sources.

Table 7-A
Online and print information sources: 2010
(Percent)

Where do you get most of your information about…?	Current news events	Science and technology	Specific scientific issues
Online Sources			
Online newspapers	12	8	8
Online magazines	*	3	4
Other online sources	11	20	48
Print sources			
Print newspapers	16	7	3
Print magazines	1	8	3
Other sources	59	53	33
Don't know	*	1	1

* = <0.5% responded

NOTES: "Other sources" includes television, radio, books, family, friends/colleagues. Percentages may not add to 100% because of rounding.

SOURCE: University of Chicago, National Opinion Research Center, General Social Survey (2010).

Science and Engineering Indicators 2012

2001. Conversely, reliance on television has dropped; only 34% of Americans report that television is their primary source of S&T news, down from 39% in 2008 (figures 7-1 and 7-2; appendix table 7-2).[2]

When Americans are seeking specific information related to S&T, they turn to the Internet as the dominant resource.[3] Asked "If you wanted to learn about scientific issues such as global warming or biotechnology, where would you get information?" 59% of Americans cited the Internet, up slightly from 55% in 2008. Television ranked as a distant second at 15%, down from 21% in 2008 (figures 7-1 and 7-2; appendix table 7-3).

In general, use of the Internet for news and information, including S&T information, is greater among younger audiences and increases with education and income. Conversely, the use of television decreases with education and income and increases with age (appendix tables 7-1, 7-2, and 7-3). According to a recent Pew Research Center survey, the Internet now outranks television as the primary source of news about national and international issues among younger adults (ages 18–29) (Pew Research Center 2011b).[4] There is no reason to expect younger generations who grew up relying more heavily on the Internet to shift to traditional media as they age.

National data that address the processes through which Americans acquire and sort through S&T information are scarce. A Pew Internet and American Life Project survey examined how Americans use the Internet to acquire information about science (Horrigan 2006). It found that a clear majority of Internet users had engaged in some information search activities, including "look[ing] up the meaning of a particular scientific term or concept" (70%), "look[ing] for an answer to a question you have about a scientific concept or theory" (68%), and "learn[ing] more about a science story or scientific discovery you first heard or read about offline" (65%). In addition, just over half had used the Internet to "complete a science assignment for school, either for yourself or for a child" (55%) or to "check the accuracy of a scientific fact or statistic" (52%). Fewer had used the Internet to "download scientific data, graphs, or charts" (43%) or to "compare different or opposing scientific theories" (37%). How skillfully or how often Americans engage in the search for scientific information—whether on the Internet or elsewhere—remains unknown.

Using information effectively involves more than just finding it. In an information-saturated society, people often need to assess the quality of the information they encounter and determine its credibility. Survey data provide some indication of how Americans assess the credibility of public information. For the past 10 years, Americans have become more skeptical of the information they encounter in major broadcast and print media, but recently this trend has leveled off. Americans' judgments of media credibility are shaped by factors other than critical thinking skills and the quality of the information provided. For example, judgments of the credibility of particular mass media information sources are associated with political party affiliations (Pew Research Center 2010a).

Evidence about how Americans judge the credibility of S&T information in the media is scant. The 2006 Pew Internet and American Life Project study of how Americans acquire science information indicates that Internet users who seek science information online do not always assume that the information they find there is accurate. The vast majority (80%) reported they have checked information at least once, either by comparing it to other information they found online, comparing it to offline sources (e.g., science journals, encyclopedia), or looking up the original source of the information (Horrigan 2006). (For additional details, see NSB 2008.)

International Comparisons

Information sources in other countries depend, in part, on access to the Internet and the prevalence of Internet news sources (Internet World Statistics 2010). Internet access is currently greater in North America than in any other region of the world. In many other countries, television is the leading source of S&T information, newspapers generally rank second, and relatively fewer survey respondents cite the Internet as an important source of S&T information. In Malaysia, for example, 82% cite television as their leading source of S&T news and information, whereas 62% cite newspapers, and 25% cite the Internet (respondents could choose multiple sources of S&T information). Television is also the dominant source of S&T information in India, where about two-thirds of survey respondents in 2004 said it was their main information source (Shukla 2005). Radio (13%) and friends/relatives (12%) ranked ahead of print sources such as newspapers, books, and magazines, which together accounted for 9% of responses. India's relatively low literacy rate (144th of 176 countries in a 2005 ranking) may contribute to this reliance on non-printed sources. On the other hand, in more widely connected South Korea, a 2008 survey found that more respondents named the Internet (28%) as their primary source of S&T information than newspapers (16%) (KOFAC 2009).

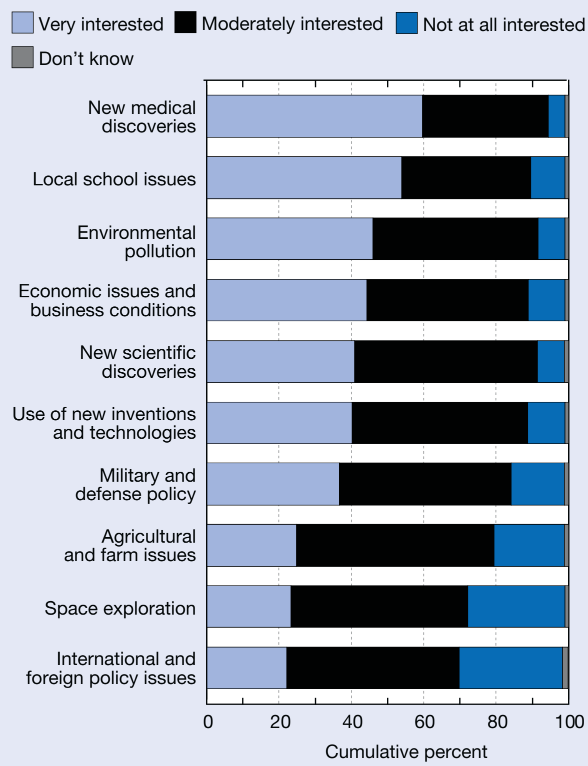
Public Interest in S&T

U.S. Patterns and Trends

Americans regularly express relatively high levels of interest in S&T news. More than four in ten Americans (41%) report being "very interested" in new scientific discoveries, half say they are "moderately interested," and just 8% are "not at all interested," according to the 2010 GSS survey (figure 7-3). The proportion of respondents "very interested" in new scientific discoveries in 2010 is about the same as in 2008 and down from 47% in 2001 (figure 7-4; appendix table 7-4).[5] Comparable data from Virginia Commonwealth University (VCU) show a stable trend in public interest in new scientific discoveries between 2001 and 2006; during this period, the proportion of Americans who said they had a lot of interest in new scientific discoveries fluctuated between 43% and 47% (VCU 2006). Interest in new scientific discoveries was greater among those with more formal education and more coursework in science and mathematics (appendix table 7-5).

Relative to other topics, however, the level of interest in S&T is not particularly high. Interest in new scientific discoveries and use of new inventions and technologies

Figure 7-3
Public interest in selected issues: 2010

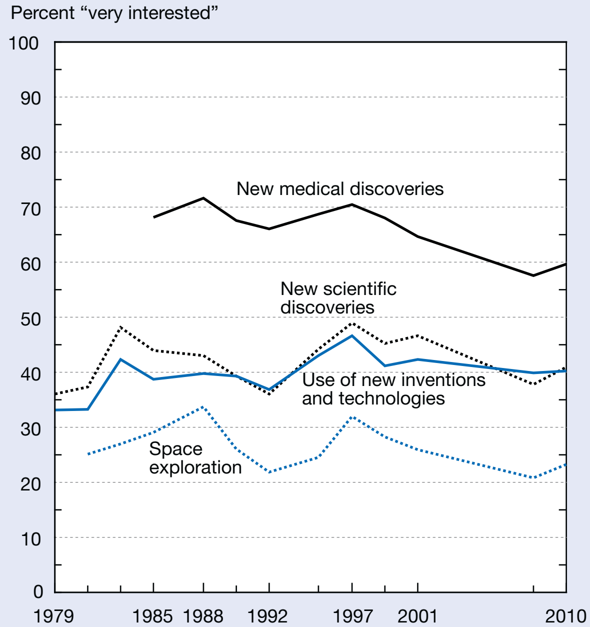


NOTE: Responses to *There are a lot of issues in the news, and it is hard to keep up with every area. I'm going to read you a short list of issues, and for each one I would like you to tell me if you are very interested, moderately interested, or not at all interested.*

SOURCE: University of Chicago, National Opinion Research Center, General Social Survey (2010). See appendix table 7-4.

Science and Engineering Indicators 2012

Figure 7-4
Public interest in selected science-related issues: 1979–2010



NOTES: Responses to *There are a lot of issues in the news, and it is hard to keep up with every area. I'm going to read you a short list of issues, and for each one I would like you to tell me if you are very interested, moderately interested, or not at all interested.* Figure shows only "very interested" responses. Figure includes all years for which data collected; other years extrapolated.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Public Attitudes Toward and Understanding of Science and Technology (1985–2001); University of Chicago, National Opinion Research Center, General Social Survey (2008, 2010). See appendix table 7-4.

Science and Engineering Indicators 2012

ranked in the middle among 10 areas considered on the 2010 GSS survey. Interest in S&T is roughly comparable to interest in economic issues and business conditions, and military and defense policy. It ranks well ahead of interest in agriculture and farming, space exploration, and foreign policy; and lags behind interest in new medical discoveries, environmental pollution, and local school issues (figure 7-3). Of course, a more inclusive concept of S&T might treat several of the topics on this list, such as space exploration and new medical discoveries, as part of the S&T category; furthermore, other topic areas often include substantial S&T content.[6]

Survey reports about attention to news show a smaller percentage of Americans paying close attention to news reports about S&T in 2008 relative to earlier years. In the 2008 Pew Research Center survey on media consumption, 13% of the respondents reported following S&T news "very closely." S&T news ranked 13th among 18 topics, tied with consumer news and ahead of entertainment, culture and the arts, celebrity news, and travel (table 7-1). As is the case for many other news topics, the percentage of Americans who said they follow S&T closely declined between 1996 and 2008. S&T's relative standing on the list of topics also slipped; it ranked ahead of seven topics in 1996, but ahead of only two of the same topics in 2008 (Pew Research Center 2008).

International Comparisons

International surveys often find similar or lower expressed interest in S&T, but few ask about interest levels using the exact same question wording, making direct comparisons difficult. In the 2010 European survey ("Eurobarometer"), 30% of respondents across all 27 European nations surveyed report being "very interested" in new scientific discoveries and technological developments, 49% are "moderately interested," and 20% are "not interested." Thus, expressed interest in S&T tends to be lower in the European Union (EU) than in the United States. The EU's average self-reported interest in S&T-related issues is about the same in 2010 as it was 2005,[7] but there is considerable variation among different countries. In both the United States and in Europe, men show more interest in S&T than women (EC 2010).[8]

About half of Chinese respondents (52%) report being interested in new scientific discovery; somewhat lower percentages are interested in new discovery and new technology (CRISP 2008).[9] Interest is lower in South Korea, where 24% of respondents were very interested in new scientific discovery (KOFAC 2009).

In other countries, the questions asked are not directly comparable to those asked in the United States. Brazilians showed a marked increase in interest about S&T in 2010 compared with 2006, along with a marked increase in interest about the environment (MCT of Brazil 2010). In Malaysia, interest toward S&T has been fairly stable between 1998 and 2008, whereas interest in environmental pollution has shown a gradual decline (MASTIC 2010).

Interest in medicine tends to be on a par with interest in S&T in Europe and China. Europeans are about equally likely to report being very interested in "new medical discoveries" as they are in "new scientific discoveries and technological development" (EC 2010). The Chinese are equally likely to report being interested in "new medical progress" and "new scientific discovery" (CRISP 2008). More Brazilians report being interested or very interested in medicine and health than in S&T (MCT of Brazil 2010); this pattern is consistent with U.S. survey data. The same pattern holds in Malaysia (MASTIC 2010).

Interest in space exploration has consistently ranked low in the United States and around the world, relative to other S&T topic areas. Surveys in Russia, China, and Japan have documented this general pattern in the past, though no recent data are available on this subject. In India, 19% of the public reported being "interested" in space exploration—lower than any other topic asked (Shukla 2005). Malaysia recently developed a space exploration program and put its own astronauts into space for the first time in 2007. In 2008, half of

Table 7-1
News followed "very closely" by American public: 1996–2008
(Percent)

Type of news	1996	1998	2000	2002	2004	2006	2008
Weather	NA	NA	NA	NA	53	50	48
Crime	41	36	30	30	32	29	28
Education	NA	NA	NA	NA	NA	NA	23
Community	35	34	26	31	28	26	22
Environment	NA	NA	NA	NA	NA	NA	21
Politics/Washington news	16	19	17	21	24	17	21
Local government	24	23	20	22	22	20	20
Health news	34	34	29	26	26	24	20
Sports	26	27	27	25	25	23	20
Religion	17	18	21	19	20	16	17
International affairs	16	16	14	21	24	17	16
Business and finance	13	17	14	15	14	14	16
Consumer news	14	15	12	12	13	12	13
Science and technology	20	22	18	17	16	15	13
Culture and arts	9	12	10	9	10	9	11
Entertainment	15	16	15	14	15	12	10
Celebrity news	NA	NA	NA	NA	NA	NA	7
Travel	NA	NA	NA	NA	NA	NA	6

NA = not available, question not asked

NOTES: Data reflect respondents who said they followed type of news "very closely." Table includes all years for which data collected.

SOURCE: Pew Research Center for the People and the Press, *Audience Segments in a Changing News Environment: Key News Audiences Now Blend Online and Traditional Sources* (17 August 2008), p. 39, Biennial News Consumption Survey (30 April–01 June 2008), http://people-press.org/reports/pdf/444.pdf, accessed 21 September 2009.

Science and Engineering Indicators 2012

Malaysians indicated they were "interested" or "very interested" in space exploration (MASTIC 2010).

Availability of S&T News in the Media

The sources of information Americans rely on for news about S&T are at least partly a function of the availability of S&T information from different venues and news media. Recent research on media coverage across a range of public policy domains found that the amount and prominence of media coverage is positively associated with public awareness of specific policy-related facts (Barabas and Jerit 2009). Thus, the amount and depth of media coverage of S&T could both reflect public interest in the topic and also influence the amount of public attention to and awareness of developments in S&T.

How much and what kinds of S&T news coverage are available in the media? The Project for Excellence in Journalism (PEJ 2010a) has conducted an extensive content analysis of media coverage since 2007 using a broad sample of about 50 outlets in the following media sectors: print, Internet, network television, cable television, and radio. Each week, stories are classified into 1 of 26 broad topic areas, including a category for S&T.[10]

These data show that S&T make up a small percentage of the total amount of news in the traditional media—less than 2% annually from 2007 to 2010 (table 7-2).[11] News coverage on the environment makes up a similarly small proportion of the news. By comparison, coverage of health and medicine makes up a greater proportion of the news but is also more variable, ranging from approximately 3% to 9% during the 4-year period.

Which stories about S&T are covered by the media? Within the S&T news coverage, stories on cyberspace issues are most common—about 27% in 2010 and 18% in 2009. Other stories compose a much smaller portion of the S&T news coverage in the media. In 2010, stories about the

Table 7-2
Traditional media coverage on science and technology, by topic area: 2007–10
(Percent)

Year	Number of stories	Science and technology	Environment	Health and medicine
2007	70,737	1.3	1.6	3.6
2008	69,942	1.1	1.3	2.7
2009	68,717	1.8	1.5	8.9
2010	52,613	1.5	1.6	5.0

NOTE: Data reflect percentage of news stories in each topic area based on content analysis of coverage by media outlets in five sectors: print, Internet, network TV, cable TV, and radio.

SOURCE: Project for Excellence in Journalism, News Coverage Index, special tabulations (21 March 2011), http://www.journalism.org/about_news_index/methodology, accessed 11 February 2011.

Science and Engineering Indicators 2012

NASA Space Shuttle mission accounted for 8% of the S&T news, roughly equal to the proportion of stem cell-related news in 2009 (table 7-3).

Analyses of the content on the three major broadcast networks (ABC, CBS, NBC) tell a similar story. The Tyndall Report has tracked the content of the three major broadcast networks for more than 20 years; the amount of air time on each nightly newscast is classified into 18 categories (Tyndall Report 2011a). Two categories with large science, engineering, and technology components are "science, space, and technology," and "biotechnology and basic medical research."[12] Neither category has ever occupied a large percentage of the approximately 15,000 minutes of annual nightly weekday newscast coverage on the networks. The airtime devoted to "science, space, and technology" averaged 339 minutes—about 2% of broadcast news—between 2000 and 2010, but fluctuated from 1% to 5% during this period (figure 7-5).[13] Time devoted to "biotechnology and basic medical research" was considerably lower, accounting for 1% or less of broadcast news (with some variation depending on the year).

The leading story on nightly news broadcasts in 2010 was the oil spill in the Gulf of Mexico (9% of the year's news). Although not classified as such, stories on the oil spill often included substantial attention to science and engineering issues (Tyndall Report 2011b). The most-covered stories on science, space, and technology in 2009 and 2010 focused on developments in the nation's space program and new developments in high technology products and tools for consumers, such as flat screen tablet computers and social networking websites (table 7-4). In the category of "biotechnology and basic medical research," cancer research garnered the most coverage, as it has done since 2006.

The media environment is rapidly changing, with *new media* and *social media* outlets continuing to proliferate and attract users. The Project for Excellence in Journalism conducts a new media content analysis focusing primarily on news-focused blogs and Twitter posts (PEJ 2010c). The analysis tracks the most-linked-to news subjects on a sample of blogs in order to capture the priorities of bloggers. The same procedure is used for Twitter posts.[14] This provides another indicator of interest in and availability of S&T news. In 2010, S&T stories composed 12% of the most-linked-to blog subjects in a given week; in 2009, that figure was 17%. On Twitter, S&T made up 38% of the most-linked-to subjects in a given week in 2010, down from 48% in 2009 (table 7-5).

Table 7-3
Leading traditional media story lines on science and technology, by topic area: 2009 and 2010
(Percent of news in each topic area)

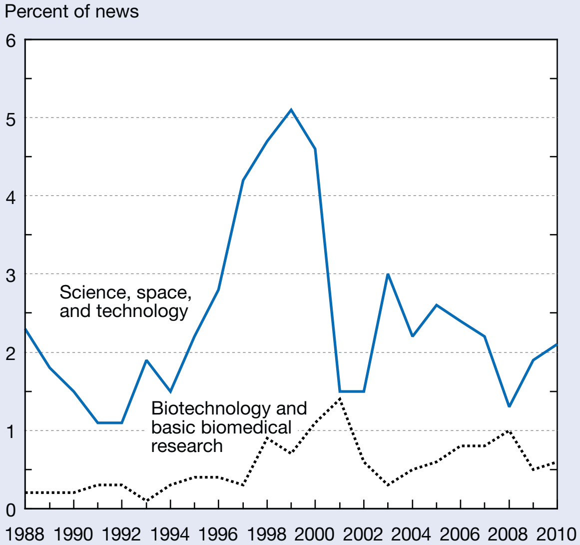
Topic area/leading story line	2009	Topic area/leading story line	2010
Science, space, and technology (*n* = 1,212 stories)		Science, space, and technology (*n* = 796 stories)	
Cyberspace issues	17.6	Cyberspace issues	26.7
Stem cell research	8.6	NASA/shuttle missions	8.1
40th anniversary of Apollo space mission	6.4	Apple product and business news	8.0
Hubble Telescope	5.2	China	2.2
Space Shuttle Endeavour	4.4	Education	2.0
Moon bombing by NASA	3.2	Google	1.7
TV switch to digital	2.5	WikiLeaks	1.5
NASA/shuttle missions	2.5	Stem cell research	1.3
Global warming/climate change	1.9	Terror threats/homeland security	1.2
Texting and driving	1.7	Texting and driving	1.0
Environment (*n* = 1,007 stories)		Environment (*n* = 830 stories)	
Global warming/climate change	37.1	BP oil spill in Gulf of Mexico	42.2
Pollution/emissions/going green	18.9	Energy debate	15.4
Energy debate	13.8	Global warming/climate change	11.5
Economy	3.4	Pollution/emissions/going green	7.0
G8 Summit	2.7	China	1.0
Health and medicine (*n* = 6,101 stories)		Health and medicine (*n* = 3,271 stories)	
Health care reform debate in Congress	65.2	Health care reform debate in Congress	62.8
Swine flu outbreak	15.7	Egg recall	2.3
Government mammogram recommendations	1.5	2010 elections	1.4
Economy	0.8	Stem cell research	1.4
Chemotherapy refused by teen cancer patient	0.6	Avandia	1.3

NOTE: Data reflect story lines with greatest percentage of news in each topic area based on content analysis of coverage by media outlets in five sectors: print, Internet, network TV, cable TV, and radio.

SOURCE: Project for Excellence in Journalism, News Coverage Index, special tabulations (21 March 2011), http://www.journalism.org/about_news_index/methodology, accessed 11 February 2011. For methodology, see http://www.journalism.org/commentary_backgrounder/new_media_index_methodology, accessed 11 February 2011.

Science and Engineering Indicators 2012

Figure 7-5
Network nightly news coverage of science and technology: 1988–2010



NOTES: Data reflect percentage of approximately 15,000 total annual minutes of weekday nightly newscasts on ABC, CBS, and NBC that were spent on science, space, and technology and on biotechnology and basic medical research. Excluded from science, space, and technology are forensic science and media content. Excluded from biotechnology and basic medical research are stories on clinical research and medical technology.

SOURCE: Tyndall Report, special tabulations (21 March 2011), http://www.tyndallreport.com, accessed 3 February 2011.

Science and Engineering Indicators 2012

What kinds of stories *go viral* on blogs and Twitter posts? There is no available quantitative measure of the most-linked-to science stories. Recent examples of most-linked-to blog stories on science include the discovery of a new kind of large rat in Papua New Guinea, news that a chemical found in blue M&Ms might have therapeutic qualities, and the discovery of a meat-eating plant (PEJ 2010d). Climate change and the controversy surrounding e-mails from a British researcher on the subject was one of the top five subjects covered by bloggers in December 2009 and made up a third of the weekly blog links 3 months later, shortly after a BBC interview on the subject (PEJ 2010b).

Involvement

Involvement with S&T outside the classroom in informal, voluntary, and self-directed settings—such as museums, science centers, zoos, and aquariums—is another indicator of the public's interest in S&T.[15] By offering visitors the flexibility to pursue individual curiosity, such institutions provide a kind of exposure to S&T that is well-suited to helping people develop further interest.[16]

In the 2008 GSS, 61% of Americans indicated that they had visited an informal science venue during the previous year (appendix table 7-6).[17] About half (52%) said they had visited a zoo or aquarium, and more than one-quarter had visited a natural history museum (28%) or an S&T museum (27%). One in three Americans had visited an art museum and 64% had visited a public library. These data are generally consistent with data collected by the Pew Internet and

Table 7-4
Leading nightly news story lines on science and technology, by topic area: 2009 and 2010
(Annual minutes of coverage)

Topic area/leading story line	2009	Topic area/leading story line	2010
Science, space, and technology		Science, space, and technology	
NASA Hubble Space Telescope repairs	40	Internet used for social networking: Facebook	34
Moon astronomy: NASA searches for evidence of water	20	Computer flatscreen table technology: iPad	20
NASA anniversary of Apollo manned moon missions	19	Cellular telephone/computer combination: iPhone	18
NASA Space Shuttle program	17	NASA manned space flights to be discontinued	18
Computer networks targeted by coordinated hackers	15	UFO speculation fascinates skywatchers	13
Internet used for social networking: Facebook	12	Internet classified ads posted online: Craigslist	11
Apple Computer CEO Steve Jobs returns to work	12	High-technology multitasking is distracting	9
Internet online commerce volume increases	12	Office copier machines have hard drive memories	9
NASA plans renewed manned missions to moon	11	Videostreams shared online in viral networks: YouTube	8
Videostreams shared online in viral networks: YouTube	6	China censors Internet access, e-mail traffic	8
Biotechnology/basic medical research		Biotechnology/basic medical research	
War on cancer/research efforts	37	War on cancer/research efforts	48
Human embryo stem cell biotechnology research	23	Human embryo stem cell biotechnology research	14
		Genetic DNA biotech analysis predicts disease	11
		Salmon genetically modified to accelerate growth	7
		Spinal cord injuries and paralysis research	5

NOTES: Data reflect annual minutes of story coverage on these topics by major networks ABC, CBS, and NBC, out of approximately 15,000 total annual minutes on weekday nightly newscasts. Shown are the story lines receiving at least 5 minutes of coverage in 2009 and 2010. Excluded from science, space, and technology are stories on forensic science and media content. Excluded from biotechnology/basic medical research are stories on clinical research and medical technology.

SOURCE: Tyndall Report, special tabulations (2 March 2011), http://www.tyndallreport.com, accessed 3 February 2011.

Science and Engineering Indicators 2012

Table 7-5
"Most-linked-to" subjects in the new media, by topic area: 2009 and 2010
(Percent)

Topic area	Blogs 2009 (*n* = 235)	Blogs 2010 (*n* = 256)	Twitter[a] 2009 (*n* = 132)	Twitter[a] 2010 (*n* = 255)
Science, space, and technology	17	12	48	38
Environment	4	4	4	2
Health and medicine	8	6	6	1

n = number of subjects coded

[a] Twitter content analysis for 2009 based on 6 months starting June 15; analysis for 2010 based on 12 months.

NOTE: Data reflect percentage of "most-linked-to" subjects in a given week, based on content analysis of news-focused blogs and social media sites.

SOURCE: Project for Excellence in Journalism, New Media Index, special tabulations (17 February 2011), http://www.journalism.org/commentary_backgrounder/new_media_index_methodology, accessed 11 February 2011.

Science and Engineering Indicators 2012

American Life Project and the Institute for Museum and Library Services. (For more detail on these surveys, see NSB 2008.) Among those who visited each of these institutions, the number of annual visits was highest for public libraries, which averaged about 15 visits per year.

The proportion of respondents who reported visiting either a zoo or aquarium, an S&T museum, and a public library is down slightly from the last time these questions were asked in 2001.[18] Respondents in households with children 18 or younger were more likely to visit a zoo or aquarium, a public library, and also a natural history museum. Minors in the household did not make a difference in the proportion of adults who visited an art museum or an S&T museum (appendix table 7-7).

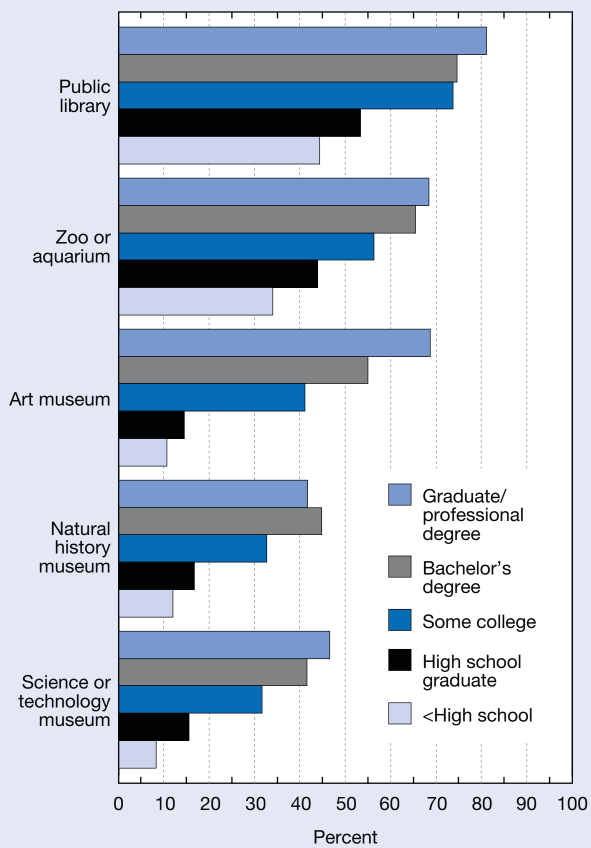
Americans with more years of formal education are more likely than others to engage in these informal science activities (figure 7-6; appendix table 7-7). Those in higher income brackets are more likely to have visited a zoo or aquarium, a natural history or S&T museum, or an art museum, but are just as likely as those in the lowest income bracket to have visited a public library. In general, visits to informal science institutions are less common among Americans who are 65 or older.

In addition, respondents who get most of their information about S&T from the Internet or use this medium to learn about scientific issues are more likely to have visited any informal science institution, even after controlling for expressed interest in scientific issues. This suggests that users experience these different sources of science information as complementing, rather than replacing, one another.

International Comparisons

Compared with the United States, visits to S&T museums are less common in China, Japan, South Korea, Malaysia, India, Europe, and Brazil (table 7-6). The proportion of respondents who indicate they have visited a zoo is similar in the United States, China, and Japan. Visiting a zoo is more common in the United States[19] than it is in South Korea, India, Malaysia, Europe, and Brazil. Unmeasured

Figure 7-6
Attendance at informal science and other cultural institutions, by institution type and education level: 2008



NOTES: Responses to *I am going to read you a short list of places and ask you to tell me how many times you visited each type of place during the last year, that is, the last 12 months.* Percentage indicates respondents who had attended the noted institution at least once.

SOURCE: University of Chicago, National Opinion Research Center, General Social Survey (2008). See appendix tables 7-6 and 7-7.

Science and Engineering Indicators 2012

Table 7-6
Visits to informal science and other cultural institutions, by country/region: Most recent year
(Percent)

Institution	United States (2008)	China (2007)	Japan (2001)	South Korea (2008)	India (2004)	Malaysia (2008)	EU (2005)	Brazil (2010)
Zoo/aquarium[a]	52	52	43	36	35	30	27	22
Natural history museum	28	14	19	NA	NA	NA	NA	NA
Science/technology museum[b]	27	17	12	11	12	11	16	8
Public library[c]	64	41	46	34	27	NA	34	29
Art museum[d]	34	18	34	34	22	30	23	14

NA = not available, question not asked

EU = European Union; data not available for Bulgaria and Romania

[a]"Zoo, aquarium, botanic garden" for China; "Zoo" for India, Malaysia, Brazil.
[b]"Science museum" for South Korea; "Science parks" for India; "National Science Centre" for Malaysia; "Science museums or technology museums or science centers" for EU.
[c]"Library" for India, Brazil.
[d]"Art museum or exhibition hall" for China; "Museum/art gallery" for South Korea; "Museum" for India, Malaysia.

NOTES: Responses to (United States, Japan, South Korea) *I am going to read you a short list of places and ask you to tell me how many times you visited each type of place during the last year, that is, the last 12 months* (percentage includes those who visited each institution one or more times); (China, EU, Brazil) *Which of the following have you visited in the last 12 months?* (multiple answers possible); (Malaysia) *In the past year, how many times did you visit the following places?* (percentage includes those who visited each institution one or more times); (India) *How frequently did you visit the following during the last 12 months?* (percentage includes those who visited each institution one or more times).

SOURCES: United States–University of Chicago, National Opinion Research Center, General Social Survey (2008); China–Chinese Association for Science and Technology/China Research Institute for Science Popularization, Chinese National Survey of Public Scientific Literacy (2007); Japan–National Institute of Science and Technology Policy/Ministry of Education, Culture, Sports, Science and Technology, Survey of Public Attitudes Toward and Understanding of Science and Technology in Japan (2001); South Korea–Korea Foundation for the Advancement of Science and Creativity (formerly Korea Science Foundation), Survey of Public Attitudes Toward and Understanding of Science and Technology (2008); India–National Council of Applied Economic Research, National Science Survey (2004); Malaysia–Malaysian Science and Technology Information Center/Ministry of Science, Technology and Innovation, Survey of the Public's Awareness of Science and Technology: Malaysia (2008); EU–European Commission, Eurobarometer 224/Wave 63.1: *Europeans, Science and Technology* (2005); Brazil–Ministry of Science and Technology of Brazil, Public Perceptions of Science and Technology (2010). See appendix table 7-6 for U.S. trends.

Science and Engineering Indicators 2012

differences in the prevalence and accessibility of informal science learning opportunities across countries prohibit attributing different visit patterns to differences in interest.

Public Knowledge About S&T

Knowledge and understanding of S&T can be relevant to public policy and the personal choices that people make. In developing measures for what is often termed *scientific literacy* across nations, the Organisation for Economic Co-operation and Development (OECD 2003) emphasizes that scientific literacy is a matter of degree and that people cannot be classified as either literate or not literate. The OECD noted that literacy had several components:

> Current thinking about the desired outcomes of science education for all citizens emphasizes the development of a general understanding of important concepts and explanatory frameworks of science, of the methods by which science derives evidence to support claims for its knowledge, and of the strengths and limitations of science in the real world. It values the ability to apply this understanding to real situations involving science in which claims need to be assessed and decisions made…
>
> Scientific literacy is the capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity. (pp. 132–33)

A good understanding of basic scientific terms, concepts, and facts; an ability to comprehend how S&T generates and assesses evidence; and a capacity to distinguish science from pseudoscience are widely used indicators of scientific literacy. U.S. survey data indicate that many Americans provide multiple incorrect answers to basic questions about scientific facts and do not apply appropriate reasoning strategies to questions about selected scientific issues. Residents of other countries, including highly developed ones, appear to perform no better, on balance, when asked similar questions**.** However, in light of the limitations of using a small number of questions largely keyed to knowledge taught in school, generalizations about Americans' knowledge of science should be made cautiously.

Understanding Scientific Terms and Concepts

U.S. Patterns and Trends

One common indicator of public understanding about science comes from an index of factual science knowledge questions covering a range of science disciplines. Responses to nine questions are used in a combined scale as an indicator of general knowledge about S&T. In 2010, Americans, on average, were able to correctly answer 5.6 out of the 9 items, for an average percent correct of 63%.

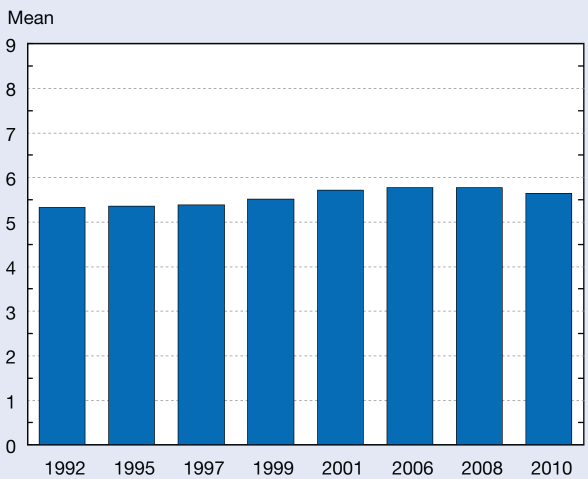
The public's level of factual knowledge about science has not changed much over the past two decades (figure 7-7). Since 2001, the average number of correct answers to a series of mostly true-false science questions in years for which fully comparable data were collected has ranged from 5.6 correct responses to 5.8 correct responses, although knowledge on individual questions has varied somewhat over time (appendix tables 7-8 and 7-9).[20] (Also see sidebar, "Measuring Factual Science Knowledge Over Time.")

Some individuals know more about science than others, of course. Factual knowledge of science is strongly related to people's level of formal schooling and the number of science and mathematics courses completed. Among those who have no more than a high school education, 49% of the questions were answered correctly, on average. Individuals who had attended college answered more items correctly; the average percent correct rose to 81% among those who had taken three or more science and mathematics courses in college (figure 7-8; appendix table 7-8).

Respondents age 65 and older are less likely than younger Americans to answer the factual science questions correctly (appendix table 7-8). Younger generations have had more formal education, on average, than Americans coming into adulthood some 50 years ago; these long-term societal changes make it difficult to know whether the association between age and factual knowledge is due primarily to aging processes, cohort differences in education, or other factors. An analysis of surveys conducted between 1979 and 2006 concluded that public understanding of science has increased over time and by generation, even after controlling for formal education levels (Losh 2009, 2011). (Also see Bauer 2009.)

Factual knowledge about science is also associated with sex. Men tend to answer more factual science knowledge questions correctly than do women. However, this pattern depends on the science domain referenced in the question. In the factual questions included in NSF surveys since 1979, men

Figure 7-7
Mean number of correct answers to trend factual knowledge of science scale: 1992–2010

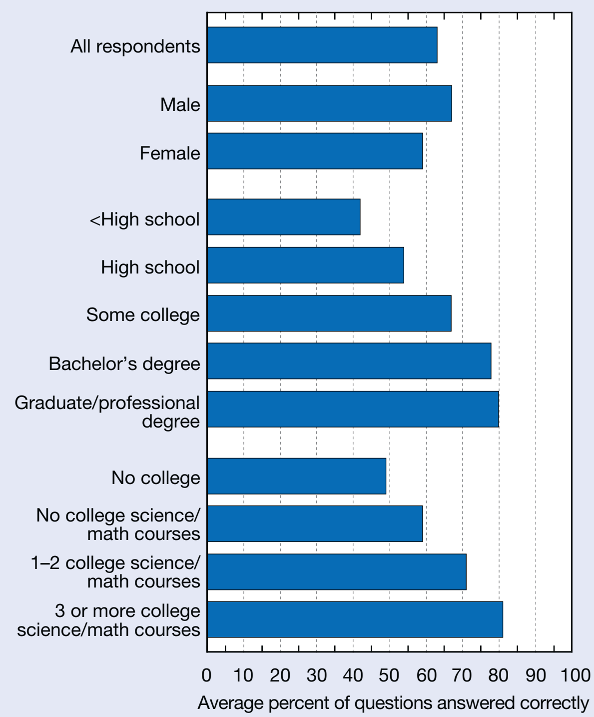


NOTES: Mean number of correct answers to nine questions included in trend factual knowledge of science scale; see appendix table 7-8 for explanation, list of questions, and percentage of questions answered correctly. See appendix tables 7-9 and 7-10 for responses to individual questions. Table includes all years for which data were collected.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Public Attitudes Toward and Understanding of Science and Technology (1992–2001); University of Chicago, National Opinion Research Center, General Social Survey (2006, 2008, 2010).

Science and Engineering Indicators 2012

Figure 7-8
Correct answers to trend factual knowledge of science scale, by respondent characteristic: 2010



NOTES: Data reflect average percentage of nine questions answered correctly. "Don't know" responses and refusals to respond counted as incorrect. See appendix table 7-8 for explanation, list of questions, and additional respondent characteristics. See appendix tables 7-9 and 7-10 for responses to individual questions.

SOURCE: University of Chicago, National Opinion Research Center, General Social Survey (2010).

Science and Engineering Indicators 2012

Measuring Factual Science Knowledge Over Time

How to measure factual knowledge about science over time is a difficult puzzle, in part because the generally accepted principles and facts of scientific fields are constantly in flux. The items in the factual knowledge index were first developed in the 1970s and aimed to tap a selection of science facts that would likely withstand the "test of time" (Miller 1998, 2011). The index aims to measure the extent to which the public has a clear understanding of the factual aspects of major scientific fields in the biological and physical sciences. The proportion of the public that provides the correct answer on any one question is less important than the pattern of responses across the set of questions used in the factual knowledge index.

As science changes and public knowledge about science changes, the exact questions that best distinguish individuals who tend to know more about science from those who tend to know less are likely to vary over time. As a result, periodic review of indicators such as these is warranted. A number of studies and analyses have been commissioned by NSF for this purpose over the years. NSF is in the process of undertaking further review and experimentation with the factual knowledge questions.

Two items used in past versions of the index have received considerable scrutiny; one concerned the "big bang" and the other concerned evolution. In the 2010 GSS, 45% of Americans answered "true" that "the universe began with a huge explosion." There was some concern that the wording of this question erred too heavily on the side of using easily comprehensible language at the cost of scientific precision. This may prompt some highly knowledgeable respondents to think that the item blurs or neglects important distinctions, and in a few cases may lead respondents to answer the question incorrectly. The other item of some concern was "human beings, as we know them today, developed from earlier species of animals." In the 2010 GSS, half of Americans answered "true" to the question about evolution. As discussed elsewhere in the chapter, evidence from a 2004 survey-based experiment suggests that responses to these items reflect more than familiarity with the concepts. (Also see NSB 2008.)

As measures of science knowledge, these questions correlate with the overall index, but the correlations for other items are generally stronger. A statistical review conducted by the Research Triangle Institute on behalf of NSF in 2004 found that all the knowledge questions, including the evolution and "big bang" questions, reflect a single underlying dimension of factual knowledge (Bann and Schwerin 2004). Later analyses have replicated this finding over time. Thus, the social science foundation for using either 11 items or 9 items together in one scale is well-supported.

This chapter relies on the 9-item factual knowledge scale for analysis of trends in knowledge over time. Responses to the 9-item factual knowledge scale and an 11-item factual knowledge scale that includes responses to the questions on evolution and the "big bang" are highly correlated with each other. Whether or not these two questions are included in a scale of factual science knowledge has little bearing on the summary portrait of Americans' knowledge that the scale conveys. In addition, knowledge differences between population groups (e.g., men and women) are similar (appendix table 7-10). Table 7-B shows that, on average, respondents in the top quartile on the trend factual knowledge scale answered 87% of the questions on the 11-item version of the scale correctly and 59% of the two additional items correctly. Those in the lower quartiles on the trend factual knowledge scale answered fewer items correctly.

Table 7-B
Correct responses on trend factual knowledge of science scale by longer factual knowledge scale: 2010
(Average percent correct)

Respondent score[a]	Trend factual knowledge of science scale, 9 items	11-item scale[b]	2-item scale[c]
Top quartile	94	87	59
2nd quartile	73	68	47
3rd quartile	51	48	37
Bottom quartile	25	24	22

[a]Quartile based on correct answers to trend factual knowledge of science scale, 9 items.
[b]11-item scale that includes the same 9 items plus responses to 2 additional items.
[c]2-item scale consisting of responses to the evolution and "big bang" questions.

NOTES: Data reflect average percentage of questions in index answered correctly. "Don't know" responses and refusals to respond counted as incorrect.

SOURCE: University of Chicago, National Opinion Research Center, General Social Survey (2010).

Science and Engineering Indicators 2012

score higher than women on questions in the physical sciences, but not on questions in the biological sciences. Women tend to score at least equally as high as men on the biological science questions and often a bit higher (table 7-7).

Comparisons of Adult and K–12 Student Knowledge

The factual knowledge questions that have been repeatedly asked in U.S. surveys involve information that was being taught in grades K–12 when most respondents were young. Because science continually generates new knowledge that reshapes how people understand the world, scientific literacy requires lifelong learning so that citizens become familiar with terms, concepts, and facts that emerge after they complete their schooling.

The 2008 GSS included several different kinds of factual science knowledge questions; seven of those questions can be directly compared with national student assessments of science knowledge. Adult Americans received a higher or similar score to fourth and eighth grade students in five of the seven factual science knowledge questions where comparisons scores were possible (table 7-8).

Comparisons should be made cautiously because of the differences in circumstances in which students and adults responded to these science knowledge questions. Students' tests were self-administered on paper, whereas the majority of respondents in the GSS answered orally to questions asked by an interviewer. Also, elementary and middle school students had an advantage over adults in that classroom preparation preceded their tests. (For more details, see NSB 2010.)

Knowledge About Nanotechnology and the Polar Regions

New developments in S&T are always on the horizon. Indicators of factual science knowledge need to probe knowledge and understanding about newly emerging science topics, as well as more established topics. Recent GSS surveys included indicators of public understanding for one such emerging area—nanotechnology.

A small minority report having heard "a lot" about nanotechnology; 31% of Americans correctly indicate that "nanotechnology involves manipulating extremely small units of matter, such as individual atoms, in order to produce better materials" is true.[21] About two in ten (18%) Americans correctly indicate that "the properties of nanoscale materials often differ fundamentally and unexpectedly from the properties of the same materials at larger scales." (Also see "Public Attitudes About Specific S&T-Related Issues.")

Table 7-7
Correct answers to factual knowledge and process questions in physical and biological sciences, by sex: 1999–2010
(Average percent correct)

Science topic/sex	1999	2001	2004	2006	2008	2010
Physical science index[a]						
Male	72	73	73	74	74	73
Female	57	59	55	59	61	60
Biological science index[b]						
Male	59	61	62	63	60	62
Female	62	65	65	66	64	65

[a]Physical science index includes five questions:
- *The center of the Earth is very hot.* (True)
- *All radioactivity is man-made*. (False)
- *Lasers work by focusing sound waves*. (False)
- *Electrons are smaller than atoms*. (True)
- *The continents have been moving their location for millions of years and will continue to move.* (True)

[b]Biological science index includes six questions (questions 3 and 4 have two parts):
- *It is the father's gene that decides whether the baby is a boy or a girl.* (True)
- *Antibiotics kill viruses as well as bacteria.* (False)
- *A doctor tells a couple that their genetic makeup means that they've got one in four chances of having a child with an inherited illness.* (1) *Does this mean that if their first child has the illness, the next three will not?* (No); (2) *Does this mean that each of the couple's children will have the same risk of suffering from the illness?* (Yes) Data represent a composite of correct responses to both questions.
- *Two scientists want to know if a certain drug is effective against high blood pressure. The first scientist wants to give the drug to 1,000 people with high blood pressure and see how many of them experience lower blood pressure levels. The second scientist wants to give the drug to 500 people with high blood pressure and not give the drug to another 500 people with high blood pressure, and see how many in both groups experience lower blood pressure levels. Which is the better way to test this drug? Why is it better to test the drug this way?* (The second way because a control group is used for comparison.) Data represent a composite of correct responses to both questions.

NOTES: Data reflect average percentage of questions in index answered correctly. "Don't know" responses and refusals to respond counted as incorrect.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Public Attitudes Toward and Understanding of Science and Technology (1999, 2001); University of Michigan, Survey of Consumer Attitudes (2004); and University of Chicago, National Opinion Research Center, General Social Survey (2006, 2008, 2010). See appendix tables 7-9 and 7-10 for factual knowledge questions. See appendix tables 7-13 and 7-14 for scientific process questions (probability and experiment).

Science and Engineering Indicators 2012

Table 7-8
Comparison of correct answers given by adults and students to factual knowledge questions: Most recent year
(Percent)

Question	Field of study	Concepts measured	Adult	Student		
			United States	United States	International	Question source
1. *A farmer thinks that the vegetables on her farm are not getting enough water. Her son suggests that they use water from the nearby ocean to water the vegetables. Is this a good idea?*	Earth and space sciences	Water cycle; nature of the oceans and their effects on water and climate; location of water, its distribution, characteristics, and its effect and influence on human activity	84	61	NA	NAEP 2005, grade 4
2. *Traits are transferred from generation to generation through the…*	Life sciences	Reproduction and heredity	79	86	74	TIMSS 2003, grade 8
3. *How do most fish get the oxygen they need to survive?*	Life sciences	Change and evolution; adaptation and natural selection	75	78	NA	NAEP 2005, grade 8
4. *What property of water is most important for living organisms?*	Physical sciences	Matter and its transformations	68	76	NA	NAEP 2000, grade 8
5. *Which one of the following is NOT an example of erosion?*	Earth and space sciences	Composition of the Earth; forces that alter the Earth's surface; rocks: their formation, characteristics, and uses; soil: its changes and uses; natural resources used by humankind; and forces within the Earth	54	37	NA	NAEP 2005, grade 8
6. *Lightning and thunder happen at the same time, but you see the lightning before you hear the thunder. Explain why this is so.*	Physical sciences	Frames of reference; force and changes in position and motion; action and reaction; vibrations and waves as motion; electromagnetic radiation and interactions of electomagnetic radiation with matter	44	36	NA	NAEP 2005, grade 8
7. *A solution of hydrochloric acid (HCl) in water will turn blue litmus paper red. A solution of the base sodium hydroxide (NaOH) in water will turn red litmus paper blue. If the acid and base solutions are mixed in the right proportion, the resulting solution will cause neither red nor blue litmus paper to change color. Explain why the litmus paper does not change color in the mixed solution.*	Chemistry	Acids and bases	20	17	21	TIMSS 2003, grade 8

NA = not available, question not asked

NAEP = National Assessment of Educational Progress; TIMSS = Trends in International Mathematics and Science Study

NOTES: Questions appeared in 2008 General Social Survey; see appendix table 7-17 for complete questions. Original sources of questions are NAEP and TIMSS.

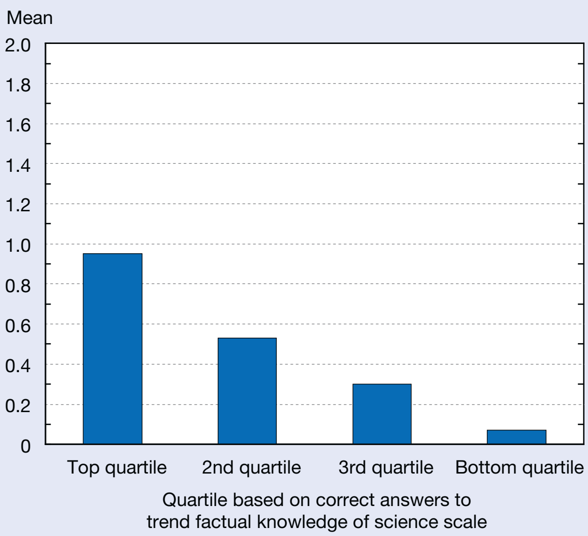
SOURCES: University of Chicago, National Opinion Research Center, General Social Survey (2008), see appendix table 7-18; NAEP, http://nces.ed.gov/nationsreportcard/itmrls/startsearch.asp, accessed 22 September 2009; TIMSS, http://nces.ed.gov/timss/results03.asp, accessed 22 September 2009.

Science and Engineering Indicators 2012

Those who scored higher on the general factual knowledge scale were also more likely to answer the two questions about nanotechnology correctly (figure 7-9).[22] Likewise, the educational and demographic characteristics associated with higher scores on the trend factual knowledge questions are also associated with higher knowledge of nanotechnology (appendix table 7-11). These data suggest that the trend factual knowledge scale, although focused on the kind of scientific facts and principles learned in school, is a reasonable indicator of factual science knowledge in general, including knowledge on newly emerging topics acquired later in life.

The 2006 and 2010 GSSs included a series of knowledge questions about the polar regions. Knowledge about the polar regions was measured using a 4-item scale of true-false questions. In 2010, Americans answered 60% of the four items correctly, on average, up from 55% in 2006. Increased knowledge about the polar region was indicated especially by two of the four questions: "The North Pole is on a sheet of ice that floats on the Arctic Ocean" (from 41% in 2006 to 48% in 2010), and "Hunting is more likely than climate change to make polar bears become extinct" (from 36% in 2006 to 44% in 2010) (appendix table 7-12). It is possible that this increase in knowledge stems, in part, from increased attention to the polar regions during the 2007–2008 International Polar Year.

Figure 7-9
Mean number of correct answers to nanotechnology questions, by correct answers to trend factual knowledge of science scale: 2010



NOTES: Mean number of correct responses to two factual questions on nanotechnology. Respondents saying they had heard "nothing at all" about nanotechnology were not asked questions; these respondents count as zero (0) correct. See appendix table 7-11 for responses to nanotechnology questions. Trend factual knowledge of science scale includes nine questions; see appendix table 7-8 for explanation and list of questions.

SOURCE: University of Chicago, National Opinion Research Center, General Social Survey (2010).

Science and Engineering Indicators 2012

However, there may be other reasons for the change including increased public attention to global climate change and its implications for the polar regions.

International Comparisons on Factual Knowledge Questions

Adults in different countries and regions have been asked identical or substantially similar questions to test their factual knowledge of science. Knowledge scores for individual items vary from country to country, and no country consistently outperforms the others. For the physical science and biological science questions reported in table 7-9, knowledge scores are relatively low in China, Russia, and Malaysia. Compared to the United States and the EU, scores in Japan are also relatively low.[23]

Science knowledge scores vary considerably across Europe, with northern European countries, led by Sweden, scoring the highest on a set of 13 questions. For a smaller set of 4 questions that were administered in 12 European countries in 1992 and 2005, each country performed better in 2005. In contrast, U.S. data on science knowledge do not show upward trends over the same period. In Europe, as in the United States, men, younger adults, and more highly educated people tend to score higher on these questions.

Reasoning and Understanding the Scientific Process

Another indicator of public understanding of science focuses on understanding of how S&T generates and assesses scientific evidence, rather than knowledge of particular facts. Past NSF surveys have used questions on three general topics—probability, experimental design, and the scientific method—to assess trends in Americans' understanding of the process of scientific inquiry. One set of questions tests how well respondents apply the principles of probabilistic reasoning to a series of questions about a couple whose children have a one in four chance of suffering from an inherited disease.[24] A second set of questions deals with the logic of experimental design, asking respondents about the best way to design a test of a new drug for high blood pressure. A third, open-ended question probes what respondents think it means to "study something scientifically." Because probability, experimental design, and the scientific method are all central to scientific research, these questions are relevant to how respondents evaluate scientific evidence. These measures are reviewed separately and then as a combined indicator of public understanding about scientific inquiry (table 7-10; appendix table 7-13).

In 2010, two-thirds of Americans correctly responded to two questions about probability of a child's genetic inheritance of illness. Understanding of probability has been fairly stable over time, with the percentage giving a correct response ranging from 64% to 69% since 1999. About half (51%) of Americans correctly identified the concept of using an experimental design or control group in the context of a medical study in 2010. This represents a marked increase in

Table 7-9
Correct answers to factual knowledge questions in physical and biological sciences, by country/region: Most recent year
(Percent giving correct answer)

Question	United States[a] (2010) (*n* = 1,932)	South Korea (2004) (*n* = 1,000)	EU (2005) (*n* =16,029)	Japan (2001) (*n* = 2,146)	Malaysia (2008) (*n* = 18,447)	India (2004) (*n* = 30,255)	China (2007) (*n* = 10,059)	Russia (2003) (*n* = 2,107)
Physical science								
The center of the Earth is very hot. (True)	84	87	86	77	66	57	49	NA
The continents have been moving their location for millions of years and will continue to move. (True)	80	87	87	83	44	32	44	40
Does the Earth go around the Sun, or does the Sun go around the Earth? (Earth around Sun)	73	86	66	NA	72	70	78	NA
All radioactivity is man-made. (False)	67	48	59	56	14	NA	40	35
Electrons are smaller than atoms. (True)	51	46	46	30	33	30	22	44
Lasers work by focusing sound waves. (False)	47	31	47	28	16	NA	20	24
The universe began with a huge explosion. (True)	38	67	NA	63	NA	34	22	35
Biological science								
The cloning of living things produces genetically identical copies. (True)	80	NA	68	NA	53	NA	NA	NA
It is the father's gene that decides whether the baby is a boy or a girl.[b] (True)	61	59	64	25	40	38	55	22
Ordinary tomatoes do not contain genes, while genetically modified tomatoes do.[c] (False)	47	NA	41	NA	NA	NA	NA	22
Antibiotics kill viruses as well as bacteria. (False)	50	30	46	23	8	39	21	18
Human beings, as we know them today, developed from earlier species of animals. (True)	47	64	70	78	NA	56	69	44

NA = not available, question not asked

EU = European Union; data not available for Bulgaria and Romania

[a]See appendix table 7-9 for U.S. trends.
[b]China and Europe surveys asked about "mother's gene" instead of "father's gene."
[c]Russia survey asked about "ordinary plants" instead of "ordinary tomatoes."

SOURCES: United States–University of Chicago, National Opinion Research Center, General Social Survey (2010); South Korea–Korea Science Foundation (now Korea Foundation for the Advancement of Science and Creativity), Survey of Public Attitudes Toward and Understanding of Science and Technology (2004); EU–European Commission, Eurobarometer 224/Wave 63.1: *Europeans, Science and Technology* (2005), and Eurobarometer 224/Wave 64.3: *Europeans and Biotechnology in 2005: Patterns and Trends* (2006); Japan–National Institute of Science and Technology Policy/Ministry of Education, Culture, Sports, Science and Technology, Survey of Public Attitudes Toward and Understanding of Science and Technology in Japan (2001); Malaysia–Malaysian Science and Technology Information Centre/Ministry of Science, Technology and Innovation, Survey of the Public's Awareness of Science and Technology: Malaysia (2008); India–National Council of Applied Economic Research, National Science Survey (2004); China–Chinese Association for Science and Technology/China Research Institute for Science Popularization, Chinese National Survey of Public Scientific Literacy (2007); Russia–Gokhberg L and Shuvalova O, *Russian Public Opinion of the Knowledge Economy: Science, Innovation, Information Technology and Education as Drivers of Economic Growth and Quality of Life,* British Council, Russia (2004).

Science and Engineering Indicators 2012

understanding from 38% in 2008 (table 7-10; appendix table 7-13).[25] Understanding of what it means to study something scientifically is considerably lower, at 18% in 2010. Correct responses on this question are lower, in part, because the task of expressing a concept in one's own words is more difficult than recognizing a correct response to a multiple-choice style closed-ended survey question. Correct responses on these questions have ranged from a low of 18% in 2010 to a high of 26% in 2001.

Taken together, 42% of Americans exhibit an understanding of scientific inquiry in 2010, up from 36% in 2008.[26] As was found for factual science knowledge, public understanding of scientific inquiry is strongly associated with people's level of formal schooling and the number of science and mathematics courses completed. Among those who have no more than a high school education, 23% are able to provide a correct response on the measure of understanding scientific inquiry. Understanding of scientific inquiry is somewhat higher among college attendees who did not take college-level science or mathematics courses. However, it is notably higher (71% correct) among individuals who completed at least three science and mathematics courses in college (figure 7-10; appendix table 7-14).

Americans age 65 and older score lower than younger adults on the scientific process measures. The differences are greatest on understanding of an experimental or control group design and on the open-ended questions about the meaning of scientific study. These differences may be related to the lower levels of formal education among older generations in the United States. The same pattern was found for factual science knowledge.

Unlike the patterns found on factual knowledge, particularly on facts related to the physical sciences, men and women obtain similar scores on understanding of scientific inquiry (figure 7-10; appendix table 7-14).

Comparisons of Adult and K-12 Student Understanding

The 2008 GSS included several additional questions on the scientific process that provide an opportunity to examine Americans' understanding of experimental design in more detail. From 29% to 57% of Americans responded correctly to questions measuring the concepts of scientific experiment and controlling variables, only 12% responded correctly to all the questions on this topic, and nearly 20% of Americans did not respond correctly to any of them (appendix table 7-15). These data raise questions about how well Americans can reliably apply a generalized understanding of experimental design across different situations.

Table 7-10
Correct answers to scientific process questions: Selected years, 1999–2010
(Percent)

Question	1999 (*n* = 1,882)	2001 (*n* = 1,574)	2004 (*n* = 2,025)	2006 (*n* = 1,864)	2008 (*n* = 2,021)	2010 (*n* = 1,454)
Understanding of scientific inquiry scale[a]	32	40	39	41	36	42
Components of understanding scientific inquiry scale						
Understanding of probability[b]	64	67	64	69	64	66
Understanding of experiment[c]	34	40	46	42	38	51
Understanding of scientific study[d]	21	26	23	25	23	18

[a]To be classified as understanding scientific inquiry, survey respondent had to (1) answer correctly the two probability questions stated in footnote b and (2) either provide "theory-testing" response to open-ended question about what it means to study something scientifically (see footnote d) or correct response to open-ended question about experiment, i.e., explain why it is better to test a drug using a control group (see footnote c).

[b]To be classified as understanding probability, survey respondent had to answer correctly *A doctor tells a couple that their genetic makeup means that they've got one in four chances of having a child with an inherited illness.* (1) *Does this mean that if their first child has the illness, the next three will not have the illness?* (No); and (2) *Does this mean that each of the couple's children will have the same risk of suffering from the illness?* (Yes).

[c]To be classified as understanding experiment, survey respondent had to answer correctly (1) *Two scientists want to know if a certain drug is effective against high blood pressure. The first scientist wants to give the drug to 1,000 people with high blood pressure and see how many of them experience lower blood pressure levels. The second scientist wants to give the drug to 500 people with high blood pressure and not give the drug to another 500 people with high blood pressure, and see how many in both groups experience lower blood pressure levels. Which is the better way to test this drug?* and (2) *Why is it better to test the drug this way?* (The second way because a control group is used for comparison.)

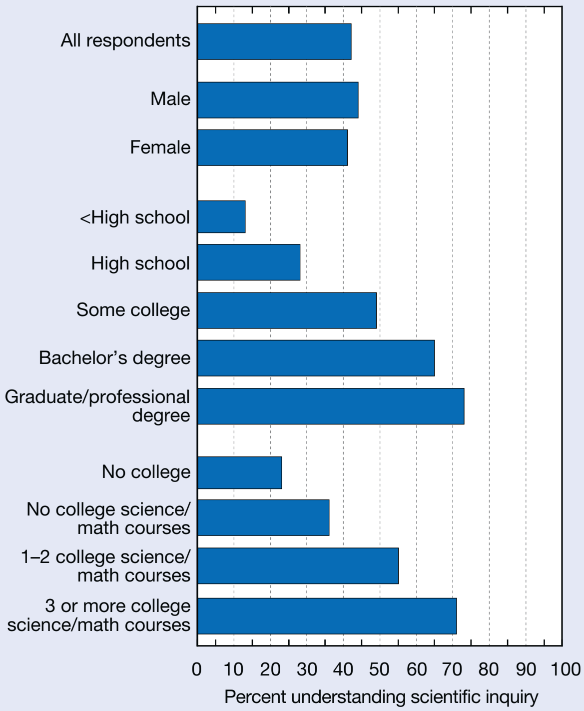
[d]To be classified as understanding scientific study, survey respondent had to answer correctly (1) *When you read news stories, you see certain sets of words and terms. We are interested in how many people recognize certain kinds of terms. First, some articles refer to the results of a scientific study. When you read or hear the term scientific study, do you have a clear understanding of what it means, a general sense of what it means, or little understanding of what it means?* and (2) (If "clear understanding" or "general sense" response) *In your own words, could you tell me what it means to study something scientifically?* (Formulation of theories/test hypothesis, experiments/control group, or rigorous/systematic comparison.)

NOTES: Data reflect percentage giving a correct response to each concept. "Don't know" responses and refusals to respond counted as incorrect and not shown. See appendix table 7-13 for more detail on probability questions and for years prior to 1999.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Public Attitudes Toward and Understanding of Science and Technology (1999, 2001); University of Michigan, Survey of Consumer Attitudes (2004); and University of Chicago, National Opinion Research Center, General Social Survey (2006, 2008, 2010).

Science and Engineering Indicators 2012

Figure 7-10
Understanding scientific inquiry, by respondent characteristic: 2010



NOTES: See appendix table 7-13 for explanation of understanding scientific inquiry and questions included in the index. See appendix table 7-14 for additional respondent characteristics.

SOURCE: University of Chicago, National Opinion Research Center, General Social Survey (2010).

Science and Engineering Indicators 2012

These questions allow a comparison between adults' understanding of experimentation and that of middle school students tested on the exact same questions. Out of the three experimental knowledge questions where direct comparison is possible, adults' scores are similar to a national sample of middle school students on one question, but lower on two others (appendix table 7-16).

Other Indicators of Public Knowledge and Understanding About S&T

The trend factual knowledge and process understanding questions are both indicators used to gauge public knowledge and understanding about S&T over time. These are but two of the potential indicators that might be useful, however (Miller 1998). A handful of other approaches have been used in recent years. These are reviewed briefly below. One provides an alternative measure of factual public knowledge about science that is rooted in national standards for what students are expected to know about science. Other approaches include indicators of understanding about statistics and the interpretation of charts, as well as indicators of the ability to distinguish between science and pseudoscience. Taken together, these approaches provide a more complete portrait of public understanding about S&T. Other approaches are currently being developed that seek to add indicators of the understanding of science as it applies to everyday life and measure public understanding of institutions and how they influence the development of S&T. (See sidebar, "Public Understanding of Science and Its Role in Everyday Life.")

National Standards and Applying Science Knowledge to Specific Problems

Recently devised measures developed in light of national standards for what students should know about scientific topics provide additional information about public knowledge and understanding. These standards go beyond the factual knowledge questions that have been used to measure trends in public knowledge of science on NSF surveys since 1979 and often include the ability to apply science knowledge to specific problems. Questions of this kind were administered as part of the 2008 GSS and were reported in NSB 2010. The 2008 GSS questions were selected from Project 2061, an initiative by the American Association for the Advancement of Science (AAAS) that develops assessment materials aligned with current curricular standards, and from three national exams administered to students.[27] The series of questions included nine factual questions, two questions that measured chart reading and the statistical concept of a "mean," and five questions that tested reasoning and understanding of the scientific process. Two of the 16 questions were open-ended and the rest were multiple-choice. (For details on the measures, see appendix table 7-17.[28])

Respondents who answered these additional factual knowledge questions correctly (on the "scale 2" index reflecting national standards) also tended to answer the trend factual knowledge questions correctly. This suggests that the trend factual knowledge questions are a reasonable indicator of the type of knowledge students are tested on in national assessments (appendix table 7-18).

Understanding of Statistics and Charts

Americans encounter basic statistics and charts in everyday life. Many media reports cite studies in health, social, economic, and political trends. Understanding statistical concepts is important to understanding the meaning of these studies and, consequently, to scientific literacy (Crettaz von Roten 2006). One test of these concepts included on the 2008 GSS found that 74% of Americans could read a simple chart correctly and 66% understood the concept of "mean" in statistics. Understanding these two concepts was associated with both formal education and the number of math and science courses taken. Older respondents were less likely than younger adults to respond correctly to these two questions. Men and women were about equally likely to answer these questions correctly (appendix table 7-15).

Public Understanding of Science and Its Role in Everyday Life

Indicators of public understanding about S&T can serve many purposes. NSF held two workshops in fall 2010 with social science experts from multiple disciplines and backgrounds to review how best to conceptualize and measure public understanding of science and engineering (Guterbock et al. 2010; Toumey et al. 2010). The workshop participants endorsed the past measures reported by NSF as useful indicators of public understanding and suggested approaches for developing additional or improved indicators. The workshop participants also endorsed the need to monitor and evaluate all indicators on an ongoing basis so that adjustments to the indicators can be implemented when needed.

The NSF-sponsored workshops identified three key functions of public knowledge about S&T. First, knowledge facilitates civic engagement with science, particularly when technologies raise emerging issues that intersect science and society. Examples of these kinds of situations include public debates at the local, state, or national levels about nuclear power and nuclear waste disposal, and debates about the role and funding of embryonic stem cell research. Second, knowledge facilitates decisionmaking in everyday life, particularly when S&T intersects with citizens' work, home, and leisure activities. Some examples include knowledge about antibiotic medications and their appropriate usage, and the principles of heat and electricity as they relate to home use. A third function of science knowledge is broadly framed as knowledge for the sake of knowing more about the world and how it works, addressing human curiosity in ways that go beyond instrumental needs for practical knowledge. This three-part framework for the role and function of public knowledge about S&T helps inform the standards against which one can judge the kinds of knowledge that are important for citizens to hold and whether the public knows "enough" about science for these three purposes.

Three different types of knowledge were identified: factual science knowledge, knowledge of scientific processes and standards for evaluating scientific evidence, and knowledge about the institutions that play a role in scientific development and how those institutions operate (also see Shen 1975). NSF surveys have included measures of both factual science knowledge and understanding of scientific processes for a number of years. Indicators of how well the public understands the workings of institutions engaged in S&T development have not been included in past NSF surveys. Research by Bauer, Petkova, and Boyadjieva (2000) developed one set of measures along these lines in surveys of the British and Bulgarian publics.

Apart from evaluating the purposes and function of the NSF indicators of public knowledge, the workshops also raised additional questions for social scientists to explore, such as research on the kinds of things that motivate greater learning about S&T and a better understanding of how such adult learning occurs.

Pseudoscience

Another indicator of public understanding about S&T comes from measuring the public's capacity to distinguish science from pseudoscience. One such indicator, on astrology, is available over time on the NSF surveys conducted since 1979. Recent surveys show a downward trend toward fewer Americans considering astrology as scientific. In the 2010 GSS, 62% of Americans indicated that they believe that astrology is "not at all scientific," 28% said that it is "sort of scientific," and just 6% considered it "very scientific." Respondents with more years of formal education were less likely to perceive astrology to be at all scientific. In 2010, 78% of college graduates indicated that astrology is "not at all scientific," compared with 58% of high school graduates. Those who scored highest on the factual knowledge measures were less likely to perceive astrology to be at all scientific (79%) than those who scored lowest (52%). Respondents who correctly understood the concept of scientific inquiry were more likely to say that astrology is "not at all scientific" (73%) than those who did not understand the concept (54%). However, the youngest age group (18–24) was less likely to say astrology is "not at all scientific" (46%) and more likely to say it is "very" or "sort of scientific" (54%) (appendix table 7-19).[29]

Public Attitudes About S&T in General

Public support for S&T can make a difference in many ways. Public openness to technological change can give U.S. businesses opportunities to build a domestic customer base, create a foundation for worldwide technological competitiveness, and foster the national advantages that flow from pioneering innovations. Broad public and political support for long-term commitments to S&T research, especially in the face of pressing immediate needs, facilitates ambitious proposals for sustained federal S&T investments to reach fruition. Public confidence that S&E community leaders are trustworthy, S&T research findings are reliable, and S&E experts bring valuable judgment and knowledge to bear on public issues encourages reliance on scientific knowledge in practical affairs. In addition, positive public perceptions of S&E occupations encourage young people to pursue S&E careers.

This section presents general indicators of public attitudes and orientations toward S&T in the United States and other countries. It covers views of the promise of S&T and reservations about science, overall support for government funding of research, confidence in scientific community leaders, perceptions of the proper influence of scientists on controversial public issues about which the research community claims expertise, and views of S&E as occupations.

Promise and Reservations About S&T

A majority of Americans see science as having, on balance, a positive effect on society and regard scientists and engineers as contributing to the well-being of society. At the same time, a majority of Americans also express reservations about the role of S&T in society.

NSF surveys dating back to 1979 show that roughly seven in ten Americans see the effects of scientific research, in general, as more positive than negative for society. In 2010, 46% of GSS respondents said the benefits of scientific research strongly outweigh the harmful results, and 23% said that benefits slightly outweigh harms. Only 9% of respondents said the harms either slightly or strongly outweigh the benefits. Of the remaining respondents, 14% volunteered that the two are about equal and 8% gave no response. These numbers are generally consistent with earlier surveys; those saying the benefits strongly or slightly outweigh the harmful results ranged from 68% to 79% over the 30-year survey period (figure 7-11; appendix table 7-20). In practically any major American social grouping, few individuals express strong doubt about the benefits of science.

Americans overwhelmingly agree that S&T will foster "more opportunities for the next generation" (appendix table 7-21). Agreement with this statement has been increasing moderately for more than a decade; nine in ten Americans agreed in 2010.[30]

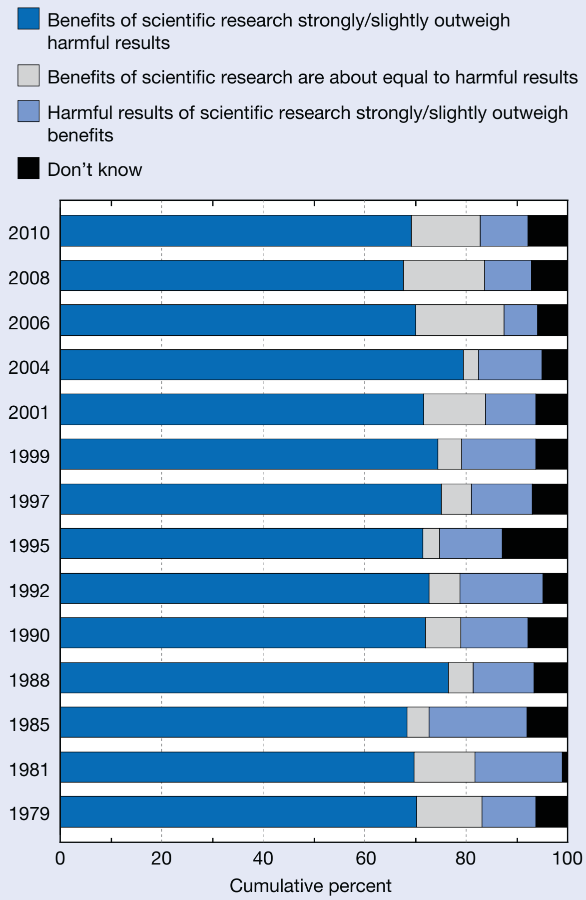
The annual VCU Life Sciences Surveys show similar results. The percentage of Americans who agreed that "developments in science helped make society better" ranged from 83% to 87% over the past decade, with about half of the public (48%) saying that science helped make society "a lot" better in 2010 and 34% saying it made society "somewhat better." Similarly, between 2002 and 2010, the surveys asked respondents whether they believed that "scientific research is essential for improving the quality of human lives" and found that agreement ranged between 87% and 92% (VCU 2010). During the same period, between 88% and 92% of respondents agreed that "new technology used in medicine allows people to live longer and better."

A survey conducted by the Pew Research Center for the People and the Press (2009a) also demonstrates a strong public regard for the benefits to society from S&E. Respondents considered a series of occupational groups and rated each in terms of their contribution to the well-being of society. Seven in ten Americans said that scientists contribute "a lot" to the well-being of our society; 64% said the same about engineers. Medical doctors were evaluated similarly, with 69% of respondents saying they contribute a lot to society. Only the military and teachers were considered by more Americans to contribute a lot to society (table 7-11).

What kinds of contributions do Americans have in mind? The Pew Research Center survey asked respondents to express, in their own words, some of the ways science has had a positive effect on society. More than half of all responses referred to medical contributions: 32% of responses referred to general improvements in healthcare and medicine and 24% referred to specific vaccines and disease research. Other responses were less common. These included space exploration (8% of responses), the environment (7% of responses), and communication and computer technologies (7% of responses).

Americans who have more years of formal education and score higher on measures of science knowledge express

Figure 7-11
Public assessment of scientific research: 1979–2010



NOTES: Responses to *People have frequently noted that scientific research has produced benefits and harmful results. Would you say that, on balance, the benefits of scientific research have outweighed the harmful results, or have the harmful results of scientific research been greater than its benefits?* In this figure, "benefits outweigh harmful results" and "harmful results outweigh benefits" each combine responses of "strongly outweigh" and "slightly outweigh." Figure includes all years for which data collected. Detail may not add to total because of rounding.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Public Attitudes Toward and Understanding of Science and Technology (1979–2001); University of Michigan, Survey of Consumer Attitudes (2004); University of Chicago, National Opinion Research Center, General Social Survey (2006, 2008, 2010). See appendix tables 7-20 and 7-23.

Science and Engineering Indicators 2012

Table 7-11
Public perceptions of various groups' contributions to the well-being of society: 2009
(Percent)

Occupational group	A lot	Some	Not very much	Nothing at all	Don't know
Members of the military	84	11	3	1	1
Teachers	77	17	3	1	2
Scientists	70	23	3	2	3
Medical doctors	69	24	4	1	2
Engineers	64	25	4	2	5
Clergy	40	37	10	5	9
Journalists	38	41	13	4	4
Artists	31	43	15	7	4
Lawyers	23	46	18	9	5
Business executives	21	43	22	9	5

NOTES: Responses to *Thinking about some different professions, how much do you think the following contribute to the well-being of our society? Do [people in occupational group] contribute a lot, some, not very much, or nothing at all to the well-being of our society?* Detail may not add to total because of rounding.

SOURCE: Pew Research Center for the People and the Press, *Public Praises Science: Scientists Fault Public, Media* (9 July 2009), http://people-press.org/report/528/, accessed 6 January 2011.

Science and Engineering Indicators 2012

more favorable attitudes about S&T. A review of numerous surveys from around the world found—other things being equal—a weak but consistent relationship between greater knowledge of science and more favorable attitudes toward science. This relationship was stronger in the United States than in any of the other countries in the study (Allum et al. 2008). (For more details, see NSB 2008.)

Americans also express reservations about S&T. The VCU Life Sciences Surveys found that a majority of Americans agree that "scientific research these days doesn't pay enough attention to the moral values of society." In 2010, 58% of respondents agreed with this statement and 35% disagreed; however, the percentage that agreed has dropped substantially, from a high of 73% in 2001. Majorities or near majorities agree with statements expressing reservations about science in other surveys, as well. For example, in the 2010 GSS, about half (51%) agreed that "science makes our way of life change too fast"; 47% disagreed. Men and women are about equally likely to express reservations about science. Those expressing fewer reservations about science on this statement tend to have more formal education, more science and math education, and more factual knowledge of science (appendix table 7-22).

International Comparisons

International surveys also indicate strong public support for S&T. Although data from other countries are not entirely comparable, they appear to indicate that Americans hold at least equally or somewhat more positive attitudes about the benefits of S&T than Europeans, Russians, and Japanese. Attitudes in China and South Korea are comparable with the United States; on some questions, attitudes are even more favorable, but reservations about science are somewhat higher in China and South Korea as well (appendix table 7-23). Attitudes about S&T have grown increasingly positive in Malaysia over recent years; in 2008, 74% of Malaysians agreed that scientific research has more positive than negative effects, up from 45% in 1998. In all of the countries and regions where survey data exist, statements about the achievements and promise of science elicit substantially more agreement than disagreement.

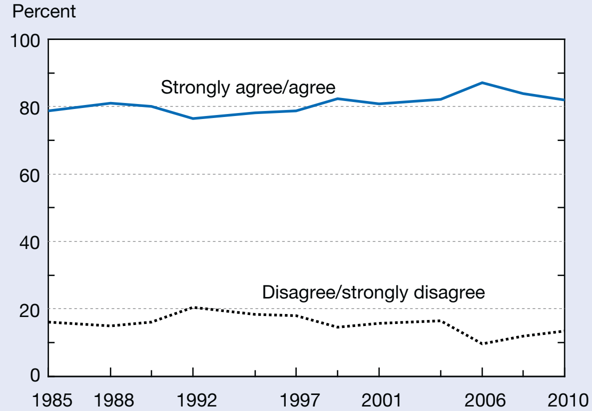
As in the United States, respondents abroad also express reservations about S&T. Numerous international surveys have asked for agreement or disagreement with a statement that "science makes our way of life change too fast" (appendix table 7-23). Levels of agreement with this statement appear to be lower in the United States than in several other countries, although there are large differences of viewpoint across European nations.

Federal Funding of Scientific Research

U.S. public opinion consistently and strongly supports federal spending on basic research. Since 1985, NSF surveys have asked Americans whether, "even if it brings no immediate benefits, scientific research that advances the frontiers of knowledge is necessary and should be supported by the federal government." In 2010, 82% agreed or strongly agreed with this statement; 14% disagreed. Agreement with this statement has ranged from a low of 76% in 1992 to a high of 87% in 2006 (figure 7-12; appendix tables 7-24 and 7-25).

The 2009 Pew Research Center Survey found that nearly three-quarters of Americans express support for federal spending on S&E. Asked whether government investments "usually pay off in the long run," or are "not worth it," 73% said spending on basic scientific research "usually pays off in the long run"; 74% said the same about engineering and technology. Furthermore, six in ten Americans said "government investment in research is essential for scientific

Figure 7-12
Public opinion on whether government should fund basic scientific research: 1985–2010

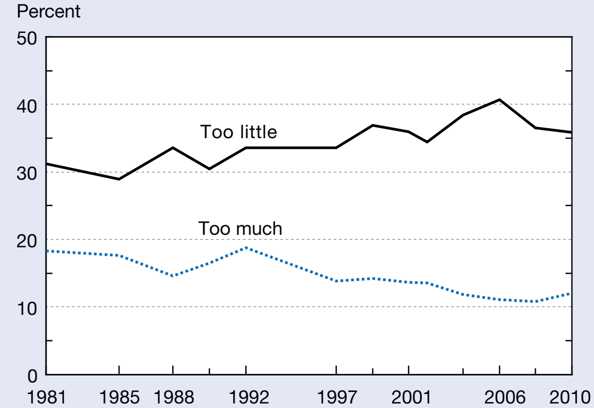


NOTES: Responses to *Even if it brings no immediate benefits, scientific research that advances the frontiers of knowledge is necessary and should be supported by the federal government. Do you strongly agree, agree, disagree, or strongly disagree?* Responses of "don't know" not shown. Survey results in 1985, 1988, 1990, 1992, 1995, 1997, 1999, 2001, 2004, 2006, 2008, and 2010; other years extrapolated.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Public Attitudes Toward and Understanding of Science and Technology (years through 2001); University of Michigan, Survey of Consumer Attitudes (2004); University of Chicago, National Opinion Research Center, General Social Survey (2006, 2008, 2010). See appendix tables 7-24 and 7-25.

Science and Engineering Indicators 2012

Figure 7-13
Public assessment of amount of government spending for scientific research: 1981–2010



NOTES: Responses to *We are faced with many problems in this country, none of which can be solved easily or inexpensively. I'm going to name some of these problems, and for each one, I'd like you to tell me if you think that the government is spending too little money on it, about the right amount, or too much: [scientific research].* Responses of "right amount" and "don't know" not shown. Survey results in 1981, 1985, 1988, 1990, 1992, 1997, 1999, 2001, 2002, 2004, 2006, 2008, and 2010; other years extrapolated.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Public Attitudes Toward and Understanding of Science and Technology (1981–2001); University of Chicago, National Opinion Research Center, General Social Survey (2002–10). See appendix table 7-26.

Science and Engineering Indicators 2012

progress," 29% said "private investment will ensure that enough scientific progress is made, even without government investment," and the remainder gave no response.

Another indicator, the proportion of Americans who thought the government was spending too little on scientific research, increased from 1981 to 2006, fluctuating between 29% and 34% in the 1980s, between 30% and 37% in the 1990s, and between 34% and 41% in the 2000s. In 2010, 36% of respondents said government spending on scientific research was "too little," 47% said it was "about right," and 12% said it was "too much" (figures 7-13 and 7-14; appendix table 7-26). Support for increased government spending is greater for a number of other program areas, with the highest support for spending on education (74%). About six in ten Americans say government should spend more on developing alternative energy sources (61%), assistance to the poor (61%), health (58%), and environmental protection (57%). Support for increased spending in other areas is lower. Support for increased spending on scientific research (36%) is roughly comparable to that for spending on improving mass transportation (40%) and parks and recreation (32%). Still, based on the proportion of the U.S. population favoring increased spending, scientific research garners more support than spending in national defense (25%), space exploration (16%), and assistance to foreign countries (8%).[31]

A more recent survey by the Pew Research Center (2011a) suggests that the economic downturn of recent years and other factors have dampened Americans' appetite for increased government spending in a number of areas. In the Pew Research Center survey, public support for increasing spending on scientific research was 36%, down from 39% in 2009; support for decreasing scientific research spending was 23% in 2011, up from 14% in 2009.

International Comparisons

In other countries where similar though not precisely comparable questions have been asked, respondents also express strong support for government spending on basic scientific research. In 2010, 72% of Europeans agreed that "even if it brings no immediate benefits, scientific research which adds to knowledge should be supported by government," and only 9% disagreed. In 2007, 74% of Chinese agreed to a similar statement. These percentages may be lower because of a difference in question wording, however. Both the European survey and the Chinese survey offered a middle option ("neither agree nor disagree"), whereas no middle category was offered in the United States (appendix table 7-23). Agreement in South Korea, Malaysia, Japan, and Brazil is comparable to that in the United States and Europe.

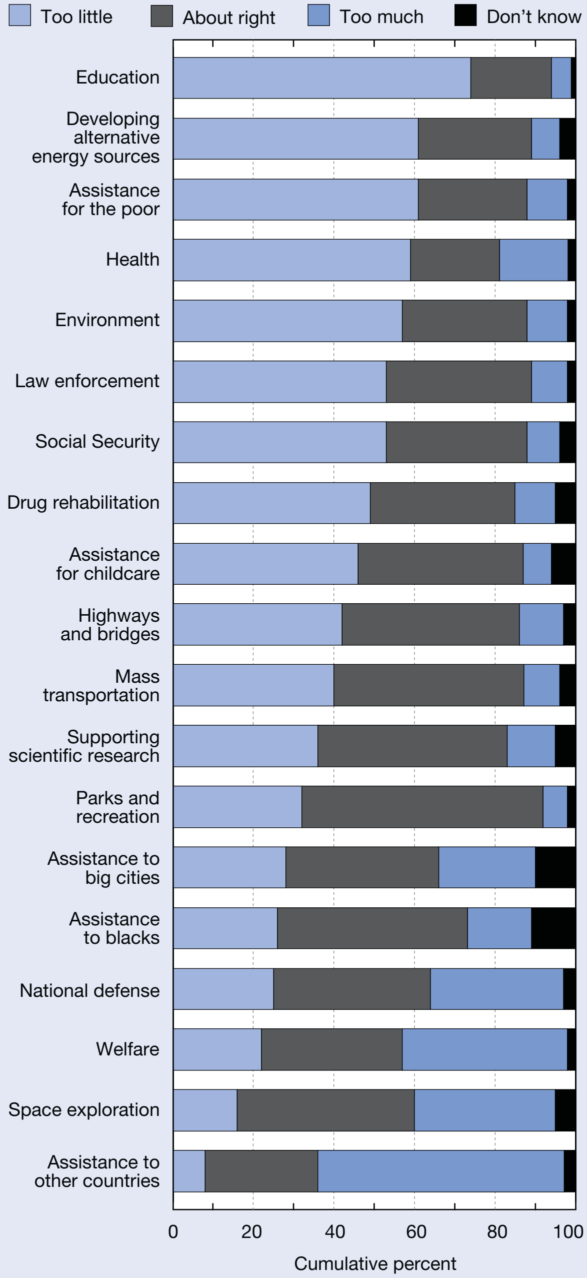
Confidence in the Science Community's Leadership

For the science-related decisions that citizens face, a comprehensive understanding of the relevant scientific research would require mastery and evaluation of a great deal of evidence. In addition to relying on direct evidence from scientific studies, citizens who want to draw on scientific evidence may consult the judgments of leaders and other experts who they believe can speak authoritatively about the scientific knowledge that is relevant to an issue.

Public confidence in leaders of the scientific community is one indicator of public willingness to rely on science. Since 1973, the GSS has tracked public confidence in the leadership of various institutions, including the scientific community. The GSS asks respondents whether they have "a great deal of confidence," "only some confidence," or "hardly any confidence at all" in the leaders of different institutions. In 2010, four in ten Americans expressed "a great deal of confidence" in leaders of the scientific community, nearly half (49%) expressed "some confidence," and fewer than one in ten (7%) expressed "hardly any confidence at all" in the scientific community (figure 7-15; appendix table 7-27).

About the same proportion expressed "a great deal of confidence" in leaders of the medical community (41%) as in leaders of the scientific community. The military was the

Figure 7-14
Public attitudes toward government spending in various policy areas: 2010

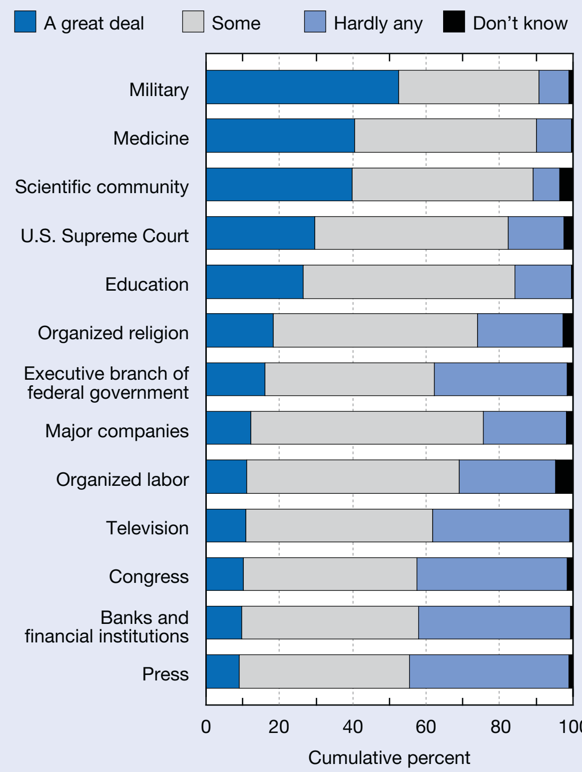


NOTE: Responses to: *We are faced with many problems in this country, none of which can be solved easily or inexpensively. I'm going to name some of these problems, and for each one I'd like you to tell me if you think that the government is spending too little money on it, about the right amount, or too much.*

SOURCE: University of Chicago, National Opinion Research Center, General Social Survey (2010). See appendix table 7-26.

Science and Engineering Indicators 2012

Figure 7-15
Public confidence in institutional leaders, by type of institution: 2010



NOTE: Responses to *As far as the people running these institutions are concerned, would you say that you have a great deal of confidence, only some confidence, or hardly any confidence at all in them?*

SOURCE: University of Chicago, National Opinion Research Center, General Social Survey (2010). See appendix table 7-27.

Science and Engineering Indicators 2012

only institution with higher levels of expressed confidence (52%). This pattern is consistent with past surveys where science usually ranked second or third in public confidence, with medicine or the military ranking first. The consistently high confidence in the leadership of the scientific community contrasts with views of other institutional leaders over the years. For example, confidence in the military has fluctuated more widely over the past three decades. The medical community has seen a long-term decline in confidence during the 1970s and 1980s. More than half of Americans expressed a great deal of confidence in medical leaders in the mid-1970s, compared to about 40% in recent years. Thirty years ago, confidence in the medical community was higher than confidence in scientific leaders. However, during the past decade, the public was about equally likely to express confidence in medical and scientific leaders.

Influence of Scientific Experts on Public Issues

Government support for scientific research derives partly from the notion that science can support policymakers in shaping many public decisions. Science can play this role more effectively if the general public supports the use of scientific knowledge in such decisions and shares the view that science is relevant.

In 2006 and 2010, the GSS asked about the appropriate influence of science on four public policy issues to which scientific research might be considered relevant. In 2010, those issues were global climate change,[32] research using human embryonic stem cells, federal income taxes, and nuclear power.[33] In 2006, those issues included GM foods but not nuclear power. Survey respondents were asked how much influence a group of scientists or engineers with relevant expertise (e.g., medical researchers, economists, nuclear engineers) should have in deciding about each issue, how well the experts understood the issue, and to what extent each would "support what is best for the country as a whole versus what serves their own narrow interests." The same questions were asked about elected officials and either religious leaders (for stem cell research) or business leaders (for the other issues). Thus, the questions allow a comparison among leadership groups at a single point in time as well as a comparison of perceptions about occupational groups over time.

The GSS data indicate that most Americans believe that scientists and engineers should have either a "great deal" or "a fair amount" of influence on these public decisions. Relative to other groups, more say that scientists and engineers should have a great deal of influence about these issues than say the same about other groups when it comes to global warming, stem cell research, nuclear power, and GM foods (table 7-12).

The only exception to that pattern was found on tax issues. When it comes to decisions about reducing federal income taxes, 18% said that economists should have "a great deal" of influence and 23% said the same about elected officials. Both the 2006 GSS and the 2010 GSS found the same patterns in Americans' preferences about each group's influence on these public issues (see appendix table 7-28).

Americans also gave scientists relatively high marks for understanding each issue, a pattern that underscores the perception of scientists and engineers as experts in these areas (table 7-13). The GSS asked respondents to rate each leadership group's understanding of a largely factual aspect of each issue on a 5-point scale ranging from "very well" to "not at all." For the issues dealing with biological or geophysical phenomena, the differences in perceived understanding were significant: between 27% and 58% of the public placed the relevant S&E group in the top category of understanding, whereas only 3% to 16% placed any of the other groups in that category. The contrast among groups was smallest for the tax issue, with economists (27%) ranking ahead of business leaders (16%) and elected officials (10%) as understanding the likely effects of reducing federal income taxes "very well." The same patterns were found in 2006 and 2010 (see appendix table 7-29).

Perceptions of impartiality in judgments about these issues may also influence preferences about the role of leadership groups in public issue debates and decisions. When asked which groups would "support what is best for the country as a whole versus what serves their own narrow interests," the patterns were similar, with more Americans saying the relevant S&E group would support what is best for the country than saying the same about other leadership groups. For all issues, S&E groups were more likely to be seen as supporting what is best for the country than other leadership groups (table 7-14; appendix table 7-30).

One factor that may limit the influence of scientific knowledge and the scientific community on public issues is the perception that significant scientific disagreement exists, making scientific knowledge uncertain (Krosnick et al. 2006). GSS respondents were asked to rate the degree of scientific consensus on a largely factual aspect of each of the issues using a 5-point scale ranging from "near complete agreement" to "no agreement at all." The degree of perceived consensus was highest for medical researchers on "the importance of stem cells for research" (58% rated this group at one of the two points nearest the "complete agreement" scale point.) A 53% majority also saw nuclear engineers as at or near complete agreement about "the risks and benefits of using nuclear power to generate electricity." About four in ten (38%) gave the same level of rating for perceived consensus to environmental scientists on "the existence and causes of global warming." Lower proportions of respondents chose one of these two points when asked about the extent to which medical researchers agree on "the risks and benefits of genetically modified foods" in 2006 (28%), or economists on "the effects of reducing federal income taxes" in 2010 (21%) (table 7-15; appendix table 7-31). (See sidebar, "Differences Between Scientists and the Public on S&T-related Issues," for more perceptions of scientific consensus.)

Table 7-12
Public preferences about various groups' influence on decisions about public issues: 2010 or most recent year
(Percent and mean score)

Public issue/group	Preferred degree of influence: A great deal	A fair amount	A little	None at all	Don't know	Mean score
Global warming: deciding what to do about global warming policy						
Environmental scientists	48	37	9	3	3	3.3
Elected officials	12	35	34	17	3	2.4
Business leaders	8	22	40	27	3	2.1
Genetically modified (GM) foods: deciding whether to restrict the sale of GM foods						
Medical researchers	41	40	10	3	5	3.3
Elected officials	7	30	37	21	5	2.2
Business leaders	3	16	41	35	5	1.9
Stem cell research: deciding about government funding for stem cell research						
Medical researchers	41	39	11	5	4	3.2
Elected officials	9	32	34	21	4	2.3
Religious leaders	7	18	36	35	4	2.0
Nuclear power: deciding whether to expand the use of nuclear power						
Nuclear engineers	38	41	11	4	6	3.2
Elected officials	10	38	35	11	6	2.5
Business leaders	5	27	42	21	5	2.2
Federal income taxes: deciding whether to reduce federal income taxes						
Economists	18	55	18	4	6	2.9
Elected officials	23	39	24	9	5	2.8
Business leaders	11	41	33	10	5	2.6

NOTES: Responses to *How much influence should each of the following groups have in deciding: what to do about global warming policy; what to do about government funding for stem cell research; whether to reduce federal income taxes; whether to expand the use of nuclear power; whether to restrict sale of genetically modified foods?* Responses on global warming, stem cell research, federal income taxes, and nuclear power are for 2010. Responses on genetically modified foods are for 2006. Mean preferred influence score based on 4-point scale, where 4 = a great deal of influence, 3 = a fair amount, 2 = a little influence, and 1 = none at all. Detail may not add to total because of rounding.

SOURCE: University of Chicago, National Opinion Research Center, General Social Survey (2006, 2010). See appendix table 7-28.

Science and Engineering Indicators 2012

With a few exceptions, responses to these questions do not differ markedly among demographic groups. Americans with more education and more science knowledge tend to have more favorable perceptions of the knowledge, impartiality, and level of agreement among scientists.

Views of S&E Occupations

Data on public esteem for S&E occupations are an indicator of the attractiveness of these occupations and their ability to recruit talented people into their ranks. Such data may also have a bearing on the public's sense that S&E affects the nation's well-being in the future.

For more than 30 years, the Harris Poll (Harris Interactive 2009) has asked about the prestige of a large number of occupations, including scientists and engineers (table 7-16). In 2009, 57% of Americans said that scientists had "very great prestige," and 39% expressed this view about engineers. Most occupations in the surveys were rated well below engineers.[34]

The percentage of survey respondents attributing "very great prestige" to scientists has fluctuated narrowly between 52% and 57% since 2003. More Americans rated scientists as having "very great prestige" than did so for almost any other occupation considered in the Harris surveys. In recent years, their rating was comparable to that of nurses, doctors, firefighters, and teachers, and ahead of military and police officers. In 2009, it was second only to firefighters.

Engineers' standing is comparable to occupations clustered just below the top group of occupations rated (including clergy, military officers, farmers, and police officers). A plurality of Americans said engineers have "very great prestige"; this figure has fluctuated between a low of 28% in 2003 and a high of 40% in 2008, and was about the same in 2009, at 39%.

The relative ratings of each occupation are, of course, dependent on the set of occupations considered on the surveys. Prestige appears to reflect perceived service orientation and public benefit more than high income or celebrity; for

Table 7-13
Public perceptions of various groups' understanding of public issues: 2010 or most recent year
(Percent and mean score)

Public issue/group	Degree of understanding (on scale of 1 to 5): Very well 5	4	3	2	Not at all 1	Don't know	Mean score
Nuclear power: understand the likely effects of using nuclear power to generate electricity							
Nuclear engineers	58	18	11	4	3	5	4.3
Elected officials	5	11	32	33	15	5	2.6
Business leaders	5	11	32	30	17	5	2.5
Stem cell research: understand stem cell research							
Medical researchers	49	26	14	3	2	5	4.2
Elected officials	4	7	34	28	24	5	2.4
Religious leaders	5	6	27	28	29	5	2.3
Global warming: understand the causes of global warming							
Environmental scientists	40	20	21	10	6	4	3.8
Elected officials	5	10	28	26	26	4	2.4
Business leaders	4	9	29	28	26	4	2.3
Genetically modified foods: understand the risks posed by genetically modified foods							
Medical researchers	32	32	18	8	5	6	3.8
Elected officials	3	6	24	33	29	5	2.2
Business leaders	4	7	24	31	28	6	2.2
Federal income taxes: understand the likely effects of reducing federal income taxes							
Economists	27	21	31	8	6	7	3.6
Elected officials	10	18	32	18	17	6	2.8
Business leaders	16	24	31	14	9	7	3.3

NOTES: Responses to *How well do the following groups understand: causes of global warming; stem cell research; likely effects of reducing federal income taxes; likely effects of using nuclear power to generate electricity; risks posed by genetically modified foods?* Responses on global warming, stem cell research, federal income taxes, and nuclear power are for 2010. Responses on genetically modified foods are for 2006. Mean understanding score based on 5-point scale, where 5 = understands very well and 1 = understands not at all. Detail may not add to total because of rounding.

SOURCE: University of Chicago, National Opinion Research Center, General Social Survey (2006, 2010). See appendix table 7-29.

Science and Engineering Indicators 2012

instance, fewer than two in ten Americans attributed "very great prestige" to entertainers or actors (table 7-16).

International Comparisons

Elsewhere, S&E occupations are also highly regarded. Among the Chinese in 2008, science (40%) rated close to medicine (41%) and teaching (43%) as an occupation that survey respondents hoped their children would pursue (CRISP 2008). In 2006, the majority of Israelis said they would be pleased if their children became scientists (77%), engineers (78%), or physicians (78%) (Yaar 2006). On at least one measure, Americans rated scientific careers more positively than was the case in at least some other countries. In 2004, a little more than 50% of South Koreans said they would feel happy if their son or daughter wanted to become a scientist. In the United States, 80% of those surveyed in 2001 expressed positive views regarding their children becoming scientists.

Public Attitudes About Specific S&T-Related Issues

Public attitudes can affect the speed and direction of S&T development. When science plays a substantial role in a national policy controversy, more than the specific policies under debate may be at stake. The policy debate may also shape public opinion and government decisions about investments in general categories of research. Less directly, a highly visible debate involving S&T issues may shape overall public impressions of either the credibility of science or the proper role of science in other, less visible public decisions.

Likewise, public attitudes about emerging areas of research and new technologies may have an influence on innovation. The climate of opinion concerning new research areas can influence levels of public and private investment in related technological innovations and, eventually, the adoption of new technologies and the growth of industries based on these technologies.

Table 7-14
Public perceptions of various groups' impartiality in making policy recommendations about public issues: 2010 or most recent year
(Percent and mean score)

Public issue/group	Extent to which group would support (on scale of 1 to 5): What is best for country 5	4	3	2	Own narrow interests 1	Don't know	Mean score
Global warming							
Environmental scientists	42	22	18	7	7	4	3.9
Elected officials	11	10	25	22	28	4	2.5
Business leaders	6	4	24	27	34	4	2.2
Genetically modified foods							
Medical researchers	34	29	19	7	6	5	3.8
Elected officials	6	10	32	25	21	5	2.5
Business leaders	2	4	25	32	32	5	2.1
Stem cell research							
Medical researchers	30	28	21	9	7	5	3.7
Elected officials	6	10	25	26	29	4	2.4
Religious leaders	9	10	24	24	27	6	2.5
Nuclear power							
Nuclear engineers	27	28	22	9	8	6	3.6
Elected officials	8	16	32	22	17	6	2.7
Business leaders	6	9	28	28	23	6	2.4
Federal income taxes							
Economists	19	27	28	11	9	6	3.4
Elected officials	10	11	27	22	24	6	2.6
Business leaders	5	11	23	29	27	6	2.4

NOTES: Responses to *When making policy decisions about [public issue], to what extent do you think [group] would support doing what is best for the country as a whole or what serves their own narrow interests?* Responses on global warming, stem cell research, federal income taxes, and nuclear power are for 2010. Responses on genetically modified foods are for 2006. Mean impartiality score based on 5-point scale, where 5 = best for the country and 1 = own narrow interests. Detail may not add to total because of rounding.

SOURCE: University of Chicago, National Opinion Research Center, General Social Survey (2006, 2010). See appendix table 7-30.

Science and Engineering Indicators 2012

Table 7-15
Public perceptions of scientific consensus on public issues: 2010 or most recent year
(Percent and mean score)

Group/public issue	Degree of consensus (on scale of 1 to 5): Near complete agreement 5	4	3	2	No agreement at all 1	Don't know	Mean score
Medical researchers on importance of stem cells for research	28	30	26	6	4	7	3.8
Nuclear engineers on risks and benefits of nuclear power to generate electricity	19	34	28	6	3	11	3.7
Environmental scientists on existence and causes of global warming	15	23	35	11	10	6	3.2
Medical researchers on risks and benefits of genetically modified foods	9	19	41	11	7	13	3.1
Economists on effects of reducing federal income taxes	5	16	38	14	15	12	2.8

NOTES: Responses to *To what extent do [people in group] agree on [public issue]?* Responses on global warming, stem cell research, federal income taxes, and nuclear power are for 2010. Responses on genetically modified foods are for 2006. Mean consensus score based on 5-point scale, where 5 = near complete agreement and 1 = no agreement at all. Detail may not add to total because of rounding.

SOURCE: University of Chicago, National Opinion Research Center, General Social Survey (2006, 2010). See appendix table 7-31.

Science and Engineering Indicators 2012

Table 7-16
Public perceptions of prestige of various occupations: Selected years, 1977–2009
(Percent saying "very great prestige")

Occupation	1977	1982	1992	1997	1998	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Firefighter	NA	NA	NA	NA	NA	NA	NA	NA	55	48	56	63	61	57	62
Scientist	66	59	57	51	55	56	53	51	57	52	56	54	54	56	57
Doctor	61	55	50	52	61	61	61	50	52	52	54	58	52	53	56
Nurse	NA	NA	NA	NA	NA	NA	NA	NA	47	44	50	55	50	52	54
Teacher	29	28	41	49	53	53	54	47	49	48	47	52	54	52	51
Military officer	NA	22	32	29	34	42	40	47	46	47	49	51	52	46	51
Police officer	NA	NA	34	36	41	38	37	40	42	40	40	43	46	46	44
Priest/minister/clergy	41	42	38	45	46	45	43	36	38	32	36	40	42	40	41
Engineer	34	30	37	32	34	32	36	34	28	29	34	34	30	40	39
Farmer	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	36	41	41	36
Architect	NA	NA	NA	NA	26	26	28	27	24	20	27	27	23	28	29
Member of Congress	NA	NA	24	23	25	33	24	27	30	31	26	28	26	28	28
Lawyer	36	30	25	19	23	21	18	15	17	17	18	21	22	24	26
Business executive	18	16	19	16	18	15	12	18	18	19	15	11	14	17	23
Athlete	26	20	18	21	20	21	22	21	17	21	23	23	16	20	21
Journalist	17	16	15	15	15	16	18	19	15	14	14	16	13	18	17
Union leader	NA	NA	12	14	16	16	17	14	15	16	15	12	13	18	17
Entertainer	18	16	17	18	19	21	20	19	17	16	18	18	12	15	17
Banker	17	17	17	15	18	15	16	15	14	15	15	17	10	15	16
Actor	NA	NA	NA	NA	NA	NA	NA	NA	13	16	16	12	9	16	15
Stockbroker	NA	NA	NA	NA	NA	NA	NA	NA	8	10	8	11	12	10	13
Accountant	NA	13	14	18	17	14	15	13	15	10	13	17	11	15	11
Real estate agent/broker	NA	NA	NA	NA	NA	NA	NA	NA	6	5	9	6	5	6	5

NA = not available, question not asked

NOTES: Responses to *I am going to read off a number of different occupations. For each, would you tell me if you feel it is an occupation of very great prestige, considerable prestige, some prestige, or hardly any prestige at all?* Data reflect responses of "very great prestige."

SOURCE: Harris Interactive, Firefighters, Scientists, and Doctors Seen as Most Prestigious Occupations: Real Estate Brokers, Accountants, and Stockbrokers Are at the Bottom of the List. *The Harris Poll* (#86, 4 August 2009), http://www.harrisinteractive.com/vault/Harris-Interactive-Poll-Research-Pres-Occupations-2009-08.pdf, accessed 7 February 2011.

Science and Engineering Indicators 2012

For these reasons, survey responses regarding controversies over policies involving science, specific research areas, and emerging technologies are relevant. In addition, responses about relatively specific matters provide insight into the practical decisions through which citizens translate more general attitudes into actions, although, like all survey responses, how these responses relate to actual behavior remains uncertain. More generally, even in democratic societies, public opinion about new S&T developments does not translate directly into actions or policy. Instead, it filters through institutions that selectively measure what the public believes and either magnify or minimize the effects of divisions in public opinion on public discourse and government policy (Jasanoff 2005). Public attitudes about specific S&T issues can differ markedly from the views of scientists. (See sidebar, "Differences Between Scientists and the Public on S&T-related Issues.")

Public attitudes toward policy issues involve a multitude of factors, not just knowledge or understanding of relevant science. Values, morals, judgments of prudence, and numerous other factors can come strongly into play; judgments about scientific fact are often secondary. In assessing the same issue, different people may find different considerations relevant.

This section discusses data on environmental issues, including global climate change, nuclear power, and energy development; cloning and stem cell research; teaching evolution in schools; agricultural biotechnology (i.e., GM food); and attitudes toward recent and novel technologies, including nanotechnology and medical biotechnology. It concludes with recent data on attitudes toward scientific research on animals and toward science and mathematics education.

Environment, Climate Change, and Energy Development

Environmental issues, such as climate change, and the closely related issue of sustainable energy sources, have become of increased salience in national policy debates and international meetings such as those at the United Nations Climate Change Conference, held in Copenhagen, Denmark in December 2009. For Americans, the April 2010 oil spill in the Gulf of Mexico further increased the salience of environmental issues—particularly the environmental hazards of offshore oil drilling—with long-running media coverage and sustained public attention (Pew Research Center 2010c).

Differences Between Scientists and the Public on S&T-related Issues

Directly comparable data on the degree to which public attitudes align with those of scientists is scarce. A study conducted by the Pew Research Center in 2009 asked the same questions of a sample of scientists belonging to the AAAS and a representative sample of the general public. The study found a striking difference between the groups across a number of specific issues including climate change, nuclear power, embryonic stem cell research, evolution, and animal research.

The public tends to underestimate the degree of consensus among scientists about evolution. Six in ten said that scientists generally agree that humans have evolved over time, and 28% said they do not generally agree about this. The survey of scientists found that 97% of scientists say that humans and other living things have evolved over time.

The public also tends to underestimate the degree of consensus among scientists about climate change; 56% said that scientists generally agree that the earth is getting warmer because of human activity, and 35% said scientists do not generally agree about this. The survey of scientists found 84% of scientists say that "the earth is getting warmer mostly because of human activity such as burning fossil fuels." A survey of earth scientists by Doran and Zimmerman (2009) also found strong consensus among scientists that the earth's temperature is rising and that human activity is "a significant contributing factor in changing mean global temperatures."

Table 7-C
Comparison of general public's and scientists' attitudes toward specific S&T-related issues: 2009
(Percent)

S&T-related issue	Scientists[a]	General public[b]
Climate change		
The earth is getting warmer due to human activity	84	49
Climate change is due to natural changes in the atmosphere	10	36
No solid evidence earth is warming	4	11
Don't know/no answer	2	4
Nuclear power		
Favor building more nuclear power plants to generate electricity	70	51
Oppose building more nuclear power plants to generate electricity	27	42
Don't know/no answer	3	7
Embryonic stem cell research		
Favor federal funding for embryonic stem cell research	93	58
Oppose federal funding for embryonic stem cell research	6	35
Don't know/no answer	1	7
Evolution		
Humans and other living things evolved over time	97	61
Humans and other living things always existed in present form	2	31
Don't know/no answer	1	8
Animal research		
Favor use of animals in scientific research	93	52
Oppose use of animals in scientific research	5	43
Don't know/no answer	2	6

[a]Survey of scientists based on sample survey of AAAS members conducted by Internet, 1 May–14 June 2009 (*n* = 2,533).
[b]Survey of general public conducted by landline and cellular telephone, 28 April–12 May 2009 (*n* = 2,001).

SOURCE: Pew Research Center for the People and the Press, 9 July 2009.

Science and Engineering Indicators 2012

Surveys taken shortly after the oil spill in the Gulf found increased willingness to trade off energy production for environmental protection when compared with surveys conducted before the oil spill (Jones 2010). In addition, there was decreased public support for offshore oil drilling shortly after the spill; since that time, public support has returned to previous levels (Pew Research Center 2010b).

Concern About Environmental Quality

The Gallup Organization's annual survey on environmental issues indicates that Americans were somewhat less concerned about environmental quality in 2010 and early 2011, after an increase in expressed concern between 2006 and 2008. The 2011 Gallup Poll found 34% of Americans worry "a great deal" about the environment, 34% worry "a fair amount," and 31% worry "only a little" or "not at all" (Saad 2011a).[35] The percentage saying they worry "a great deal" was the same in 2010 (figure 7-16). Relative to other concerns, environmental quality ranked lower on the list than a number of other concerns including the economy (71%) and federal spending and the budget deficit (64%).

Environmental concerns are infrequently mentioned in response to open-ended questions about the most important problems facing the nation. Only about 2% of Americans mentioned the environment or pollution in an open-ended question asking "What do you think is the most important problem facing this country today?" (Jones 2011c).

Climate Change

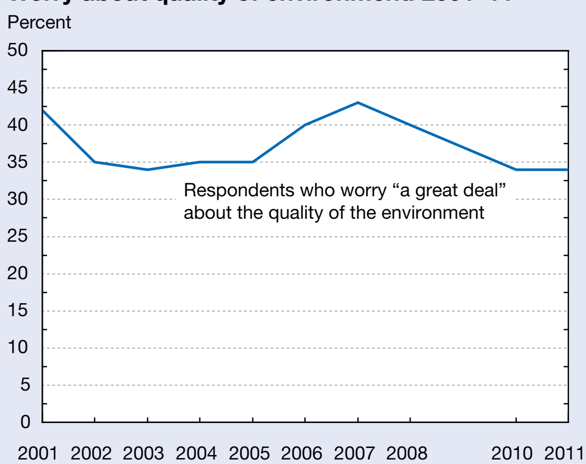
Climate change (often colloquially referred to as *global warming*), has become a prominent environmental issue for the American public. In a 2008 survey asking Americans to report, in their own words, the "single biggest environmental problem the world faces at this time," the most common response was climate change (25%), followed by pollution (24%), energy problems (11%), and toxic substances in the environment (6%) (ABC News 2008).

Other surveys, using structured questions, also show evidence of widespread awareness of the issue of climate change. The Gallup Polls registered gradual increases in the percentage of Americans who say they understand the "global warming" issue "very well" or "fairly well," from 68% in 2004 to 82% in 2010 (The Gallup Organization 2010).

Public debate about climate change has centered on both the existence of climate change and the likely causes of any change occurring. Gallup surveys found a decline in the percentage of Americans who consider climate change to be primarily due to human activities. When asked whether "the increases in the earth's temperature over the last century" are largely the result of human activities rather than natural changes, half of Americans said human activities in 2010, down 8 points from 2008, and 46% said natural changes (Newport 2010).[36]

A large number of surveys have been conducted about climate change, both in the United States and abroad. The Pew Global Attitudes survey conducted in 2010 among 22 nations found 37% of Americans consider global climate change a "very serious problem," one third said it was "somewhat serious," and a minority said it was "not too serious" (15%) or "not a problem" (13%). The percentage of Americans saying climate change is "very serious" decreased 10 points from 47% in 2007. Americans express less concern about climate change than individuals in a number of other countries where majorities consider climate change a very serious problem: Germany, Japan, South Korea, India, Kenya, Argentina, Brazil, Mexico, Lebanon, and Turkey. Half or near half of the citizens in Spain, Jordan, and Indonesia say the same. The Chinese and British are about equally likely as Americans to say climate change is a very serious problem (41% and 40%, respectively). The only publics with lower concern than Americans about climate change were those in Poland (31%) and Pakistan (22%). A World Public Opinion survey conducted in 2009 in 15 nations found a similar pattern, with Americans, Russians, and Chinese least likely to consider climate change a "very serious" problem.

Figure 7-16
Worry about quality of environment: 2001–11



NOTES: Responses to the following: *How much do you personally worry about the quality of the environment: a great deal, a fair amount, only a little, or none at all?* Figure shows only responses for "a great deal." Poll conducted annually in March.

SOURCE: Saad L, Americans' worries about economy, budget top other issues, The Gallup Poll (21 March 2011), http://www.gallup.com/poll/146708/Americans-Worries-Economy-Budget-Top-Issues.aspx, accessed 22 March 2011.

Science and Engineering Indicators 2012

Assessment of Potential Problems

Public assessments of the degree to which potential hazards pose a threat to the environment have been surprisingly stable over the past two decades. A series of questions on the GSS surveys conducted in 1993, 1994, 2000, and 2010 show that Americans consider pollution of America's rivers, lakes, and streams to be more dangerous to the environment than any of several other potential problems; in 2010, 69% considered water pollution to be very or extremely dangerous. Air pollution caused by industry was considered very or extremely dangerous to the environment by 63%, whereas air pollution caused by cars was less likely to be considered very or extremely dangerous to the environment (43%) (table 7-17).

Furthermore, 48% of Americans considered the "rise in temperature caused by climate change" to be very or extremely dangerous to the environment, according to the 2010 GSS. A decade earlier, that figure was 40%. The percentage saying that climate change was not very or not at all dangerous to the environment rose during the same period, from 11% in 2000 to 18% in 2010. The percentage holding no opinion decreased during the same period.

Nuclear power stations were considered very or extremely dangerous to the environment by 45% of Americans in 2010. Perceptions of environmental danger from nuclear power stations were about the same as when this question

Table 7-17
Public assessment of potential environmental problems: 1993–2010
(Percent)

Potential problem/opinion	1993	1994	2000	2010
Pollution of America's lakes, rivers, and streams				
Extremely/very dangerous	66	61	66	69
Somewhat dangerous	27	29	23	24
Not very/not dangerous	4	5	5	4
Don't know	3	5	7	2
Air pollution caused by industry				
Extremely/very dangerous	61	53	62	63
Somewhat dangerous	30	37	29	31
Not very/not dangerous	4	5	2	4
Don't know	4	5	6	2
Pesticides and chemicals used in farming				
Extremely/very dangerous	37	33	45	52
Somewhat dangerous	48	49	39	37
Not very/not dangerous	11	13	8	8
Don't know	4	5	7	3
Rise in temperature caused by climate change[a]				
Extremely/very dangerous	41	35	40	48
Somewhat dangerous	34	35	33	27
Not very/not dangerous	14	16	11	18
Don't know	12	14	15	6
Nuclear power stations				
Extremely/very dangerous	40	41	NA	45
Somewhat dangerous	34	35	NA	30
Not very/not dangerous	16	15	NA	19
Don't know	9	9	NA	7
Air pollution caused by cars				
Extremely/very dangerous	48	43	45	43
Somewhat dangerous	38	42	41	46
Not very/not dangerous	7	9	6	8
Don't know	7	7	8	3
Modifying the genes of certain crops				
Extremely/very dangerous	NA	NA	21	25
Somewhat dangerous	NA	NA	32	33
Not very/not dangerous	NA	NA	25	26
Don't know	NA	NA	22	16

NA = not available, question not asked

[a]Wording was changed from "the greenhouse effect" to "climate change" in 2010.

NOTES: Responses to *In general, do you think that [potential problem] is extremely dangerous for the environment, very dangerous, somewhat dangerous, not very dangerous, or not dangerous at all for the environment?* Table includes all years for which data collected. Detail may not add to total because of rounding.

SOURCE: University of Chicago, National Opinion Research Center, General Social Survey (1993–2010).

Science and Engineering Indicators 2012

was first asked in 1993. However, it is important to note that these data were collected prior to concerns about the risk to human health and the environment from damage to nuclear energy plants in the aftermath of the earthquake and tsunami in Japan in March 2011.

Assessments of environmental dangers changed substantially on only one issue—pesticides and chemicals used in farming. About half of Americans (52%) called these very or extremely dangerous to the environment in 2010, up from 45% in 2000 and 37% in 1993.

Concern about environmental dangers from GM crops appears to be modest. In the 2010 GSS, a quarter of Americans said modifying the genes of crops is very or extremely dangerous to the environment, and a roughly equal portion

(26%) said this is not very or not at all dangerous to the environment. Another 16% of Americans held no opinion about the dangers of GM crops, suggesting that the public has a more limited awareness or understanding of this issue.

Nuclear Power and Other Energy Sources

Public debate about energy sources in recent years has emphasized the need for lessened U.S. reliance on imported oil and more focus on alternative, renewable energy sources. A Gallup/*USA Today* poll conducted in early 2011 found more than eight in ten (83%) Americans favor legislation that "provides incentives for using solar and other alternative energy sources," and 15% are opposed. Two-thirds favor legislation that "expands drilling and exploration for oil and gas" (Jones 2011b). These findings are in keeping with public preferences on government spending in the 2010 GSS survey; 61% of Americans said the government is spending "too little" on developing alternative sources of energy.

Support for nuclear energy has varied over the past 15 years. American public opinion was fairly evenly divided in the late 1990s and support increased in the late 2000s. According to the 2010 GSS, about six in ten (61%) Americans favor or strongly favor increasing the use of nuclear energy to generate electricity in the United States, about three in ten (28%) oppose or strongly oppose, and the remainder gave no opinion. Similarly, the proportion of Americans who favor the use of nuclear power as "one of the ways to provide electricity" ranged from 57% to 62% between 2009 and early 2011 on Gallup surveys (Jones 2011a). The 2011 survey was conducted prior to damage to nuclear energy plants in Japan stemming from the earthquake and tsunami in March 2011. A Pew Research Center survey conducted shortly after the disaster in Japan suggests that Americans' support for nuclear power declined, but the long-term effect on Americans' attitudes toward nuclear power is unknown at this time (Pew Research Center 2011c). A substantial minority of Americans (42%) said nuclear power plants are not safe in a 2009 Gallup Poll, and prior surveys indicate that three out of five Americans oppose the construction of a nuclear energy plant in their local communities (Jones 2009).[37]

International Comparisons

In 2010, Europeans were divided about whether or not nuclear energy will "improve our way of life" (39%) or "make things worse" (39%). The remainder said nuclear energy will have no effect (10%) or held no opinion (13%). Assessments of nuclear energy were more negative when this question was first asked in 1999, and have been increasingly divided since that time (EC 2010). Support for nuclear energy varies a great deal among European countries. In general, citizens of countries that have operational nuclear power plants are considerably more likely to support nuclear energy than citizens of other countries (see NSB 2010).[38]

Stem Cell Research and Human Cloning

Unlike many issues involving scientific research, studies using embryonic stem cells have generated considerable public controversy. In the case of stem cell research, many people's attitudes are strongly related to their views about moral fundamentals. There is less reason to believe that this is the case for other S&T issues, such as nuclear power.

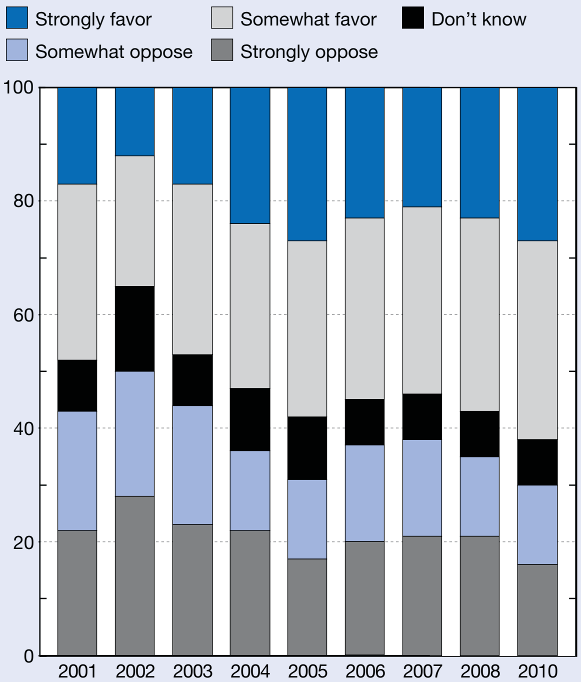
Public support for "medical research that uses stem cells from human embryos" grew over the past decade, from a low of 35% in favor in 2002. Since 2004, a majority of the public has favored stem cell research, with 62% favoring in 2010 and 31% opposed (VCU 2010) (figure 7-17). Annual Gallup Poll data draw a similar picture: the percentage of Americans who find stem cell research "morally acceptable" has fluctuated from a low of 52% in 2002 to a high of 64% in 2007; in 2011, 62% said it was "morally acceptable" and 30% said it was "morally wrong" (Saad 2011b).

Support for stem cell research is greater when the question posed asks about research that uses stem cells from sources that do not involve human embryos. About seven out of ten respondents (71%) favored this type of research in 2010, down slightly from 75% in 2007 (VCU 2010). Support is also greater when the question is framed as an emotionally compelling personal issue ("If you or a member of your family had a condition such as Parkinson's Disease, or a spinal cord injury, would you support the use of embryonic stem cells in order to pursue a treatment for that condition?") In this case, 70% of Americans support treatments that use stem cells and 21% do not (VCU 2006).

Americans are overwhelmingly opposed to human cloning when there is no mention of a medical purpose. In a 2010 survey, the idea of cloning or genetically altering humans was rejected by eight in ten Americans (VCU 2010). Opinions are more mixed when questions mention "cloning technology" that is used only to help medical research develop new treatments for disease; opinion about therapeutic cloning has been slowly growing more positive in recent years, with 55% in favor and 40% opposed in 2010 (table 7-18). The specter of reproductive cloning can generate apprehension about therapeutic cloning. Asked how concerned they were that "the use of human cloning technology to create stem cells for human therapeutic purposes will lead to a greater chance of human reproductive cloning," more than two-thirds of Americans said they were either very (31%) or somewhat (38%) concerned (VCU 2006).

Public attitudes toward cloning technology are not grounded in a strong grasp of the difference between reproductive and therapeutic cloning (see Glossary for definitions.) In the 2008 VCU survey, most Americans (64%) said they were "not very clear" or "not clear at all" about this distinction, with 26% saying they were "somewhat clear" and only 8% characterizing themselves as "very clear" about it. The number of Americans who professed greater comprehension in 2008 was lower than it was when VCU began asking this question in 2002. Additionally, self-assessed understanding of stem cell research declined between 2008 and 2010. In 2010, a 54% majority of Americans were "very clear" or "somewhat clear" about the difference between stem cells that come from human embryos, stem cells that come from adults, and stem cells that come from other sources, down from 64% in 2008 (VCU 2010).

Figure 7-17
Public attitudes toward stem cell research: 2001–10
Cumulative percent



NOTES: Responses to *On the whole, how much do you favor or oppose medical research that uses stem cells from human embryos?* Question most recently asked 12–18 May 2010. Survey not conducted in 2009. Detail may not add to total because of rounding.

SOURCE: Virginia Commonwealth University (VCU), VCU Life Sciences Survey (2010), http://www.vcu.edu/lifesci/images2/survey2010.pdf, accessed 4 March 2011.

Science and Engineering Indicators 2012

An international survey on attitudes toward stem cell research in a dozen European countries, the United States, Japan, and Israel found that awareness, knowledge, and attitudes about this type of research vary widely (Fundacion BBVA 2008). Overall, Americans were more aware of stem cell research than residents of most other countries and more often responded correctly to knowledge questions on this subject. All the same, Americans were somewhat more likely than residents of several countries in Europe to believe that stem cell research is immoral (appendix table 7-32).

Teaching Evolution in the Schools

In the United States, the topic of whether and how evolution should be taught in the school system has been a frequent source of controversy for almost a century. Public views about evolution and the role of teaching evolution in the schools have been relatively stable over the course of 30 years. In surveys sponsored by NSF between 1979 and 2010, many Americans appear skeptical of established scientific ideas about evolution. For example, when asked about the statement "human beings, as we know them today, developed from earlier species of animals" on the 2010 GSS survey, 38% considered this statement false and 47% said it was true (appendix table 7-10).

An experimental study included in the 2004 Michigan Survey of Consumer Attitudes suggests that survey responses to such questions reflect more than unfamiliarity with basic elements of science. Some of the survey respondents were asked a question that tested knowledge about evolution ("human beings, as we know them today, developed from earlier species of animals"). Other respondents were asked a question about what the theory of evolution asserts ("according to the theory of evolution, human beings, as we know

Table 7-18
Public opinion on medical technologies derived from stem cell research: 2010 or most recent year
(Percent)

Question	Favor	Oppose
1. *If you or a member of your family had a condition such as Parkinson's Disease, or a spinal cord injury, would you support the use of embryonic stem cells in order to pursue a treatment for that condition?* (Yes or no)	70	21
2. *Do you favor or oppose medical research that uses stem cells from sources that do NOT involve human embryos?* (Strongly favor, somewhat favor, somewhat oppose, or strongly oppose)	71	21
3. *How much do you favor or oppose using human cloning technology IF it is used ONLY to help medical research develop new treatments for disease?* (Strongly favor, somewhat favor, somewhat oppose, or strongly oppose)	55	40
4. *The technology now exists to clone or genetically alter animals. How much do you favor or oppose allowing the same thing to be done in humans?* (Strongly favor, somewhat favor, somewhat oppose, or strongly oppose)	15	80

NOTES: Question 1 asked during 7–21 November 2006. Questions 2, 3, and 4 asked during 12–18 May 2010. Detail does not add to total because "don't know" responses not shown.

SOURCE: Virginia Commonwealth University (VCU), VCU Life Sciences Survey (2006 for question 1; 2010 for questions 2, 3, and 4), http://www.vcu.edu/lifesci/images2/survey2010.pdf, accessed 4 March 2011.

Science and Engineering Indicators 2012

them today, developed from earlier species of animals"). Respondents were much more likely to answer correctly if the question was framed as being about scientific theories rather than as being about the natural world. When the question about evolution was prefaced by "according to the theory of evolution," 74% responded that the statement was true; conversely, only 42% considered the statement true when it was not prefaced as such. (For more details, see NSB 2008.) These differences may indicate that many Americans hold religious or other beliefs that cause them to be skeptical of certain established scientific ideas, even when they have some basic familiarity with those ideas.

When surveys ask for opinions about whether and how evolution should be taught in U.S. public schools, two key patterns emerge. First, when asked whether creation should be taught alongside of or in addition to evolution, a majority of Americans favor this pluralistic approach to education. Second, when asked whether creation should be taught instead of evolution—thereby replacing it in the science curriculum—a majority oppose this idea, while a sizeable minority favor it. In the most recent survey, 49% opposed teaching creation instead of evolution in the public schools and 38% favored it (Plutzer and Berkman 2008; Berkman and Plutzer 2010).

Genetically Modified Food

Although the introduction of GM crops has provoked much less public controversy in the United States than in Europe, U.S. public support for this application of biotechnology is limited. According to a 2008 CBS/*New York Times* poll, 44% of Americans indicate they have heard nothing or "not much" about GM ingredients added to foods to make them taste better and last longer (CBS-NYT 2008). However, 87% believe that these foods should be labeled and 53% expect that it is "not very likely" or "not at all likely" that they would buy food that is labeled as such.

Overall, these results are consistent with a series of five surveys conducted by the Pew Initiative on Food and Biotechnology between 2001 and 2006. These studies consistently found that only about one-fourth of U.S. consumers favor "the introduction of genetically modified foods into the U.S. food supply" (Mellman Group, Inc. 2006). The percentage of U.S. survey respondents reporting a negative reaction to the phrase "genetically modified food" (44%) was more than twice the 20% that reported a positive reaction (Canadian Biotechnology Secretariat 2005). Nonetheless, consumers in the United States express more favorable views than Europeans, with Canadians falling somewhere in between (Gaskell et al. 2006).

Although the FDA proposed guidelines for the approval process for genetically engineered animals in September 2008 (Maugh and Kaplan 2008), past surveys have generally found that U.S. residents are even more wary of genetic modification of animals than they are of genetic modification of plants (Mellman Group, Inc. 2005). Many express support for regulatory responses, but this support appears to be quite sensitive to the way issues are framed. Thus, whereas 29% expressed a great deal of confidence in "the Food and Drug Administration or FDA," only about half as many expressed the same confidence when the question was posed about "government regulators" (Mellman Group, Inc. 2006). (Additional findings from earlier U.S. surveys can be found in NSB 2006 and NSB 2008.)

Nanotechnology

Nanotechnology involves manipulating matter at unprecedentedly small scales to create new or improved products that can be used in a wide variety of ways. Nanotechnology has been the focus of relatively large public and private investments for almost a decade, and innovations based on nanotechnology are increasingly common. However, relative to other new technologies, nanotechnology is still in an early stage of development and the degree of risk remains uncertain (Chatterjee 2008, Barlow et al. 2009).

As noted earlier, public awareness and understanding of nanotechnology remains limited despite increased federal funding and more than 600 nanotechnology products already on the market (The National Academies 2008a).[39] According to the 2010 GSS, 24% of Americans report having heard "a lot" or "some" about nanotechnology, up four percentage points from 2008 and 2006. A plurality (44%) of Americans report having heard "nothing at all" about nanotechnology (appendix table 7-33). In 2010, among the minority of respondents who had heard "a lot" or "some" about this technology, 65% correctly indicated that "nanotechnology involves manipulating extremely small units of matter, such as individual atoms, in order to produce better materials," and 39% correctly indicated that "the properties of nanoscale materials often differ fundamentally and unexpectedly from the properties of the same materials at larger scales."

After receiving a brief explanation of nanotechnology, GSS respondents were asked about the likely balance between the benefits and harms of nanotechnology. Among all respondents to the 2010 GSS, regardless of their awareness of nanotechnology, 37% said the benefits will outweigh the harmful results, 11% expected the harms to predominate, and 43% held no opinion (appendix table 7-34). The balance of opinion was similar in 2006 and 2008.

In the GSS data, favorable attitudes toward and familiarity with nanotechnology are strongly associated. That is, Americans who say they are more familiar with nanotechnology are more likely to believe that its benefits will outweigh the risks. Among those who have heard "a lot" or "some" about nanotechnology, 65% said the benefits will outweigh the harms, 8% said harmful results will outweigh any benefits, 5% said benefits and harms would be about equal, and 22% had no opinion.[40] However, this association does not mean that when people become more familiar with nanotechnology their attitudes necessarily become positive (Cobb 2005; Lee, Scheufele, and Lewenstein 2005). Furthermore, recent research suggests that attitudes toward nanotechnology are likely to vary depending on the context in which it is applied, with energy applications viewed much more positively than those in health and human enhancements (Pidgeon et al. 2009).

International Comparisons

In Europe, 45% of survey respondents said they had heard of nanotechnology on the 2010 Eurobarometer, which described nanotechnology in terms of consumer product applications. Overall, 44% of Europeans agreed that nanotechnology should be encouraged, 35% disagreed, and 22% had no opinion about this issue (Gaskell et al. 2010).

Other Emerging Technologies

Opinions on other new and emerging technologies show an often receptive public, but one where opinion is likely to be fluid due to low levels of familiarity with the issue and any relevant concerns for public debate.

Synthetic biology, an emerging field that applies biologic science to design and construct new biological parts, organisms, or artificially engineered biological systems, provides one example. About one-quarter (26%) of Americans have heard "some" or "a lot" about synthetic biology, up from 9% in 2008 (Peter D. Hart Research Associates, Inc. 2010). When first asked to weigh the benefits and harms from synthetic biology, one-third thought the benefits and risks would be about equal, a similar percentage had no opinion, and the remainder was split about equally between those who felt the benefits would outweigh the risks and those who felt the risks would outweigh the benefits. After hearing a balanced description of the benefits and risks of synthetic biology, a greater proportion said the risks will outweigh the benefits than said the benefits will outweigh the risks.

International Comparisons

The 2010 Eurobarometer survey included an extensive series of questions about new and emerging biotechnologies. As in the United States, familiarity with synthetic biology tends to be limited. These data show that public familiarity with new technologies is often associated with opinions about the technology. In the case of nanotechnology, Europeans who are more familiar with the technology are more likely to see nanotechnology as safe and beneficial. In the cases of GM foods and animal cloning, greater familiarity with the technology is not associated with positive assessments of it (Gaskell, et al. 2010).

Animal Research

The medical research community conducts experimental tests on animals for many purposes, including to advance scientific understanding of biological processes and test the effectiveness of drugs and procedures that may eventually be used to improve human health.

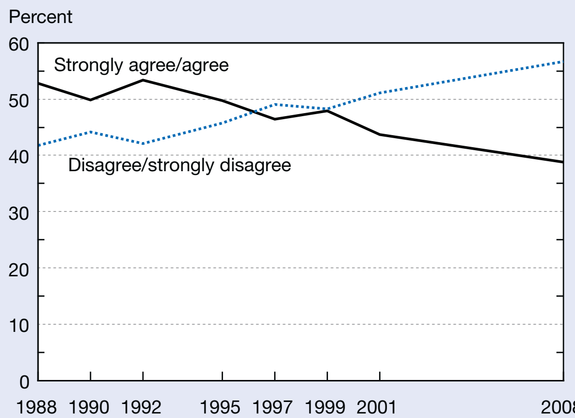
Most Americans support at least some kind of animal research. A 52% majority favors the use of animals in scientific research, whereas 43% are opposed, according to a 2009 Pew Research Center survey. Nearly two-thirds said they favor "using animals in medical research" (VCU 2007). Further, 55% of Americans consider "medical testing on animals" to be "morally acceptable," whereas 38% say it is "morally wrong," according to a 2011 Gallup survey (Saad 2011b). A 2008 Gallup survey also found a majority of respondents supported this kind of research; 64% opposed "banning all medical research on laboratory animals" and 59% opposed "banning all product testing on laboratory animals" (Newport 2008).

There is a sizeable gender gap in opinions about animal research. Women are less likely than men to support animal research; 42% of women favor the use of animals in research, compared with 62% of men (Pew Research Center 2009a). Similarly, women are less likely than men to say that medical testing on animals is "morally acceptable" (Saad 2010).

Opposition to using animals in research has grown in the past two decades. When asked whether scientists should be allowed to do "research that causes pain and injury to animals like dogs and chimpanzees if it produces new information about human health problems," between 42% and 45% of Americans disagreed in the early 1990s. This proportion increased to 51% in 2001 and 56% in 2008 (figure 7-18; appendix tables 7-35 and 7-36).[41]

Past NSF surveys suggest that the public is more comfortable with the use of mice in scientific experiments than the use of dogs and chimpanzees (NSB 2002). In 2001, 68% of

Figure 7-18
Public attitudes toward whether scientific research that causes pain to animals should be allowed: 1988–2008



NOTES: Responses to *Scientists should be allowed to do research that causes pain and injury to animals like dogs and chimpanzees if it produces new information about human health problems. Do you strongly agree, agree, disagree, or strongly disagree?* Responses of "don't know" not shown. Survey results in 1988, 1990, 1992, 1995, 1997, 1999, 2001, and 2008; other years extrapolated.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Public Attitudes Toward and Understanding of Science and Technology (1988–2001); University of Chicago, National Opinion Research Center, General Social Survey (2008). See appendix tables 7-35 and 7-36.

Science and Engineering Indicators 2012

Americans agreed that "scientists should be allowed to do research that causes pain and injury to animals like mice if it produces new information about human health problems," compared to 44% who expressed agreement when the question focused on dogs and chimpanzees (NSB 2002).

International comparisons on animal research are scarce. Half of Malaysians agree that "although research on animals may cause suffering, it has to be done for the sake of mankind." In Europe, two-thirds agree that "scientists should be allowed to do research on animals like mice if it produces new information about human health problems." A survey conducted by the Gallup Organization in 2003 showed that Americans and Canadians were more likely to tolerate scientific research on animals than the British. When asked, "Regardless of whether or not you think it should be legal, please tell me whether you personally believe that in general medical testing on animals is morally acceptable or morally wrong," the majority of adults in the United States and Canada believed it was morally acceptable (63% and 59%, respectively). In contrast, the majority of British respondents thought it was morally wrong (54%) (Mason Kiefer 2003).

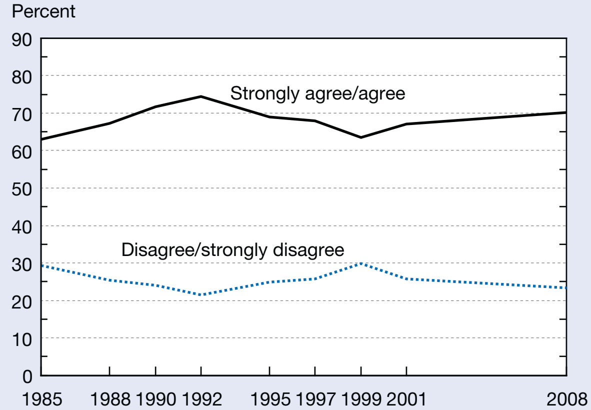
Science, Engineering, and Mathematics Education

In much of the public discourse about how Americans will fare in an increasingly S&T-driven world, quality education in science and mathematics is seen as crucial for both individuals and the nation as a whole.

In the 2008 GSS, the majority of Americans in all demographic groups agreed that the quality of science and mathematics education in American schools was inadequate (appendix tables 7-37 and 7-38). Their level of agreement increased with education, science knowledge, income, and age. Dissatisfaction with the quality of math and science education increased from 63% in 1985 to 70% in 2008, peaking at 75% in 1992 (figure 7-19). Further, about half of Americans said that their local public schools did not put enough emphasis on teaching science and math, an equal portion (48%) said the emphasis was about right, and just 2% said there was too much emphasis on teaching science and math in the local schools (Rose and Gallup 2007).

In addition, the proportion of Americans who said they believe the federal government is spending too little money on improving education in the biennial GSS surveys has remained greater than 70% since the early 1980s. This is consistently one of the top areas where the public feels government spending is too low (figure 7-14; appendix table 7-26).

Figure 7-19
Public assessment of whether the quality of science and mathematics education in America is inadequate: 1985–2008



NOTES: Responses to *The quality of science and mathematics education in American schools is inadequate. Do you strongly agree, agree, disagree, or strongly disagree?* Responses of "don't know" not shown. Survey results in 1985, 1988, 1990, 1992, 1995, 1997, 1999, 2001, and 2008; other years extrapolated.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Public Attitudes Toward and Understanding of Science and Technology (1985–2001); University of Chicago, National Opinion Research Center, General Social Survey (2008). See appendix tables 7-37 and 7-38.

Science and Engineering Indicators 2012

Conclusion

The portrait of public knowledge and attitudes concerning S&T depends, in part, on the standard used for judgment. One standard involves comparing a country's knowledge and attitudes with those recorded in other countries. When the data are examined using other countries as a benchmark, the United States compares relatively favorably. Compared with adult residents of other developed countries, American adults appear to know as much or more about science, and they express as much or more optimism about technology.

A second standard involves comparing Americans' knowledge and attitudes today with those of the past. By this standard, the survey data, while not showing marked improvements in public understanding, provide little or no evidence of declining knowledge. Relative to Americans in the recent past, today's American public scores as well on knowledge measures and tends to be more skeptical about scientific claims for pseudoscience, such as astrology. Additionally, younger Americans are more knowledgeable about S&T than older cohorts; this pattern suggests that the long-term outlook for public knowledge is promising.

Similarly, general U.S. attitudes about the promise and contribution of science to society remain strongly positive. Three decades of data consistently show that Americans endorse the past achievements and future promise of S&T and are favorably predisposed to continued government investment in science. When Americans compare science with other institutions, science's relative ranking is equally or more favorable than in the past. In addition, the prestige of the engineering profession has increased in recent years.

A third standard involves assessing what a technologically advanced society requires (either today or in the future) to compete in the world economy and enable its citizens to better take advantage of scientific progress in their own lives.

By this standard, there is more reason for concern. Trend data show that significant minorities of Americans cannot answer relatively simple knowledge questions about S&T, often express basic misconceptions about emerging technologies such as nanotechnology, and believe that relatively great scientific uncertainty surrounds the existence and causes of global climate change. Sizable proportions of the population express reservations about how the speed of technological change affects our way of life, and about the use of animals in medical research.

Regardless of the standard used in assessing public attitudes and understanding of S&T, one pattern in the data stands out: Americans who are more highly educated—particularly those who are college-educated and have completed college courses in science and mathematics—tend to know and understand more about S&T. Although it is not clear whether this association is causal, the pattern underscores the need for continued attention to the education system and the possible role of science, technology, engineering, and mathematics education in fostering public understanding of S&T.

Notes

1. Data from Pew show that the proportion of Americans who read the newspaper declined from 40% to 34% between 2006 and 2008, and that newspapers would have lost more readers if they did not have online versions. Most of the loss in newspaper readership since 2006 came from those who read the print version of the newspaper—in 2008, 27% said they had read only the print version of a daily newspaper the day before, compared to 34% in 2006. However, audiences are getting news from both traditional sources (television, print) and the Internet and blending these sources together, rather than choosing between one or the other (Pew Research Center 2008).

2. The 2010 GSS included two alternatives for distinguishing between print and online sources of information. The data in figure 7-1 are based on an approach that used followup questions asking whether references to newspapers, magazines, or the Internet included primarily print or online sources. An alternative approach offered response options that distinguish between online and print-format sources for newspapers and magazines, without branching into followup questions (see sidebar, "The Blending of Print and Online Sources of Science News"). Estimates of information sources for television, books, and other sources where there is no need to distinguish between print and online venues are comparable for both approaches to measurement. For most respondents, a response of newspapers appears to reflect reliance on print newspapers. Using the branched approach, the percentage indicating reliance on printed newspapers is similar to the percentage saying the same on the question with direct response options; less than 1% initially indicated a reliance on newspapers and then responded that they primarily relied on online newspapers in a followup question. When respondents are initially given options which distinguish between online newspapers and other online sources, however, somewhat fewer respondents indicate a reliance on any type of Internet source (31% vs. 35%).

3. The Internet is also a primary source of information for most Americans when they are seeking information on other topics, such as health. See Pew Internet and American Life Project surveys (Fox 2010; Jansen 2010).

4. Analyses that examine age differences in patterns of media use through repeated cross-sectional surveys hide considerable generational effects, because they only show a snapshot of a single point in time (Losh 2009).

5. In 2001, this question was part of a single-purpose telephone survey focused on S&T. In 2008, these data were collected as part of a face-to-face multipurpose survey covering a broad range of behavior and attitudes. It is unclear whether these differences in data collection or a change in public opinion account for the decline in interest observed between 2001 and 2008.

6. In interpreting survey data that use the phrase "science and technology," it is important to take into account the uncertainties surrounding its meaning and the different associations Americans make when they hear it.

7. Note that the Eurobarometer surveys include a different set of countries because the composition of the European Union changes over time. In 2010, the survey included 27 countries; in 2005, it included 25 countries.

8. The question asked on the Eurobarometer surveys has changed over time, making the data not always strictly comparable with previous Eurobarometer surveys or with U.S. data.

9. The China survey asked about interest levels on a 3-point scale with response options translated as "interested," "ordinary" interest level, and "not interested."

10. The analysis is based on a purposive selection of five media sectors, outlets within each sector, and specific programs or articles for study. The index is designed to capture the main news stories covered each week. Coding of programs and articles is limited to the first 30 minutes of most radio, cable, and network news programs, the front page of newspapers, and the top five stories on websites. Each selected unit of study is coded on 17 variables according to an established coding protocol. The team of individuals performing the content analysis is directed by a coding manager, a training coordinator, a methodologist, and a senior researcher. Intensive tests of intercoder reliability are conducted annually. For variables that require little or no inference, intercoder agreement was 97% in 2010. For variables requiring more inference, intercoder agreement ranged from 78% to 85% in 2010. Intercoder agreement was similar in earlier years. For more details, see http://www.journalism.org/about_news_index/methodology.

11. The total amount of news consists of the space devoted to news in print and online news sources and the time devoted to news on radio and TV sources.

12. "Science, space, and technology" includes stories on manned and unmanned space flight, astronomy, scientific research, computers, the Internet, and telecommunications

media technology. It excludes forensic science and telecommunications media content. "Biotechnology and basic medical research" includes stem cell research, genetic research, cloning, and agribusiness bioengineering, and excludes clinical research and medical technology. Stories often do not fall neatly into a single category or theme.

13. The peak in the coverage of the category "Science, space, and technology" in 1999 includes major network coverage of stories about the so-called Millennium Bug and business issues from the dot.com boom, such as the rise of Internet commerce and the browser antitrust wars.

14. The sample of news links on blogs and Twitter posts comes from two prominent Web-tracking sites, Icerocket and Tweetmeme, using the links to articles embedded on the sites as a proxy for the subject of the blog post or Tweet. The Web-tracking sites provide a list of the most-linked-to news stories based on the number of blogs, tweets, or other sites that link to each. Typically, the linked-to stories originate from traditional media sources. PEJ staff manually capture the list of most-linked-to stories each weekday, and the coding staff categorize the top five linked-to articles from this list of approximately 50 linked-to articles each week. The coding procedures are similar to those used for the News Coverage Index of traditional media sources. For more, see http://www.journalism.org/commentary_backgrounder/new_media_index_methodology.

15. People can become involved with S&T through many kinds of non-classroom activities. Examples of such activities include participating in government policy processes, going to movies that feature S&T, bird watching, and building computers. *Citizen science* is a term used for activities by citizens with no specific science training who participate in the research process through activities such as observation, measurement, or computation. Nationally representative data on this sort of involvement with S&T are unavailable.

16. Involvement in informal S&T activities is also thought to foster learning and knowledge about S&T (see Falk and Dierking 2010).

17. In the 2008 GSS, respondents received two different introductions to this question. Response patterns did not vary depending on which introduction was given.

18. In 2001, this question was part of a single-purpose telephone survey focused on science and technology. In 2008, these data were collected as part of a face-to-face multipurpose survey covering a broad range of behavior and attitudes. It is unclear whether these differences in data collection or a change in visit behavior account for the decline observed between 2001 and 2008.

19. In the United States, this measure included visits to a zoo or aquarium.

20. Survey items that test factual knowledge sometimes use easily comprehensible language at the cost of scientific precision. This may prompt some highly knowledgeable respondents to feel that the items blur or neglect important distinctions, and in a few cases may lead respondents to answer questions incorrectly. In addition, the items do not reflect the ways that established scientific knowledge evolves as scientists accumulate new evidence. Although the text of the factual knowledge questions may suggest a fixed body of knowledge, it is more accurate to see scientists as making continual, often subtle modifications in how they understand existing data in light of new evidence.

21. Respondents who say they know "nothing at all" about nanotechnology were not asked the two knowledge questions about this topic; they are classified as holding incorrect responses to both questions.

22. The two nanotechnology questions were asked only of respondents who said they had some familiarity with nanotechnology, and a sizable majority of the respondents who ventured a response different from "don't know" answered the questions correctly. To measure nanotechnology knowledge more reliably, researchers would prefer a scale with more than two questions.

23. In its own international comparison of scientific literacy, Japan ranked itself 10th among the 14 countries it evaluated (National Institute of Science and Technology Policy 2002).

24. Early NSF surveys used additional questions to measure understanding of probability. Bann and Schwerin (2004) identified a smaller number of questions that could be administered to develop a comparable indicator. Starting in 2004, the NSF surveys used these questions for the trend factual knowledge scale.

25. A change of this magnitude in a 2-year period is unusual. Because classification of knowledge on these items includes open-ended questions, it is possible that some of the change could stem from unknown differences in coding practices by the GSS staff over time.

26. Classification as understanding scientific inquiry is based on providing a correct response to the measure of understanding probability and providing a correct response to either the measure of understanding an experiment or the open-ended measure of understanding a scientific study.

27. The questions were selected from the Trends in Mathematics and Science Studies (TIMSS), National Assessment of Educational Progress (NAEP), practice General Educational Development (GED) exams, and AAAS Project 2061.

28. The scoring of the open-ended questions closely followed the scoring of the corresponding test administered to middle-school students.

For the NAEP question, "Lightning and thunder happen at the same time, but you see the lightning before you hear the thunder. Explain why this is so," the question was scored as follows:

1) Complete: The response provided a correct explanation including the relative speeds at which light and sound travel. For example, "Sound travels much slower than light so you see the light sooner at a distance."

2) Partial: The response addressed speed and used terminology such as thunder for sound and lightning for light, or made a general statement about speed but did not indicate

which is faster. For example, "One goes at the speed of light and the other at the speed of sound."
3) Unsatisfactory/Incorrect: Any response that did not relate or mention the faster speed of light or its equivalent, the slower speed of sound. For example, "Because the storm was further out," or "Because of static electricity."

For the TIMSS question, "A solution of hydrochloric acid (HCl) in water will turn blue litmus paper red. A solution of the base sodium hydroxide (NaOH) in water will turn red litmus paper blue. If the acid and base solutions are mixed in the right proportion, the resulting solution will cause neither red nor blue litmus paper to change color. Explain why the litmus paper does not change color in the mixed solution," the question was scored as follows:
1) Correct: The response had to refer to a neutralization or a chemical reaction that results in products that do not react with litmus paper. Three kinds of answers were classified as correct:
a. The response referred explicitly to the formation of water (and salt) from the neutralization reaction. For example, "Hydrochloric acid and sodium hydroxide will mix together to form water and salt, which is neutral."
b. The response referred to neutralization (or the equivalent) even if the specific reaction is not mentioned. For example, "The mixed solution is neutral, so litmus paper does not react.")
c. The response referred to a chemical reaction taking place (implicitly or explicitly) to form products that do not react with litmus paper (or a similar substance), even if neutralization was not explicitly mentioned. For example, "The acid and base react, and the new chemicals do not react with litmus paper."
2) Partially correct: The response mentioned only that acids and bases are "balanced," "opposites," "cancel each other out," or that it changes to a salt without mentioning the neutralization reaction. These answers suggest that the respondent remembered the concept but the terminology they used was less precise, or that the answer was partial. For example, "They balance each other out."
3) Incorrect: The response did not mention any of the above in a–c or is too partial or incomplete, and/or uses terminology that is too imprecise. For example, "Because they are base solutions—the two bases mixed together there is no reaction," or "There is no change. Both colors change to the other."

29. The pseudoscience section focuses on astrology because of the availability of long-term national trend indicators on this subject. Other examples of pseudoscience include the belief in lucky numbers, the existence of unidentified flying objects (UFOs), extrasensory perception (ESP), or magnetic therapy.

30. Methodological issues make fine-grained comparisons of data from different survey years suspect. For instance, although the question content and interviewer instructions were identical in 2004 and 2006, the percentage of respondents who volunteered "about equal" (an answer not among the choices given) was substantially different. This difference may have been produced by the change from telephone interviews in 2004 to in-person interviews in 2006 (though telephone interviews in 2001 produced results that are similar to those in 2006). More likely, customary interviewing practices in the three different organizations that administered the surveys affected their interviewers' willingness to accept responses other than those that were specifically offered on the interview form, including "don't know" responses.

31. This type of survey question asks respondents about their assessment of government spending in several areas without mentioning the possible negative consequences of spending (e.g., higher taxes, less money available for higher priority expenditures). A question that focused respondents' attention on such consequences might yield response patterns less sympathetic to greater government funding.

32. The GSS questions on global climate change used the term "global warming."

33. The 2010 GSS survey included ratings of nuclear engineers in addition to medical researchers, environmental scientists, and economists. As discussed below, the patterns of results were similar whether the group with relevant expertise was engineers or scientists.

34. There are many different types of specializations within occupations, and prestige may well vary within the same occupation or industry.

35. This survey was conducted prior to the earthquake and tsunami in Japan on March 11, 2011.

36. There is some evidence from a large scale experimental study that the wording used in such questions ("global warming" or "climate change") can have an effect on reported beliefs about global climate change (Schuldt, Konrath, and Schwarz 2011). Earlier studies suggested that such wording differences had little effect (EC 2008; Villar and Krosnick 2010).

37. The two questions from the 2009 Gallup survey were each asked to half of the sample (n = 500).

38. Countries with nuclear plants include Belgium, Bulgaria, the Czech Republic, Finland, France, Germany, Hungary, Lithuania, the Netherlands, Romania, Slovakia, Slovenia, Spain, Sweden, and the United Kingdom. Two exceptions to this pattern are Romania and Spain, both of which have operational nuclear power plants but where the level of support for nuclear energy is below the EU average. An earlier Eurobarometer study showed that respondents in Spain and Romania were less aware of the fact that their countries have nuclear power plants than respondents in other countries with nuclear plants in operation (EC 2008a). This low level of awareness regarding the operation of a nuclear plant in their country may lead to a less positive attitude about nuclear energy.

39. According to a report from The National Academies, more than 600 products involving nanotechnology are already on the market; most of them are health and fitness products such as skin care products and cosmetics (The National Academies, 2008b).

40. This pattern of data is consistent with findings from a meta-analysis of 22 studies conducted in the United States and elsewhere by Satterfield et al. (2009).

41. The increase in the proportion of respondents who disagree with this statement may be related to methodological issues, because of the changes in data collection. See note 5.

Glossary

Biotechnology: The use of living things to make products.

Climate change: Any distinct change in measures of climate lasting for a long period of time. Climate change means major changes in temperature, rainfall, snow, or wind patterns lasting for decades or longer. Climate change may result from natural factors or human activities.

EU: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom.

Genetically modified (GM) food: A food product containing some quantity of any genetically modified organism as an ingredient.

Global warming: An average increase in temperatures near the Earth's surface and in the lowest layer of the atmosphere. Increases in temperatures in the Earth's atmosphere can contribute to changes in global climate patterns. Global warming can be considered part of climate change along with changes in precipitation, sea level, etc.

Nanotechnology: Manipulating matter at unprecedentedly small scales to create new or improved products that can be used in a wide variety of ways.

Synthetic biology: An emerging field that applies biologic science to design and construct new biological parts, organisms, or artificially engineered biological systems.

Reproductive cloning: Technology used to generate genetically identical individuals with the same nuclear DNA as another individuals.

Therapeutic cloning: Use of cloning technology in medical research to develop new treatments for diseases; differentiated from human reproductive cloning.

References

ABC News. 2008. Fuel costs boost conservation efforts: 7 in 10 reducing 'carbon footprint.' ABC News/Planet Green/Stanford University Poll: Environment/Energy, August 9, 2008. http://abcnews.go.com/images/PollingUnit/1067a1Environment2008.pdf. Accessed 20 June 2011.

Allum N, Sturgis P, Tabourazi D, Brunton-Smith I. 2008. Science knowledge and attitudes across cultures: A meta-analysis. *Public Understanding of Science* 17(January):35–54.

Bann CM, Schwerin MJ. 2004. Public knowledge and attitudes scale construction: Development of short forms. Research Triangle Park, NC: National Science Foundation, Division of Science Resources Statistics.

Barabas J, Jerit J. 2009. Estimating the causal effects of media coverage on policy-specific knowledge. *American Journal of Political Science* 53(1):73–89.

Barlow S, Chesson A, Collins JD, Flynn A, Hardy A, Jany KD, Knaap A, Kuiper H, Larsen JC, Le Neindre P, Schans J, Schlatter J, Silano V, Skerfving S, Vannier P. 2009. The potential risks arising from nanoscience and nanotechnologies on food and feed safety. Parma, Italy: European Food Safety Authority. http://www.efsa.europa.eu/en/efsajournal/doc/s958.pdf. Accessed 20 June 2011.

Bauer MW. 2009. The evolution of public understanding of science—discourse and comparative evidence. *Science, Technology and Society* 14:2(2009):221–240.

Bauer MW, Petkova K, Boyadjieva P. 2000. Public knowledge of and attitudes to science: Alternative measures that may end the "science war." *Science, Technology, & Human Values* 25(1):30–51.

Berkman M, E Plutzer. 2010. *Evolution, Creationism, and the Battle to Control America's Classrooms*. New York: Cambridge University Press.

Canadian Biotechnology Secretariat (CBS). 2005. Canada–U.S. Survey on Biotechnology. Ottawa, Ontario.

CBS News/New York Times Poll (CBS-NYT). April 2008. Retrieved from The Polling Report, http://www.pollingreport.com/food.htm, accessed 24 October 2011.

Chatterjee R. 2008. The continuing uncertainty of nano risks and regulations. *Environmental Science & Technology* 42(21):7733. http://pubs.acs.org/doi/pdfplus/10.1021/es802396x. Accessed 22 June 2009.

China Research Institute for Science Popularization (CRISP). 2008. Chinese public understanding of science and attitudes towards science and technology. Beijing, China.

Cobb MD. 2005. Framing effects on public opinion about nanotechnology. *Science Communication* 27(2):221–239.

Crettaz von Roten F. 2006. Do we need a public understanding of statistics? *Public Understanding of Science* 15:243–249.

Doran PT, Zimmerman MK. 2009. Examining the scientific consensus on climate change. *Eos* 90(3), January 20, 2009.

European Commission (EC). 2008a. Attitudes towards radioactive waste. Special Eurobarometer 297/Wave 69.1. http://ec.europa.eu/public_opinion/archives/ebs/ebs_297_en.pdf. Accessed 24 October 2011.

European Commission (EC). 2008b. Europeans' attitudes towards climate change. Special Eurobarometer 300. http://ec.europa.eu/public_opinion/archives/ebs/ebs_300_full_en.pdf. Accessed 20 June 2011.

European Commission (EC). 2010. Science and Technology Report. Special Eurobarometer 340, European Commission Directorate-General for Research, June 2010.

Falk, JH, Dierking LD. 2010. The 95 percent solution: School is not where most Americans learn most of their science. *American Scientist* 98:486–493.

Fox S. 2010. Mobile health 2010, Pew Internet and American Life Project, October 19, 2010. http://www.pewinternet.org/~/media//Files/Reports/2010/PIP_Mobile_Health_2010.pdf. Accessed 13 March 2011.

Fundacion BBVA. 2008. BBVA Foundation international study on attitudes to stem cell research and hybrid embryos. http://www.fbbva.es/TLFU/dat/international_study_biotechnology_08.pdf. Accessed 23 June 2009.

The Gallup Organization. 2010. In iPOLL, the Roper Center for Public Opinion Research. http://roperweb.ropercenter.uconn.edu/. Accessed 15 February 2011.

Gaskell G, Stares S, Allansdottir A, Allum A, Corchero C, Fischler C, Hampel J, Jackson J, Kronberger N, Mejlgaard N, Revuelta G, Schreiner C, Torgerson H, Wagner W. 2006. Eurobarometer 224/Wave 64.3. Europeans and biotechnology in 2005: Patterns and trends. Brussels: European Commission. http://ec.europa.eu/research/biosociety/pdf/eb_64_3_final_report_second_edition_july_06.pdf. Accessed 20 June 2011.

Gaskell G, Stares S, Allansdottir A, Allum N, Castro P, Esmer Y, Fischler C, Jackson J, Kronberger N, Hampel J, Mejlgaard N, Quintanilha A, Rammer A, Revuelta G, Stoneman P, Torgersen H, Wagner W. 2010. Europeans and biotechnology in 2010: Winds of change? European Commission Directorate-General for Research, October 2010.

Gokhberg L, Shuvalova O. 2004. *Russian Public Opinion of the Knowledge Economy: Science, Innovation, Information Technology and Education as Drivers of Economic Growth and Quality of Life*. Moscow, Russia: The British Council-Russia.

Guterbock, T, Allum N, Besley J, Conrad F, Holbrook A, Keeter S, Losh S, Mondak J, Reeve B, Rexrode D, Sikkink D, Stares S, Tourangeau R, Toumey C. 2010. *Measurement and Operationalization of the "Science in the Service of Citizens and Consumers" Framework*. Report of the 2010 NSF Science Indicators Instrumentation Workshop, National Science Foundation, 31 January 2011.

Harris Interactive. 2009. Firefighters, scientists, and doctors seen as most prestigious occupations: Real estate brokers, accountants, and stockbrokers are at the bottom of the list, Harris Poll, #86 Harris Interactive (4 August 2009) http://www.harrisinteractive.com/vault/Harris-Interactive-Poll-Research-Pres-Occupations-2009-08.pdf. Accessed 7 February 2011.

Horrigan J. 2006. The Internet as a resource for news and information about science. Pew Internet and American Life Project, November 20, 2006. http://www.pewinternet.org/~/media//Files/Reports/2006/PIP_Exploratorium_Science.pdf. Accessed 20 June 2011.

Internet World Statistics. 2010. http://www.internetworldstats.com/stats.htm. Accessed 4 March 2011.

Jansen J. 2010. Use of the internet in higher-income households. Pew Internet and American Life Project, November 24 2010. http://www.pewinternet.org/~/media//Files/Reports/2010/PIP-Better-off-households-final.pdf. Accessed 13 March 2011.

Jasanoff S. 2005. *Designs on Nature: Science and Democracy in Europe and the United States*. Princeton: Princeton University Press.

Jones JM. 2009. Support for nuclear energy inches up to a new high: Majority believes nuclear plants are safe. The Gallup Organization, March 20, 2009. http://www.gallup.com/poll/117025/Support-Nuclear-Energy-Inches-New-High.aspx. Accessed 20 June 2011.

Jones JM. 2010. Oil spill alters views on environmental protection; Majority now favors protecting environment over developing energy supplies. The Gallup Organization, May 27, 2010. http://www.gallup.com/poll/137882/Oil-Spill-Alters-Views-Environmental-Protection.aspx. Accessed 7 February 2011.

Jones JM. 2011a. Disaster in Japan raises nuclear concerns in U.S.: Americans divided over construction of nuclear power plants in U.S. The Gallup Organization, March 16, 2011. http://www.gallup.com/poll/146660/Disaster-Japan-Raises-Nuclear-Concerns.aspx. Accessed 21 March 2011.

Jones JM. 2011b. In U.S., alternative energy bill does best among eight proposals: Two thirds favor expanded drilling and exploration for oil and gas. The Gallup Organization, February 2, 2011. http://www.gallup.com/poll/145880/Alternative-Energy-Bill-Best-Among-Eight-Proposals.aspx. Accessed 7 February 2011.

Jones JM. 2011c. Unemployment solidifies position as most important problem: 35 percent mentioning it is highest since 1983. The Gallup Organization, February 11, 2011. http://www.gallup.com/poll/146081/Unemployment-Solidifies-Position-Important-Problem.aspx. Accessed 20 June 2011.

Korea Foundation for the Advancement of Science and Creativity (KOFAC). 2009. Survey of public attitudes towards and understanding of science and technology 2008. Seoul, Korea.

Krosnick JA, Holbrook AL, Lowe L, Visser, PS. 2006. The origins and consequences of democratic citizens' policy agendas: A study of popular concern about global warming. *Climatic Change*. 77(July):7–43.

Lee CL, Scheufele DA, Lewenstein BV. 2005. Public attitudes toward emerging technologies: Examining the interactive effects of cognitions and affect on public attitudes toward nanotechnology. *Science Communication* 27(2):240–267.

Losh SC. 2009. Generation, education, gender and ethnicity in American digital divides. In: Ferro E, Dwivedi YK, Gil-Garcia JR, Williams MD, editors. *IGI Handbook: Overcoming Digital Divides: Constructing an Equitable and Competitive Information Society*. Hershey, PA: IGI Global.

Losh SC. 2011. Age, generational, and educational effects on American public understanding of science: 1979–2006. In: MW Bauer, R Shukla, and N Allum, editors., *The Culture of Science: How the Public Relates to Science Across the Globe*. New York: Routledge.

Malaysian Science and Technology Information Centre (MASTIC), Ministry of Science, Technology and

Innovation. 2010. The public awareness of science and technology Malaysia 2008.

Malhotra N, Krosnick JA, Haertel E. 2007, August. The psychometric properties of the GSS Wordsum Vocabulary Test. GSS Methodological Report 11.

Mason Kiefer, H. 2003. Americans, Britons at odds on animal testing. The Gallup Organization, September 2, 2003. http://www.gallup.com/poll/9178/Americans-Britons-Odds-Animal-Testing.aspx. Accessed 20 June 2011.

Maugh II TH, Kaplan K. 2008. FDA proposes approval process for genetically engineered animals. Los Angeles Times. http://articles.latimes.com/2008/sep/19/science/sci-genetic19. Accessed 24 October 2011.

Mellman Group, Inc. 2006. Review of public opinion research. http://www.pewtrusts.org/uploadedFiles/wwwpewtrustsorg/Public_Opinion/Food_and_Biotechnology/2006summary.pdf. Accessed 20 June 2011.

Miller JD. 1998. The measurement of scientific literacy. *Public Understanding of Science* 7:203–223.

Miller JD. 2011. The conceptualization and measurement of civic science literacy for the twenty-first century. In: J Meinwald, JG Hildebrand, editors, *Science and the educated American: A core component of liberal education*. Cambridge, MA: American Academy of Arts and Sciences.

Ministry of Science and Technology (MCT) of Brazil. 2010. Public perceptions of science and technology. http://portaldoprofessor.mec.gov.br/storage/materiais/0000014919.pdf. Accessed 21 June 2011.

The National Academies. 2008a. Review of the federal strategy for nanotechnology-related environmental safety research. Washington, DC: The National Academies Press. http://books.nap.edu/openbook.php?record_id=12559&page=R1. Accessed 20 June 2011.

The National Academies. 2008b. Understanding and responding to climate change: Highlights of National Academies report. Washington, DC: The National Academies Press. http://dels.nas.edu/resources/static-assets/materials-based-on-reports/booklets/climate_change_2008_final.pdf. Accessed 20 June 2011.

National Institute of Science and Technology Policy, Ministry of Education, Culture, Sports, Science and Technology. 2002. The 2001 survey of public attitudes toward and understanding of science and technology in Japan. Tokyo, Japan.

National Science Board (NSB). 2002. *Science and Engineering Indicators 2002.* NSB-02-01A. Arlington, VA: National Science Foundation.

National Science Board (NSB). 2006. *Science and Engineering Indicators 2006.* NSB 06-01; NSB 06-01A. Arlington, VA: National Science Foundation.

National Science Board (NSB). 2008. *Science and Engineering Indicators 2008.* NSB 08-01; NSB 08-01A. Arlington, VA: National Science Foundation.

National Science Board (NSB). 2010. *Science and Engineering Indicators 2010.* NSB 08-01; NSB 10-01A. Arlington, VA: National Science Foundation.

Newport F. 2008. Post-Derby tragedy: 38% support banning animal racing. http://www.gallup.com/poll/107293/PostDerby-Tragedy-38-Support-Banning-Animal-Racing.aspx. Accessed 24 October 2011.

Newport F. 2010. Americans' global warming concerns continue to drop: Multiple indicators show less concern, more feelings that global warming is exaggerated. The Gallup Organization, March 11, 2010. http://www.gallup.com/poll/126560/Americans-Global-Warming-Concerns-Continue-Drop.aspx. Accessed 21 February 2011.

Organisation for Economic Co-operation and Development (OECD). 2003. The PISA 2003 assessment framework—Mathematics, reading, science and problem solving knowledge and skills. Paris.

Peter D. Hart Research Associates, Inc. 2010. Awareness and impressions of synthetic biology, September 9, 2010. Conducted on behalf of the Synthetic Biology Project, The Woodrow Wilson International Center for Scholars. http://bio.org/ind/syntheticbiology/hart2010report_final.pdf. Accessed 20 June 2011.

Pew Global Attitudes Project. 2010. Obama more popular abroad than at home, global image of U.S. continues to benefit: 22-Nation Pew Global Attitudes Survey, June 17, 2010. http://pewresearch.org/pubs/1630/obama-more-popular-abroad-global-american-image-benefit-22-nation-global-survey. Accessed 18 February 2011.

Pew Research Center for the People and the Press. 2008. Key news audiences now blend online and traditional sources: Audience segments in a changing news environment, August 17, 2008. http://people-press.org/report/444/news-media. Accessed 20 June 2011.

Pew Research Center for the People and the Press. 2009a. Public praises science; scientists fault public, media: Scientific achievements less prominent than a decade ago, July 9, 2009. http://people-press.org/report/528/. Accessed 6 January 2011.

Pew Research Center for the People and the Press. 2009b. Support for health care overhaul, but it's not 1993, March 19, 2009. http://people-press.org/category/publications/survey-reports/2009/. Accessed 24 February 2011.

Pew Research Center for the People and the Press. 2010a. Americans spend more time following the news, September 12, 2010. http://people-press.org/report/652/. Accessed 3 February 2011.

Pew Research Center for the People and the Press. 2010b. Little change in opinions about global warming: Increasing partisan divide on energy policies, October 27, 2010. http://people-press.org/report/669/. Accessed 20 June 2011.

Pew Research Center for the People and the Press. 2010c. Top Stories of 2010: Haiti Earthquake, Gulf Oil Spill, December 21, 2010. http://people-press.org/report/687/. Accessed 18 February 2011.

Pew Research Center for the People and the Press. 2011a. Fewer want spending to grow, but most cuts remain unpopular: Changing views of federal spending, February 11, 2011. http://people-press.org/report/702/. Accessed 15 February 2011.

Pew Research Center for the People and the Press. 2011b. Internet gains on television as public's main source of news, January 4, 2011. http://people-press.org/report/689/. Accessed 15 February 2011.

Pew Research Center for the People and the Press. 2011c. Opposition to nuclear power rises amid Japanese Crisis: Support for offshore oil and gas drilling rebounds, March 21, 2011. http://people-press.org/2011/03/21/opposition-to-nuclear-power-rises-amid-japanese-crisis/. Accessed 27 March 2011.

Pidgeon N, Harthorn BH, Bryant K, Rogers-Hayden T. 2009. Deliberating the risks of nanotechnologies for energy and health applications in the United States and United Kingdom. *Nature Nanotechnology* 4:95–98.

Plutzer E, M Berkman. 2008. The Polls—Trends: Evolution, creationism, and the teaching of human origins in schools. *Public Opinion Quarterly* 72(3):540–553.

Project for Excellence in Journalism (PEJ). 2010a. About the News Coverage Index: methodology. http://www.journalism.org/about_news_index/methodology. Accessed 11 February 2011.

Project for Excellence in Journalism (PEJ). 2010b. "Climategate" re-ignites the blogosphere debate. http://www.journalism.org/print/19508. Accessed 11 February 2011.

Project for Excellence in Journalism (PEJ). 2010c. New Media Index Methodology, September 16, 2010, http://www.journalism.org/commentary_backgrounder/new_media_index_methodology. Accessed 11 February 2011.

Project for Excellence in Journalism (PEJ). 2010d. The Science Gap. http://www.journalism.org/numbers_report/science_gap. Accessed 24 June 2010.

Project for Excellence in Journalism (PEJ). 2010e. The state of the news media: An annual report on American journalism. http://www.stateofthemedia.org/2010/. Accessed 11 February 2011.

Rose LC, Gallup AM. 2007. The 39th annual Phi Delta Kappa/Gallup poll of the public's attitudes toward the public schools. *Phi Delta Kappan* September 2007, 89(1):33–48.

Saad L. 2010. Four moral issues sharply divide Americans. The Gallup Organization, May 26, 2010; May 3–6, 2010. http://www.gallup.com/poll/137357/Four-Moral-Issues-Sharply-Divide-Americans.aspx. Accessed 22 February 2011.

Saad L. 2011a. Americans' worries about economy, budget top other issues. The Gallup Organization, March 21, 2011. http://www.gallup.com/poll/146708/Americans-Worries-Economy-Budget-Top-Issues.aspx?version=print. Accessed 21 March 2011.

Saad L. 2011b. Doctor-assisted suicide is moral issue dividing Americans most: Pornography, gay relations produce biggest generational gaps. The Gallup Organization, May 31, 2011. http://www.gallup.com/poll/147842/Doctor-Assisted-Suicide-Moral-Issue-Dividing-Americans.aspx?version=print. Accessed 21 June 2011.

Satterfield, T, Kandlikar M, Beaudrie CEH, Conti J, Harthorn BH. 2009. Anticipating the perceived risk of nanotechnologies. *Nature Nanotechnology* 4 (11):752–758.

Schuldt JP, Konrath SH, Schwarz N. 2011. "Global Warming" or "Climate Change"? Whether the planet is warming depends on question wording. *Public Opinion Quarterly* 75(1):115–124.

Shen, BSP. 1975. Science literacy and the public understanding of science. In: Day S, editor, *Communication of Scientific Information*. Basel: Karger.

Shukla R. 2005. *India Science Report: Science Education, Human Resources, and Public Attitude toward Science and Technology.* New Delhi, India: National Council of Applied Economic Research.

Toumey C, Besley J, Blanchard M, Brown M, Cobb M, Ecklund EH, Glass M, Guterbock TM, Kelly AE, Lewenstein B. 2010. Science in the service of citizens and consumers: The NSF workshop on public knowledge of science, 22–23 October 2010. National Science Foundation.

Tyndall Report. 2011a. Special tabulations (February 2011a), http://www.tyndallreport.com. Accessed 3 February 2011.

Tyndall Report. 2011b. Year in review: 2010. http://www.tyndallreport.com. Accessed 3 February 2011.

Villar A, Krosnick JA. 2010. "Global Warming" vs. "Climate Change": Does word choice matter? *Climatic Change* 105(1-2):1–12.

Virginia Commonwealth University (VCU). 2006. Opinions shifting on stem cell research; opposition to cloning continues. VCU Life Sciences Survey. http://www.vcu.edu/lifesci/images2/ls_survey_2006_report.pdf. Accessed 20 June 2011.

Virginia Commonwealth University (VCU). 2007. Widespread support for non-embryonic stem cell research but continued need for both kinds of research. VCU Life Sciences Survey. http://www.vcu.edu/lifesci/images2/survey2007.pdf. Accessed 20 June 2011.

Virginia Commonwealth University (VCU). 2008. VCU survey finds support for genetic research, testing, and government spending on scientific research. VCU Life Sciences Survey. http://www.vcu.edu/lifesci/images2/survey2008.pdf. Accessed 20 June 2011.

Virginia Commonwealth University (VCU). 2010. VCU survey finds public divided over increasing offshore oil drilling: Majority think risks outweigh benefits. VCU Life Sciences Survey, May 27, 2010. http://www.vcu.edu/lifesci/images2/survey2010.pdf. Accessed 4 March 2011.

WorldPublicOpinion.org. 2009. Public attitudes to climate change: Findings from a multi-country poll. The Program on International Policy Attitudes (PIPA), University of Maryland, conducted on behalf of The World Bank, December 2009.

Yaar E. 2006. Science and technology in the Israeli consciousness. Samuel Neaman Institute. Haifa, Israel. http://www.neaman.org.il/Neaman/publications/publication_item.asp?fid=757&parentfid=488&iid=3428. Accessed 20 June 2011.

Chapter 8
State Indicators

Elementary/Secondary Education

Higher Education

Workforce

Financial Research and Development Inputs

Research and Development Outputs

Science and Technology in the Economy

List of Tables

List of Figures

Introduction

Chapter Overview

To address the interest of the policy and research communities in the role of science and technology (S&T) in state and regional economic development, this chapter presents findings on state trends in S&T education, the employed workforce, finance, and research and development. This chapter includes 58 indicators for individual states, the District of Columbia, and Puerto Rico.

Although data for Puerto Rico are reported whenever available, they frequently were collected by a different source, making it unclear whether the methodology used for data collection and analysis is comparable with that used for the states. For this reason, Puerto Rico was not ranked with the states, not assigned a quartile value, and not displayed on the maps. Data for United States territories and protectorates, such as American Samoa, Guam, Northern Mariana Islands, and Virgin Islands, were available only on a sporadic basis and thus are not included.

The indicators are designed to present information about various aspects of state S&T infrastructure. The data used to calculate the indicators were gathered from public and private sources. When possible, data covering a 10-year span are presented to assist in identifying trends. However, consistent data were not always available for the 10-year period, in which case, data are given only for the years in which comparisons are appropriate. Most indicators contain data for 2008–09; some contain data for 2010.

Ready access to accurate and timely information is an important tool for formulating effective S&T policies at the state level. By studying the programs and performance of their peers, state policymakers may be able to better assess and enhance their own programs and performance. Corporations and other organizations considering investments at the state level may also benefit from this information. The tables are intended to provide quantitative data that may be relevant to technology-based economic development. More generally, the chapter aims to foster further consideration of the appropriate uses of state-level indicators.

Types of Indicators

Fifty-eight indicators are included in this chapter and grouped into the following areas:

- Elementary and secondary education
- Higher education
- Workforce
- Financial R&D inputs
- Research and development outputs
- S&T in the economy

The first two areas address state educational attainment. Student achievement is expressed in terms of performance, which refers to the average state score on a standardized test, and proficiency, which is expressed as the percentage of students who have achieved at least the expected level of competence on the standardized test.

Comparable state-level performance data are not available for high school students. Although performance and proficiency data in science are available for students in grade 12 at the national level but not at the state level, data on performance and proficiency in mathematics is not available at either the federal or state level for students in grade 12. Instead, mastery of college-level material through performance on Advanced Placement Exams has been included as a measure of the skills being developed by the top-performing high school students. Other indicators in education focus on state spending, teacher salaries, student costs, and undergraduate and graduate degrees in S&E. Three indicators measure the level of education in the populations of individual states.

Workforce indicators focus on the level of S&E training in the employed labor force. These indicators reflect the higher education level of the labor force and the degree of specialization in S&E disciplines and occupations.

Financial indicators address the sources and level of funding for R&D. They show how much R&D is being performed relative to the size of a state's business base. This section enables readers to compare the extent to which R&D is conducted by industrial, academic, or state agency performers.

The final two sections provide measures of outputs. The first focuses on the work products of the academic community. It includes the number of new doctorates conferred, the publication of academic articles, and patent activity from the academic community and from all sources in the state.

The last section of output indicators examines the robustness of a region's S&T-related economic activity. These indicators include venture capital activity, Small Business Innovation Research awards, and high-technology business activity. Although data that adequately address both the quantity and quality of R&D results are difficult to find, these indicators offer a reasonable information base.

This edition includes six new indicators. Consistent with other indicators in the chapter, they are normalized. The first covers AP Calculus AB exams and is presented as a percentage of high school students scoring 3 or higher on the exam. The second covers the number of bachelor's degrees in science and engineering that were conferred relative to the size of the population in the appropriate age range. The third provides an indication of the degree to which a state's educational infrastructure provides the highest level of training in science and engineering and is presented as the number of doctorate degrees conferred in science and engineering as a percentage of all science and engineering degrees conferred. The fourth indicator covers state funds for higher education and is presented as the percentage of state gross domestic product. The fifth addresses the amount of state funding for public research universities per enrolled student. Finally, the last new indicator focuses on the percentage of technical workers in a state's workforce.

Data Sources and Considerations

Raw data for each indicator are presented in the tables. Each table provides an average value for all states, labeled “United States.” For most indicators, the state average was calculated by summing the values for the 50 states and the District of Columbia for both the numerator and the denominator and then dividing the two. Any alternate approach is indicated in the notes at the bottom of the table.

The values for most indicators are expressed as ratios or percentages to facilitate comparison between states that differ substantially in size. For example, an indicator of higher education achievement is not defined as the absolute number of degrees conferred in a state because sparsely populated states are unlikely to have or need as extensive a higher education system as states with larger populations. Instead, the indicator is defined as the number of degrees per number of residents in the college-age cohort, which measures the intensity of educational services relative to the size of the resident population.

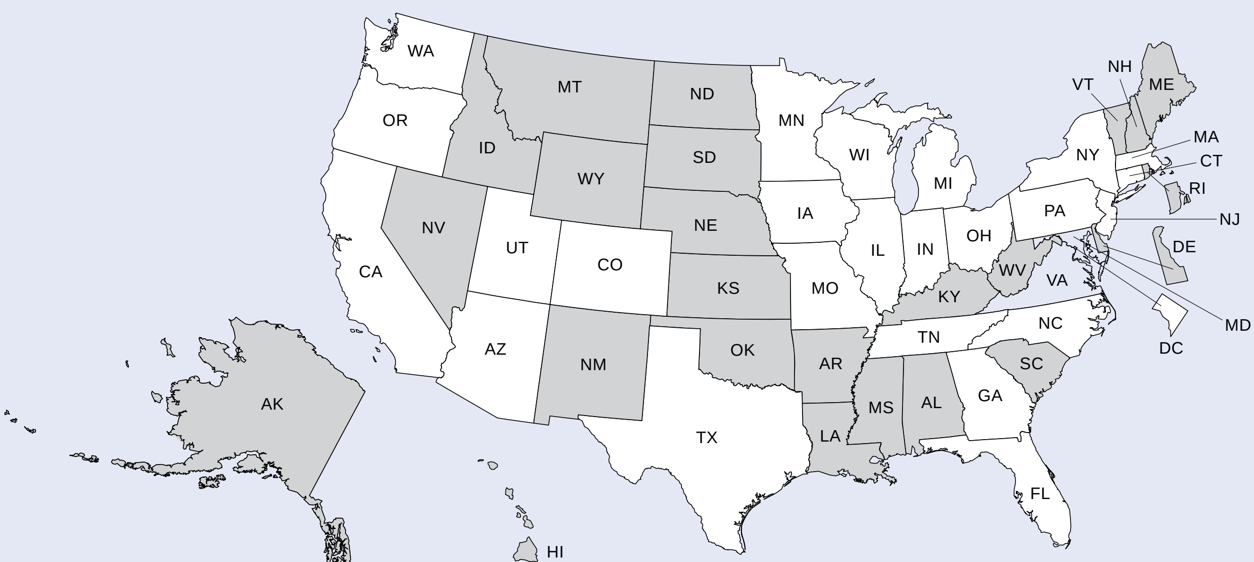
Readers must exercise caution when evaluating the indicator values for the District of Columbia. Frequently, the indicator value for the District of Columbia is appreciably different from the indicator values for any of the states. The District of Columbia is unique because it is an urban region with a large federal presence and many universities. In addition, it has a large student population and provides employment for many individuals who live in neighboring states. Indicator values can be quite different depending on whether data attributed to the District of Columbia are based on where people live or where they work.

Key Elements for Indicators

Six key elements are provided for each indicator. The first element is a map color-coded to show in which quartile each state placed on that indicator for the latest year that data were available. This helps the reader quickly grasp geographic patterns. On the indicator maps, the darkest color indicates states that rank in the first or highest quartile, and white indicates states that rank in the fourth or lowest quartile. Cross-hatching indicates states for which no data are available.

The sample map below shows the outline of each state. The state is identified by its postal code. In 1978, Congress initiated the Experimental Program to Stimulate Competitive Research (EPSCoR) at the National Science Foundation to build R&D capacity in states that have historically been less competitive in receiving federal R&D funding. Subsequently, several federal agencies established similar programs, the largest of which is the Institutional Development Award (IdeA) program at the National Institutes of Health. States shown with a gray background in figure 8-A are states in the EPSCoR group. The EPSCoR group of states are those eligible

Figure 8-A
U.S. map and list of abbreviations



NOTE: Gray states indicate EPSCoR states

AK........ Alaska	HI.........Hawaii	ME........Maine	NJ.........New Jersey	SD........South Dakota
AL........ Alabama	IA.........Iowa	MI.........Michigan	NM.......New Mexico	TN........Tennessee
AR........ Arkansas	ID.........Idaho	MN........Minnesota	NV........Nevada	TX.........Texas
AZ........ Arizona	IL..........Illinois	MO.......Missouri	NY........New York	UT........Utah
CA........ California	IN.........Indiana	MS........Mississippi	OH........Ohio	VA.........Virginia
CO....... Colorado	KS........Kansas	MT........Montana	OK........Oklahoma	VT.........Vermont
CT........ Connecticut	KY........Kentucky	NC........North Carolina	OR........Oregon	WA........Washington
DC....... District of Columbia	LA........Louisiana	ND........North Dakota	PA.........Pennsylvania	WI.........Wisconsin
DE........ Delaware	MA.......Massachusetts	NE.........Nebraska	RI..........Rhode Island	WV........West Virginia
FL........ Florida	MD.......Maryland	NH........New Hampshire	SC........South Carolina	WY.......Wyoming
GA....... Georgia				

for EPSCoR-like programs in at least five federal agencies or departments. The 24 EPSCoR states are Alabama, Alaska, Arkansas, Delaware, Hawaii, Idaho, Kansas, Kentucky, Louisiana, Maine, Mississippi, Montana, Nebraska, Nevada, New Hampshire, New Mexico, North Dakota, Oklahoma, Rhode Island, South Carolina, South Dakota, Vermont, West Virginia, and Wyoming. The EPSCoR Program is discussed further in chapter 5, “Academic Research and Development,” in the sidebar “EPSCoR: The Experimental Program to Stimulate Competitive Research.” The remaining 26 states are considered states in the non-EPSCoR group.

The second element is a state distribution chart illustrating state values for the latest data year for that indicator (figure 8-B). States are listed alphabetically by postal code and are centered over the mid-point of the range for their indicator values. Indicator values are presented along the x-axis of the chart. States stacked together have indicator values in the same range but not necessarily identical values. The reader is referred to the table for values of the indicators. All of the indicators are broad measures, and several rely on sample estimates that have a margin of error. Small differences in state values generally carry little useful information.

The third element, at the bottom of the map box, is a short citation for the data source. The full citation appears under the table on the facing page.

The fourth element, in a shaded box on the lower left side of the page, is a summary of findings that includes the national average and comments on national and state trends and patterns for the particular indicator. Although most of the findings are directly related to the data, some represent interpretations that are meant to stimulate further investigation and discussion.

The fifth element, on the lower right side of the page, is a description of the indicator and includes information pertaining to the underlying data.

The final element is the data table, which appears on the facing page. Up to 3 years of data and the calculated values of the indicator are presented for each state, the District of Columbia, and Puerto Rico.

For selected indicators, the data table has been expanded to include the average data and indicator value for the 50 states and the District of Columbia, and the averages for the EPSCoR and non-EPSCoR states. These averages have been calculated in two ways. The first two lines, “EPSCoR states” and “Non-EPSCoR states,” treat each group as a single geographical unit, ignoring the division of that unit into separate states. The ratio for the group is calculated by totaling the numerator value of each of the states in the group and the denominator value of each of the states in the group and dividing to compute an average. For example, the EPSCoR states average of R&D by gross domestic product by state, shown in table 8-39, is calculated by summing the R&D of all the EPSCoR states, summing the gross domestic product of these states, and dividing to compute an average. States with more R&D and a larger gross domestic product affect this average more than smaller ones do, just as data on California affect U.S. totals more than data on Wyoming do.

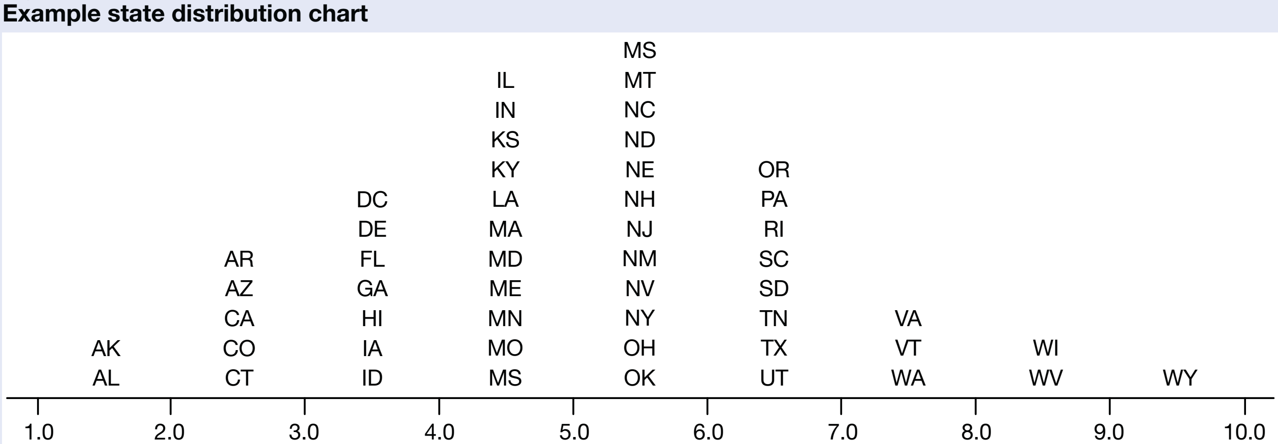
The first and second lines, “Average EPSCoR state value” and “Average non-EPSCoR state value,” represent the average of the individual state ratios for an indicator. The average EPSCoR state value for R&D by gross domestic product by state is calculated by summing the ratios for the 24 EPSCoR states and dividing by 24. All state ratios count equally in this computation. Examples of this calculation are shown in tables 8-5 and 8-18.

High-Technology Industries

To define high-technology industries, this chapter uses a modification of the approach employed by the Bureau of Labor Statistics (BLS) (Hecker 2005). BLS’s approach is based on the intensity of high-technology employment within an industry.

High-technology occupations include scientific, engineering, and technician occupations. These occupations employ

Figure 8-B
Example state distribution chart



workers who possess an in-depth knowledge of the theories and principles of science, engineering, and mathematics, which is generally acquired through postsecondary education in some field of technology. An industry is considered a high-technology industry if employment in technology-oriented occupations accounts for a proportion of that industry's total employment that is at least twice the 4.9% average for all industries (i.e., 9.8% or higher).

In this chapter, the category "high-technology industries" refers only to private sector businesses. In contrast, BLS includes the "Federal Government, excluding Postal Service" in its listing of high-technology industries.

Each industry is defined by a four-digit code that is based on the listings in the 2002 North American Industry Classification System (NAICS). The 2002 NAICS codes contain a number of additions and changes from the previous 1997 NAICS codes that were used to classify business establishments in data sets covering the period 1998–2002, and therefore cannot be applied to data sets from earlier years.

The list of high-technology industries used in this chapter includes the 46 four-digit codes from the 2002 NAICS listing shown in table 8-A.

Appendix Tables

Additional data tables pertaining to the indicators in this chapter have been included in the appendix. These tables provide supplemental information to assist the reader in evaluating the data used in an indicator. The appendix tables contain state-level data on the performance of students in different racial/ethnic and gender groups on the National Assessment of Educational Progress evaluations. Additional data on the coefficient of variation for data sources in the chapter also are presented in the appendix tables when they are available.

Reference

Hecker D. 2005. High-technology employment: A NAICS-based update. *Monthly Labor Review* 128(7):57–72.

Table 8-A
2002 NAICS codes that constitute high-technology industries

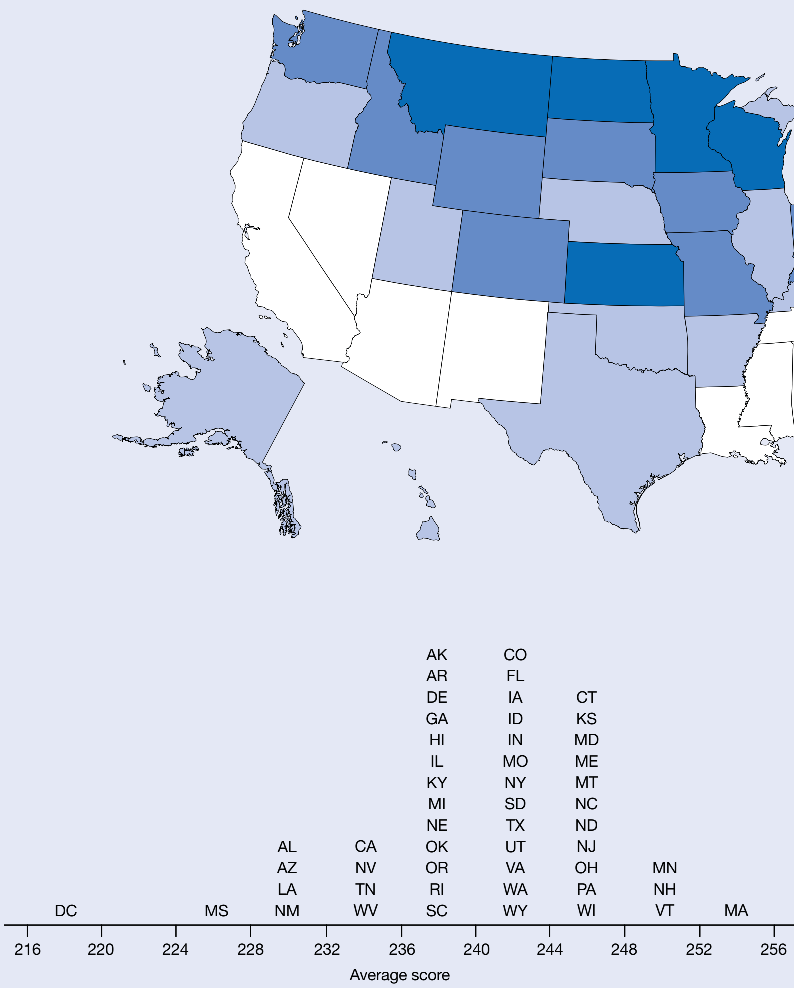
NAICS code	Industry
1131, 1132	Forestry
2111	Oil and gas extraction
2211	Electric power generation, transmission, and distribution
3241	Petroleum and coal products manufacturing
3251	Basic chemical manufacturing
3252	Resin, synthetic rubber, and artificial synthetic fibers and filaments manufacturing
3253	Pesticide, fertilizer, and other agricultural chemical manufacturing
3254	Pharmaceutical and medicine manufacturing
3255	Paint, coating, and adhesive manufacturing
3259	Other chemical product and preparation manufacturing
3332	Industrial machinery manufacturing
3333	Commercial and service industry machinery manufacturing
3336	Engine, turbine, and power transmission equipment manufacturing
3339	Other general purpose machinery manufacturing
3341	Computer and peripheral equipment manufacturing
3342	Communications equipment manufacturing
3343	Audio and video equipment manufacturing
3344	Semiconductor and other electronic component manufacturing
3345	Navigational, measuring, electromedical, and control instruments manufacturing
3346	Manufacturing and reproducing magnetic and optical media
3353	Electrical equipment manufacturing
3364	Aerospace product and parts manufacturing
3369	Other transportation equipment manufacturing
4234	Professional and commercial equipment and supplies, merchant wholesalers
4861	Pipeline transportation of crude oil
4862	Pipeline transportation of natural gas
4869	Other pipeline transportation
5112	Software publishers
5161	Internet publishing and broadcasting
5171	Wired telecommunications carriers
5172	Wireless telecommunications carriers (except satellite)
5173	Telecommunications resellers
5174	Satellite telecommunications
5179	Other telecommunications
5181	Internet service providers and Web search portals
5182	Data processing, hosting, and related services
5211	Monetary authorities, central bank
5232	Securities and commodity exchanges
5413	Architectural, engineering, and related services
5415	Computer systems design and related services
5416	Management, scientific, and technical consulting services
5417	Scientific research and development services
5511	Management of companies and enterprises
5612	Facilities support services
8112	Electronic and precision equipment repair and maintenance

NAICS = North American Industry Classification System

Science and Engineering Indicators 2012

Fourth Grade Mathematics Performance

Figure 8-1
Average fourth grade mathematics performance: 2009



1st quartile (244–252)
2nd quartile (241–243)
3rd quartile (236–240)
4th quartile (219–235)

Achievement levels
(Scores range from 0–500)

Advanced 282–500
Proficient 249–281
Basic................................ 214–248

SOURCE: National Center for Education Statistics, National Assessment of Educational Progress.

Findings

- In 2009, the nationwide average mathematics score of fourth grade public school students was 239, a significant increase from 224 in 2000. This improvement occurred almost entirely during the initial portion of the decade, with no change in the nationwide average math score between 2007 and 2009.
- The states with the highest average fourth grade performance scores are concentrated in the northern United States.
- The gap in mathematics scores between white and black fourth graders decreased from 30 points to 26 points between 2000 and 2009. The gap in mathematics scores between white and Hispanic fourth graders decreased from 26 points to 21 points between 2000 and 2009. There were no significant changes in either of these gaps between 2007 and 2009.
- The average mathematics scores for both male and female fourth grade students increased over the decade, but the size of the gender gap in fourth grade mathematics scores remained unchanged at 2 points.

This indicator represents each state's average score on the National Assessment of Educational Progress (NAEP) in mathematics for its fourth grade students in public schools. The NAEP mathematics assessment is a federally authorized measure of student performance in which all 50 states and the District of Columbia participated in 2009.

Student performance is presented in terms of average scores on a scale from 0 to 500. An average score designated as NA (not available) indicates that the state either did not participate in the assessment or did not meet the minimum guidelines for reporting. NAEP allows students with disabilities or limited English-language proficiency to use certain accommodations (e.g., extended time, individual testing, or small group testing). All data presented here represent scores from tests taken with accommodations offered.

Table 8-1
Average fourth grade mathematics performance, by state: 2000, 2005, and 2009
(Score out of 500)

State	2000	2005	2009
United States	224*	237*	239
Alabama	217*	225*	228
Alaska	NA	236	237
Arizona	219*	230	230
Arkansas	216*	236	238
California	213*	230	232
Colorado	NA	239	243
Connecticut	234*	242	245
Delaware	NA	240*	239
District of Columbia	192*	211*	219
Florida	NA	239*	242
Georgia	219*	234	236
Hawaii	216*	230*	236
Idaho	224*	242	241
Illinois	223*	233*	238
Indiana	233*	240*	243
Iowa	231*	240*	243
Kansas	232*	246	245
Kentucky	219*	231*	239
Louisiana	218*	230	229
Maine	230*	241	244
Maryland	222*	238	244
Massachusetts	233*	247*	252
Michigan	229*	238	236
Minnesota	234*	246	249
Mississippi	211*	227	227
Missouri	228*	235*	241
Montana	228*	241*	244
Nebraska	225*	238	239
Nevada	220*	230	235
New Hampshire	NA	246*	251
New Jersey	NA	244*	247
New Mexico	213*	224*	230
New York	225*	238*	241
North Carolina	230*	241	244
North Dakota	230*	243*	245
Ohio	230*	242	244
Oklahoma	224*	234*	237
Oregon	224*	238	238
Pennsylvania	NA	241*	244
Rhode Island	224*	233	239
South Carolina	220*	238	236
South Dakota	NA	242	242
Tennessee	220*	232	232
Texas	231*	242	240
Utah	227*	239	240
Vermont	232*	244*	248
Virginia	230*	240*	243
Washington	NA	242	242
West Virginia	223*	231*	233
Wisconsin	NA	241*	244
Wyoming	229*	243	242
Puerto Rico	NA	NA	NA

*significantly different ($p < .05$) from the 2009 score for the jurisdiction; NA = not available

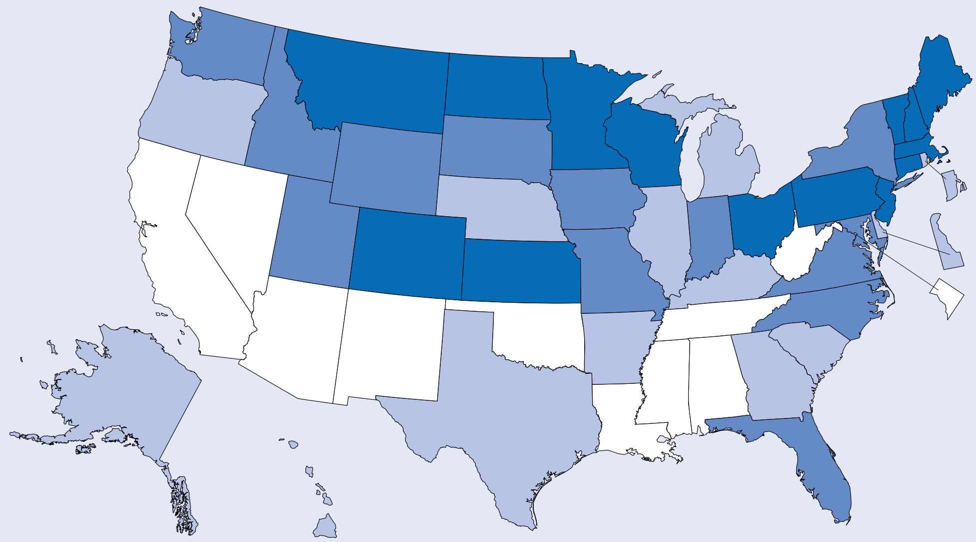
NOTES: National average for United States is reported value in National Assessment of Educational Progress (NAEP) reports. NAEP grade 4 mathematics scores for public schools only.

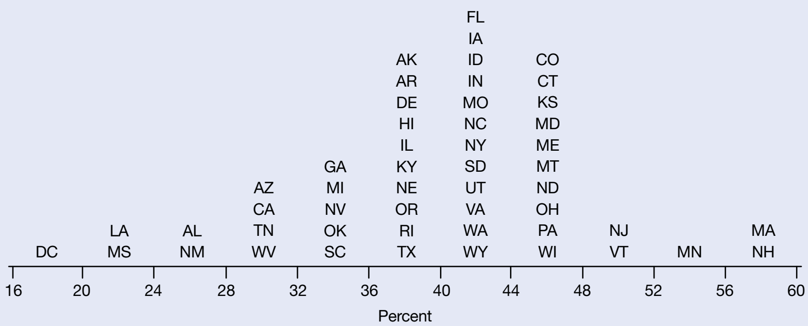
SOURCE: National Center for Education Statistics, NAEP (various years).

Science and Engineering Indicators 2012

Fourth Grade Mathematics Proficiency

Figure 8-2
Students reaching proficiency in fourth grade mathematics: 2009
(Percentage of students scoring 249 or above)





- 1st quartile (45%–57%)
- 2nd quartile (40%–44%)
- 3rd quartile (34%–39%)
- 4th quartile (17%–33%)

Achievement levels
(Scores range from 0–500)

Advanced	282–500
Proficient	249–281
Basic	214–248

SOURCE: National Center for Education Statistics, National Assessment of Educational Progress.

Findings

- In 2009, 38% of fourth grade public school students nationwide performed at or above the proficient level in mathematics, which represents a statistically significant increase from 22% in 2000 and 35% in 2005.
- All 41 jurisdictions that participated in both the 2000 and 2009 assessments showed significant increases in mathematics proficiency levels for public school fourth graders in 2009.
- Substantial differences in mathematics proficiency exist among racial/ethnic groups of fourth graders. The gap between white and black students increased from 26% to 35% between 2000 and 2009. The gap between white and Hispanic students increased from 23% to 29% during this period. All racial/ethnic groups showed gains between 2000 and 2009, but at varying rates.
- The gender gap in mathematics proficiency among fourth graders decreased from 5% to 3% between 2000 and 2009. The range by state in 2009 was 17%–59% for males and 17%–55% for females.

This indicator represents the proportion of a state's fourth grade students in public schools that has met or exceeded the proficiency standard in mathematics. The National Assessment Governing Board sets performance standards that provide a context for interpreting National Assessment of Educational Progress (NAEP) results. The standards define "proficiency," as well as "advanced" and "basic" accomplishment. For the fourth grade, the proficient level (scores 249–281) represents solid academic performance and demonstrates competency over challenging subject-matter knowledge. The advanced level (282–500) signifies superior performance. The basic level (214–248) denotes partial mastery of knowledge and skills that are prerequisite for proficient work.

Approximately 168,800 fourth grade students in 9,510 schools participated in the 2009 NAEP mathematics assessment.

NAEP allows students with disabilities or limited English-language proficiency to use certain accommodations (e.g., extended time, individual testing, or small group testing). All data presented here represent scores from tests taken with accommodations offered.

Table 8-2
Students reaching proficiency in fourth grade mathematics, by state: 2000, 2005, and 2009
(Percent)

State	2000	2005	2009
United States	22*	35*	38
Alabama	13*	21*	24
Alaska	NA	34	38
Arizona	16*	28	28
Arkansas	14*	34	36
California	13*	28	30
Colorado	NA	39	45
Connecticut	31*	43	46
Delaware	NA	36*	36
District of Columbia	5*	10*	17
Florida	NA	37*	40
Georgia	17*	30	34
Hawaii	14*	27*	37
Idaho	20*	41	41
Illinois	20*	32*	38
Indiana	30*	38*	42
Iowa	26*	37*	41
Kansas	29*	47	46
Kentucky	17*	26*	37
Louisiana	14*	24	23
Maine	23*	39	45
Maryland	21*	38	44
Massachusetts	31*	49*	57
Michigan	28*	37	35
Minnesota	33*	47	54
Mississippi	9*	19	22
Missouri	23*	31*	41
Montana	24*	38*	45
Nebraska	24*	36	38
Nevada	16*	26*	32
New Hampshire	NA	47*	56
New Jersey	NA	46*	49
New Mexico	12*	19*	26
New York	21*	36*	40
North Carolina	25*	40	43
North Dakota	25*	40*	45
Ohio	25*	43	45
Oklahoma	16*	29	33
Oregon	23*	37	37
Pennsylvania	NA	41*	46
Rhode Island	22*	31*	39
South Carolina	18*	36	34
South Dakota	NA	40	42
Tennessee	18*	28	28
Texas	25*	40	38
Utah	23*	37	41
Vermont	29*	44*	51
Virginia	24*	40	43
Washington	NA	42	43
West Virginia	17*	25*	28
Wisconsin	NA	40*	45
Wyoming	25*	42	40
Puerto Rico	NA	NA	NA

*significantly different ($p < .05$) from the 2009 score for the jurisdiction; NA = not available

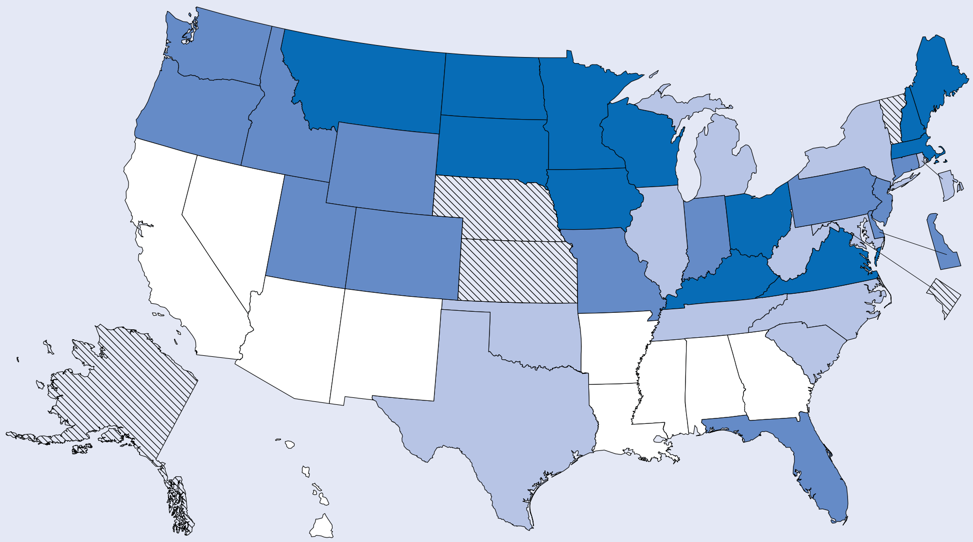
NOTES: National average for United States is reported value in National Assessment of Educational Progress (NAEP) reports. NAEP grade 4 mathematics scores for public schools only.

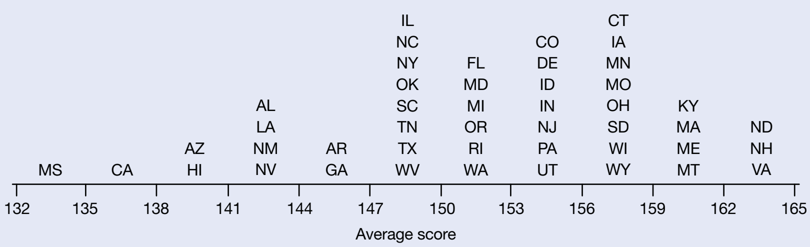
SOURCE: National Center for Education Statistics, NAEP (various years).

Science and Engineering Indicators 2012

Fourth Grade Science Performance

Figure 8-3
Average fourth grade science performance: 2009





Achievement levels
(Scores range from 0–300)

Advanced 224–300
Proficient 167–223
Basic................................ 131–166

SOURCE: National Center for Education Statistics, National Assessment of Educational Progress.

Findings

- In 2009, the nationwide average science score of fourth grade public school students was 149. Average scores for individual states ranged between 133 and 163.
- Of the 47 states and jurisdictions that participated in the fourth grade science assessment, 24 states had scores that were higher than the national average, 13 were not significantly different, and 10 were lower.
- Nationally, the gap in science scores between white and black public school fourth grade students was 35 points, and the gap between white and Hispanic public fourth grade students was 32 points.
- Male fourth grade public school students scored 1 point higher in science than female fourth grade public school students although females scored higher in life science than did males.

This indicator represents each state's average score on the National Assessment of Educational Progress (NAEP) in science for its fourth grade students in public schools. The national science assessment was updated in 2009 to keep pace with key developments in science. It contains questions covering the content areas of physical, life, and earth and space science. The 2009 assessment is based on a new framework, and these results, therefore, cannot be compared to those from previous science assessments. They provide a current snapshot of what fourth graders can do in science and will provide a basis for comparisons for the future.

Student performance is presented in terms of average scores on a scale from 0 to 300 with a mean of 150 and a standard deviation of 35. An average score designated as NA (not available) indicates that the state either did not participate in the assessment or did not meet the minimum guidelines for reporting.

NAEP allows students with disabilities or limited English-language proficiency to use certain accommodations (e.g., extended time, individual testing, or small group testing). All data presented here represent scores from tests taken with accommodations offered.

Table 8-3
Average fourth grade science performance, by state: 2009
(Score out of 300)

State	2009
United States	149
Alabama	143
Alaska	NA
Arizona	138
Arkansas	146
California	136
Colorado	155
Connecticut	156
Delaware	153
District of Columbia	NA
Florida	151
Georgia	144
Hawaii	140
Idaho	154
Illinois	148
Indiana	153
Iowa	157
Kansas	NA
Kentucky	161
Louisiana	141
Maine	160
Maryland	150
Massachusetts	160
Michigan	150
Minnesota	158
Mississippi	133
Missouri	156
Montana	160
Nebraska	NA
Nevada	141
New Hampshire	163
New Jersey	155
New Mexico	142
New York	148
North Carolina	148
North Dakota	162
Ohio	157
Oklahoma	148
Oregon	151
Pennsylvania	154
Rhode Island	150
South Carolina	149
South Dakota	157
Tennessee	148
Texas	148
Utah	154
Vermont	NA
Virginia	162
Washington	151
West Virginia	148
Wisconsin	157
Wyoming	156
Puerto Rico	NA

NA = not available

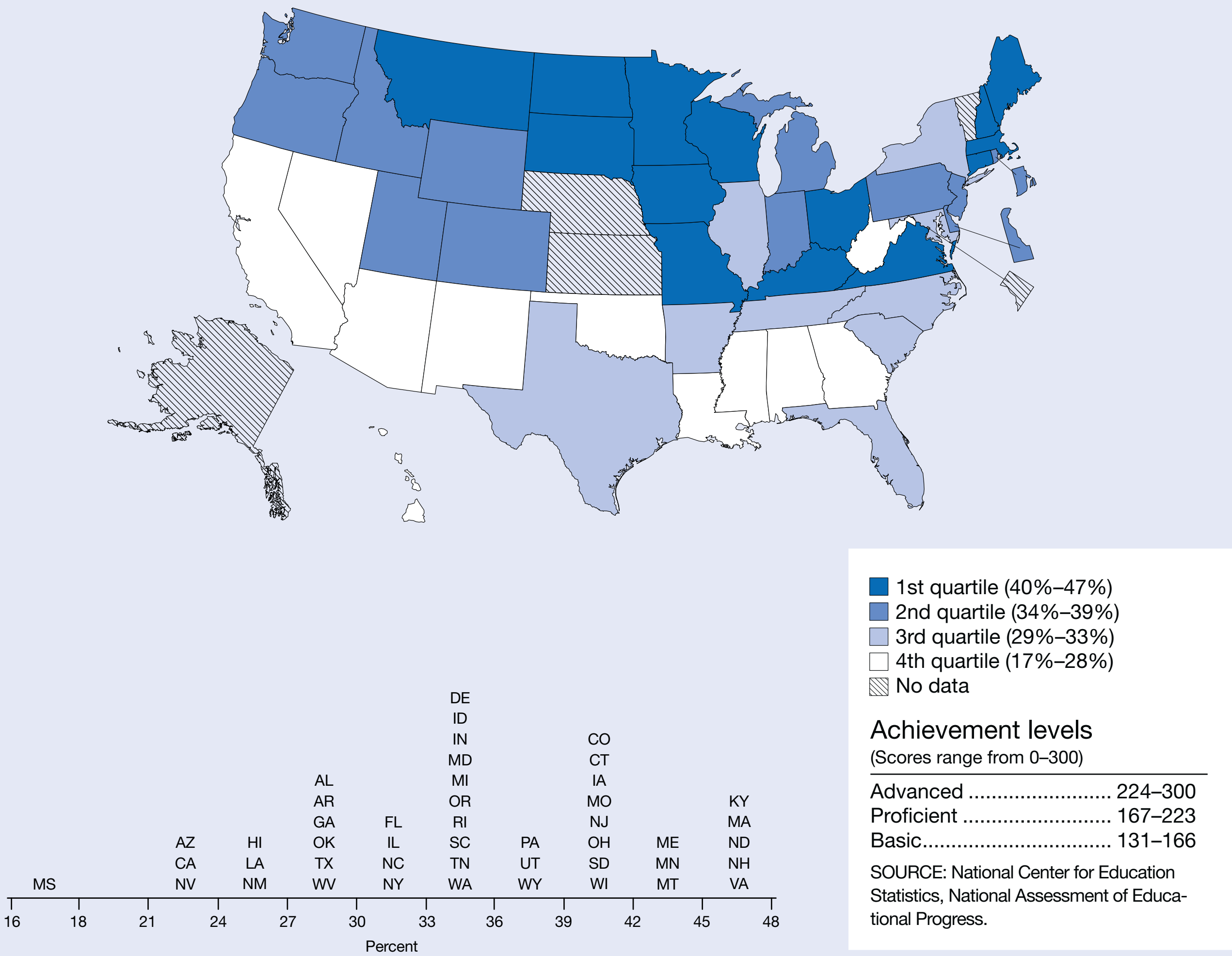
NOTES: National average for United States is reported value in National Assessment of Educational Progress (NAEP) reports. NAEP grade 4 science scores for public schools only.

SOURCE: National Center for Education Statistics, NAEP (various years).

Science and Engineering Indicators 2012

Fourth Grade Science Proficiency

Figure 8-4
Students reaching proficiency in fourth grade science: 2009
(Percentage of students scoring 167 or above)



Achievement levels
(Scores range from 0–300)

Advanced 224–300
Proficient 167–223
Basic................................. 131–166

SOURCE: National Center for Education Statistics, National Assessment of Educational Progress.

Findings

- In 2009, 32% of fourth grade public school students nationwide performed at or above the proficient level in science. Among the states, there were significant differences in the percentage of fourth grade public school students who demonstrated proficiency in science. State values for this indicator ranged from 17% to 47%.
- Nationally, the percentage of fourth grade white students demonstrating proficient performance in science was 46% compared to 13% for Hispanic students and 10% for black students.
- A gender difference was reported with 34% of male fourth grade public school students scoring at or above the proficient level in science compared to 31% of their female counterparts. The range by state was 18%–49% for males and 16%–49% for females.

This indicator represents the proportion of a state's fourth grade students in public schools that has met or exceeded the proficiency standard in science. The National Assessment Governing Board sets performance standards that provide a context for interpreting National Assessment of Educational Progress (NAEP) results. The standards define "proficiency," as well as "advanced" and "basic" accomplishment. For the fourth grade, the proficient level (scores 167–223) represents solid academic performance and demonstrates competency over challenging subject-matter knowledge. The advanced level (224–300) signifies superior performance. The basic level (131–166) denotes partial mastery of knowledge and skills that are prerequisite for proficient work.

The National Center for Education Statistics has advised that science achievement levels are to be used on a trial basis and should be interpreted with caution. Approximately 156,500 fourth grade students in 9,330 schools participated in the 2009 NAEP science assessment. A designation of NA (not available) indicates that the state either did not participate in the assessment or did not meet minimum guidelines for reporting. NAEP allows students with disabilities or limited English-language proficiency to use certain accommodations (e.g., extended time, individual testing, or small group testing). All data presented here represent scores from tests taken with accommodations offered.

Table 8-4
Students reaching proficiency in fourth grade science, by state: 2009
(Percent)

State	2009
United States	32
Alabama	27
Alaska	NA
Arizona	22
Arkansas	29
California	22
Colorado	39
Connecticut	40
Delaware	34
District of Columbia	NA
Florida	32
Georgia	27
Hawaii	25
Idaho	35
Illinois	32
Indiana	35
Iowa	41
Kansas	NA
Kentucky	45
Louisiana	25
Maine	42
Maryland	33
Massachusetts	45
Michigan	34
Minnesota	43
Mississippi	17
Missouri	40
Montana	43
Nebraska	NA
Nevada	23
New Hampshire	47
New Jersey	39
New Mexico	24
New York	30
North Carolina	30
North Dakota	45
Ohio	41
Oklahoma	28
Oregon	34
Pennsylvania	38
Rhode Island	34
South Carolina	33
South Dakota	40
Tennessee	33
Texas	29
Utah	38
Vermont	NA
Virginia	46
Washington	35
West Virginia	28
Wisconsin	41
Wyoming	37
Puerto Rico	NA

NA = not available

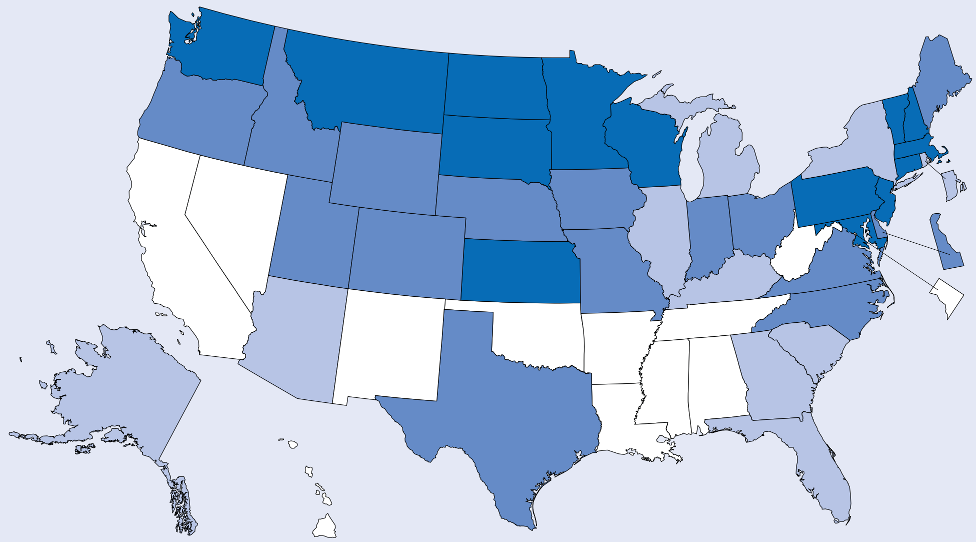
NOTES: National average for United States is reported value in National Assessment of Educational Progress (NAEP) reports. NAEP grade 4 science scores for public schools only.

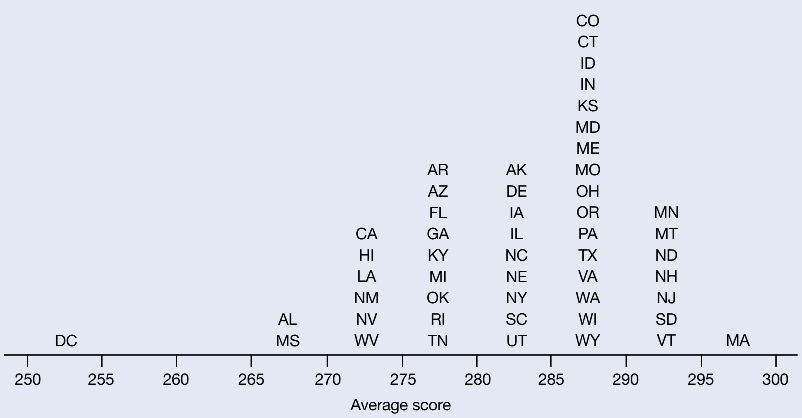
SOURCE: National Center for Education Statistics, NAEP (various years).

Science and Engineering Indicators 2012

Eighth Grade Mathematics Performance

Figure 8-5
Average eighth grade mathematics performance: 2009





- 1st quartile (288–299)
- 2nd quartile (284–287)
- 3rd quartile (277–283)
- 4th quartile (254–276)

Achievement levels
(Scores range from 0–500)

Advanced	333–500
Proficient	299–332
Basic	262–298

SOURCE: National Center for Education Statistics, National Assessment of Educational Progress.

Findings

- In 2009, the nationwide average mathematics score of eighth grade public school students was 282, a statistically significant increase from 272 in 2000. Eighth graders scored higher in mathematics in 2009 than in any previous assessment year.
- Of the 40 jurisdictions that participated in both the 2000 and 2009 mathematics assessments, 35 showed statistically significant increases over the decade.
- Since 2007, eighth grade mathematics scores increased for public school students in 15 states; nearly half of those states showing an increase were located in the West. No states showed a decline.
- The gaps in mathematics scores between white eighth graders and black or Hispanic eighth graders narrowed between 2000 and 2009 although significant gaps still exist.
- The average mathematics scores for both male and female eighth grade students increased over the decade, but the size of the gender gap remained unchanged at 2 points.

This indicator represents each state's average score on the National Assessment of Educational Progress (NAEP) in mathematics for its eighth grade students in public schools. The NAEP mathematics assessment is a federally authorized measure of student performance in which all 50 states and the District of Columbia participated in 2009.

Student performance is presented in terms of average scores on a scale from 0 to 500. An average score designated as NA (not applicable) indicates that the state either did not participate in the assessment or did not meet the minimum guidelines for reporting. NAEP allows students with disabilities or limited English-language proficiency to use certain accommodations (e.g., extended time, individual testing, or small group testing). All data presented here represent scores from tests taken with accommodations offered.

Table 8-5
Average eighth grade mathematics performance, by state: 2000, 2005, and 2009
(Score out of 500)

State	2000	2005	2009
Average EPSCoR state value	270	275	280
Average non-EPSCoR state value	274	280	284
United States	272 *	278*	282
Alabama	264	262	269
Alaska	NA	279*	283
Arizona	269 *	274	277
Arkansas	257 *	272	276
California	260 *	269	270
Colorado	NA	281*	287
Connecticut	281	281	289
Delaware	NA	281*	284
District of Columbia	235 *	245*	254
Florida	NA	274	279
Georgia	265 *	272	278
Hawaii	262 *	266*	274
Idaho	277 *	281*	287
Illinois	275 *	278	282
Indiana	281 *	282*	287
Iowa	NA	284	284
Kansas	283 *	284*	289
Kentucky	270 *	274*	279
Louisiana	259 *	268*	272
Maine	281 *	281*	286
Maryland	272 *	278*	288
Massachusetts	279 *	292*	299
Michigan	277	277	278
Minnesota	287 *	290	294
Mississippi	254 *	262	265
Missouri	271 *	276*	286
Montana	285	286	292
Nebraska	280 *	284	284
Nevada	265 *	270	274
New Hampshire	NA	285*	292
New Jersey	NA	284*	293
New Mexico	259 *	263*	270
New York	271 *	280	283
North Carolina	276 *	282	284
North Dakota	282 *	287*	293
Ohio	281 *	283	286
Oklahoma	270 *	271*	276
Oregon	280	282	285
Pennsylvania	NA	281*	288
Rhode Island	269 *	272*	278
South Carolina	265 *	281	280
South Dakota	NA	287	291
Tennessee	262 *	271*	275
Texas	273 *	281*	287
Utah	274 *	279	284
Vermont	281 *	287*	293
Virginia	275 *	284*	286
Washington	NA	285	289
West Virginia	266 *	269	270
Wisconsin	NA	285	288
Wyoming	276 *	282*	286
Puerto Rico	NA	NA	NA

*significantly different ($p < .05$) from the 2009 score for the jurisdiction; NA = not available

EPSCoR = Experimental Program to Stimulate Competitive Research

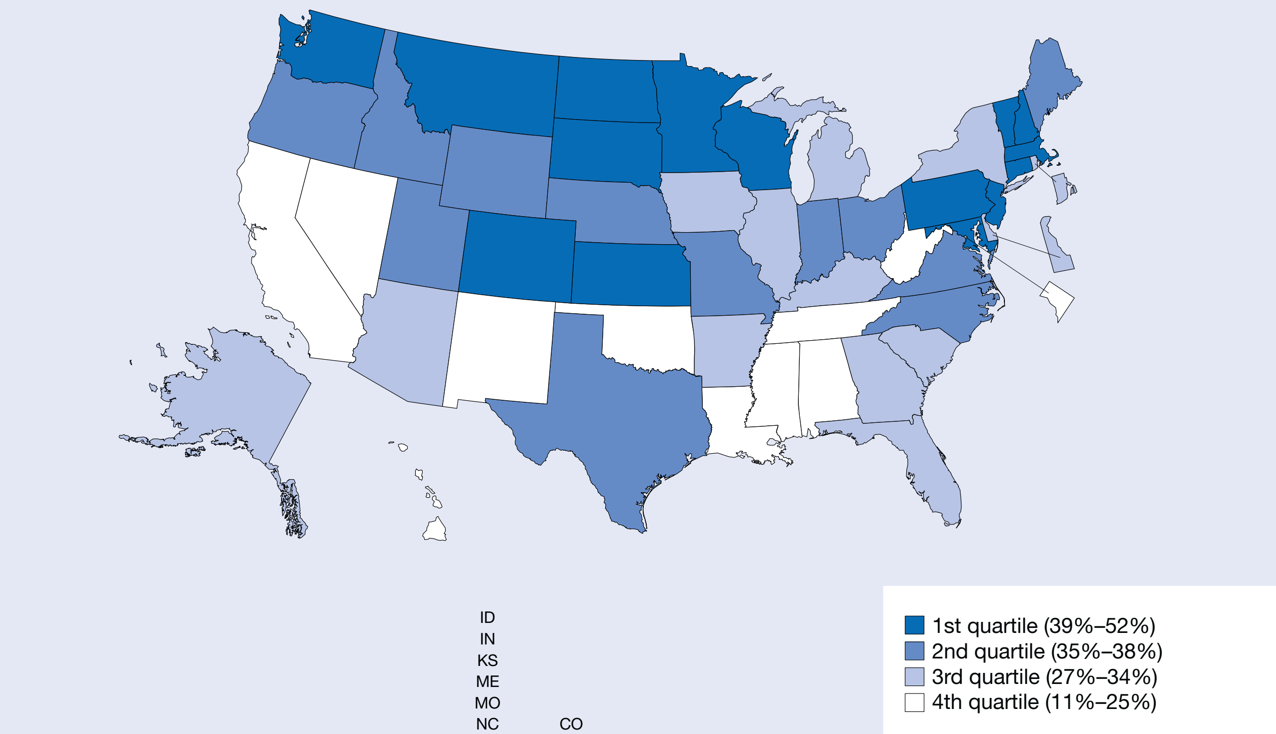
NOTES: National average for United States is reported value in National Assessment of Educational Progress (NAEP) reports. NAEP grade 8 mathematics scores for public schools only. For explanation of EPSCoR and non-EPSCoR averages, see chapter introduction.

SOURCE: National Center for Education Statistics, NAEP (various years).

Science and Engineering Indicators 2012

Eighth Grade Mathematics Proficiency

Figure 8-6
Students reaching proficiency in eighth grade mathematics: 2009
(Percentage of students scoring 299 or above)



Achievement levels

(Scores range from 0–500)

Advanced	333–500
Proficient	299–332
Basic	262–298

SOURCE: National Center for Education Statistics, National Assessment of Educational Progress.

Findings

- In 2009, 33% of eighth grade public school students nationwide performed at or above the proficient level in mathematics, which represents a significant increase from 25% in 2000 and 28% in 2005. Of the 39 states that participated in both the 2000 and 2009 assessments, 30 showed statistically significant increases in mathematics proficiency among public school eighth graders over the decade. Only eight showed a significant increase from 2007 to 2009.
- Substantial differences in mathematics proficiency exist among racial/ethnic groups of eighth graders even though the gap in performance scores narrowed. The gap between white and black students who are proficient in mathematics increased from 28% to 31% between 2000 and 2009. The gap between white and Hispanic students remained around 25% during this period. All racial/ethnic groups showed gains between 2000 and 2009, but at varying rates.
- The gender gap in mathematics proficiency among eighth graders remained at 3% between 2000 and 2009 although the percentage of proficient students increased for both sexes during this period. The range by state for 2009 was 12%–53% for males and 11%–50% for females.

This indicator represents the proportion of a state's eighth grade students in public schools that has met or exceeded the proficiency standard in mathematics. The National Assessment Governing Board sets performance standards that provide a context for interpreting National Assessment of Educational Progress (NAEP) results. The standards define "proficiency," as well as "advanced" and "basic" accomplishment. For the eighth grade, the proficient level (scores 299–332) represents solid academic performance and demonstrates competency over challenging subject-matter knowledge. The advanced level (333–500) signifies superior performance. The basic level (262–298) denotes partial mastery of knowledge and skills that are prerequisite for proficient work.

Approximately 161,700 eighth grade students in 7,030 schools participated in the 2009 NAEP mathematics assessment. NAEP allows students with disabilities or limited English-language proficiency to use certain accommodations (e.g., extended time, individual testing, or small group testing). All data presented here represent scores from tests taken with accommodations offered.

Table 8-6
Students reaching proficiency in eighth grade mathematics, by state: 2000, 2005, and 2009
(Percent)

State	2000	2005	2009
United States	25*	28*	33
Alabama	16	15	20
Alaska	NA	29	33
Arizona	20*	26	29
Arkansas	13*	22	27
California	17*	22*	23
Colorado	NA	32*	40
Connecticut	33	35	40
Delaware	NA	30	32
District of Columbia	6	7	11
Florida	NA	26	29
Georgia	19*	23	27
Hawaii	16*	18*	25
Idaho	26*	30*	38
Illinois	26*	29	33
Indiana	29*	30*	36
Iowa	NA	34	34
Kansas	34*	34*	39
Kentucky	20*	23*	27
Louisiana	11*	16	20
Maine	30	30*	35
Maryland	27*	30*	40
Massachusetts	30*	43*	52
Michigan	28	29	31
Minnesota	39	43	47
Mississippi	9*	14	15
Missouri	21*	26*	35
Montana	36	36	44
Nebraska	30*	35	35
Nevada	18*	21	25
New Hampshire	NA	35	43
New Jersey	NA	36*	44
New Mexico	12*	14*	20
New York	24*	31	34
North Carolina	27*	32	36
North Dakota	30*	35*	43
Ohio	30*	34	36
Oklahoma	18	20	24
Oregon	31	33	37
Pennsylvania	NA	31*	40
Rhode Island	22*	24*	28
South Carolina	17*	30	30
South Dakota	NA	36	42
Tennessee	16*	21	25
Texas	24*	31*	36
Utah	25*	30	35
Vermont	31*	38*	43
Virginia	25*	33	36
Washington	NA	36	39
West Virginia	17	17	19
Wisconsin	NA	36	39
Wyoming	23*	29*	35
Puerto Rico	NA	NA	NA

*significantly different ($p < .05$) from the 2009 score for the jurisdiction; NA = not available

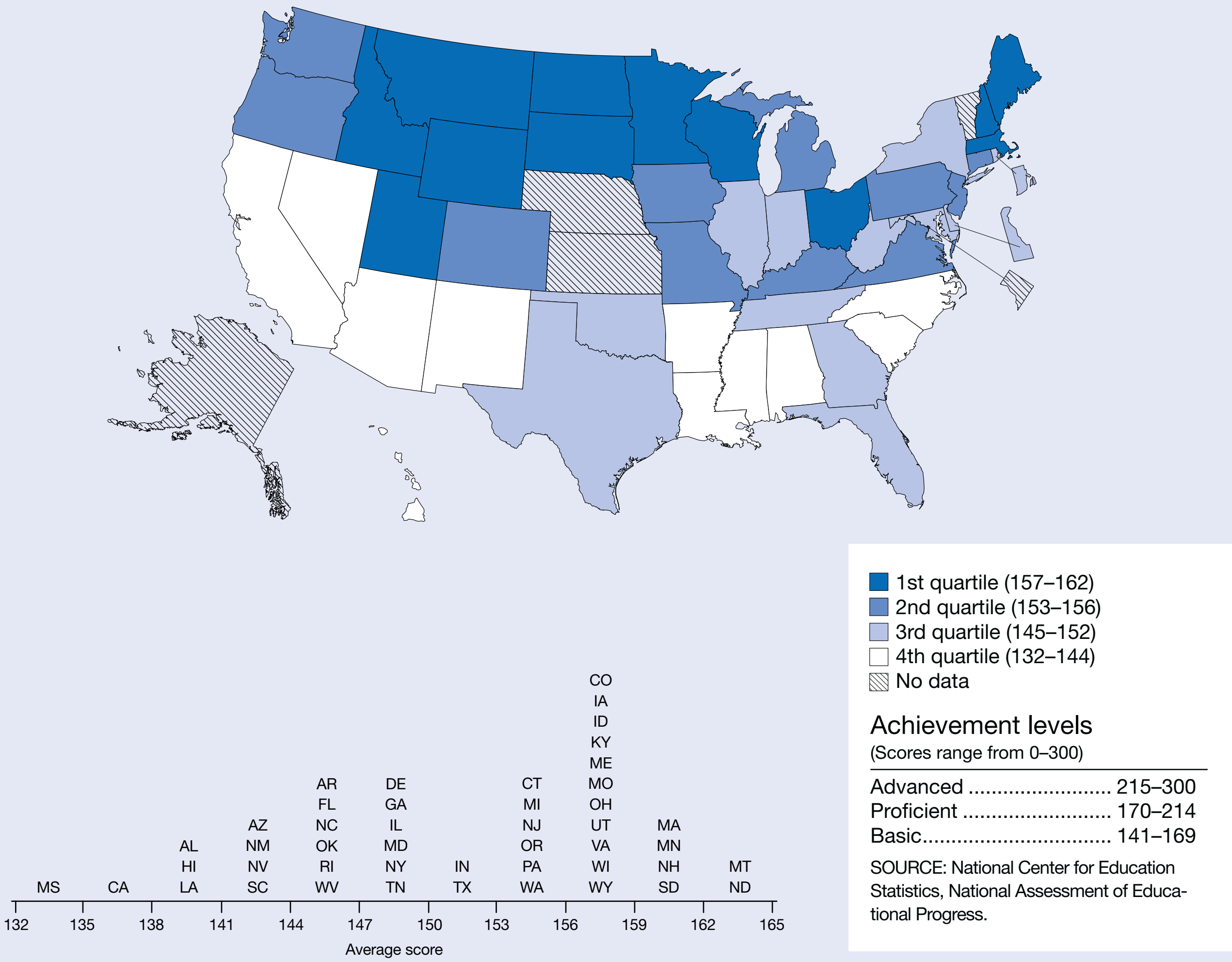
NOTES: National average for United States is reported value in National Assessment of Educational Progress (NAEP) reports. NAEP grade 8 mathematics scores for public schools only.

SOURCE: National Center for Education Statistics, NAEP (various years).

Science and Engineering Indicators 2012

Eighth Grade Science Performance

Figure 8-7
Average eighth grade science performance: 2009



Achievement levels
(Scores range from 0–300)

Advanced	215–300
Proficient	170–214
Basic	141–169

SOURCE: National Center for Education Statistics, National Assessment of Educational Progress.

Findings

- In 2009, the nationwide average science score of eighth grade public school students was 149. Average scores for individual states ranged from a high of 162 to low of 132.
- Of the 47 states and jurisdictions that participated, 25 had scores that were higher than the national average and 15 had scores that were lower.
- Nationally, the science score gap between white and black public school eighth grade students was 36 points, and the gap between white and Hispanic public eighth grade students was 30 points.
- Male eighth grade public school students nationally scored 4 points higher in science than female eighth grade public school students.

This indicator represents each state's average score on the National Assessment of Educational Progress (NAEP) in science for its eighth grade students in public schools. The national science assessment was updated in 2009 to keep pace with key developments in science. It contains questions covering the content areas of physical, life, and earth and space science. The 2009 assessment is based on a new framework, therefore, these results cannot be compared to those from previous science assessments. They provide a current snapshot of what eighth graders can do in science and will provide a basis for comparisons for the future.

Student performance is presented in terms of average scores on a scale from 0 to 300 with a mean of 150 and a standard deviation of 35. An average score designated as NA (not applicable) indicates that the state either did not participate in the assessment or did not meet the minimum guidelines for reporting.

NAEP allows students with disabilities or limited English-language proficiency to use certain accommodations (e.g., extended time, individual testing, or small group testing). All data presented here represent scores from tests taken with accommodations offered.

Table 8-7
Average eighth grade science performance, by state: 2009
(Score out of 300)

State	2009
United States	149
Alabama	139
Alaska	NA
Arizona	141
Arkansas	144
California	137
Colorado	156
Connecticut	155
Delaware	148
District of Columbia	NA
Florida	146
Georgia	147
Hawaii	139
Idaho	158
Illinois	148
Indiana	152
Iowa	156
Kansas	NA
Kentucky	156
Louisiana	139
Maine	158
Maryland	148
Massachusetts	160
Michigan	153
Minnesota	159
Mississippi	132
Missouri	156
Montana	162
Nebraska	NA
Nevada	141
New Hampshire	160
New Jersey	155
New Mexico	143
New York	149
North Carolina	144
North Dakota	162
Ohio	158
Oklahoma	146
Oregon	154
Pennsylvania	154
Rhode Island	146
South Carolina	143
South Dakota	161
Tennessee	148
Texas	150
Utah	158
Vermont	NA
Virginia	156
Washington	155
West Virginia	145
Wisconsin	157
Wyoming	158
Puerto Rico	NA

NA = not available

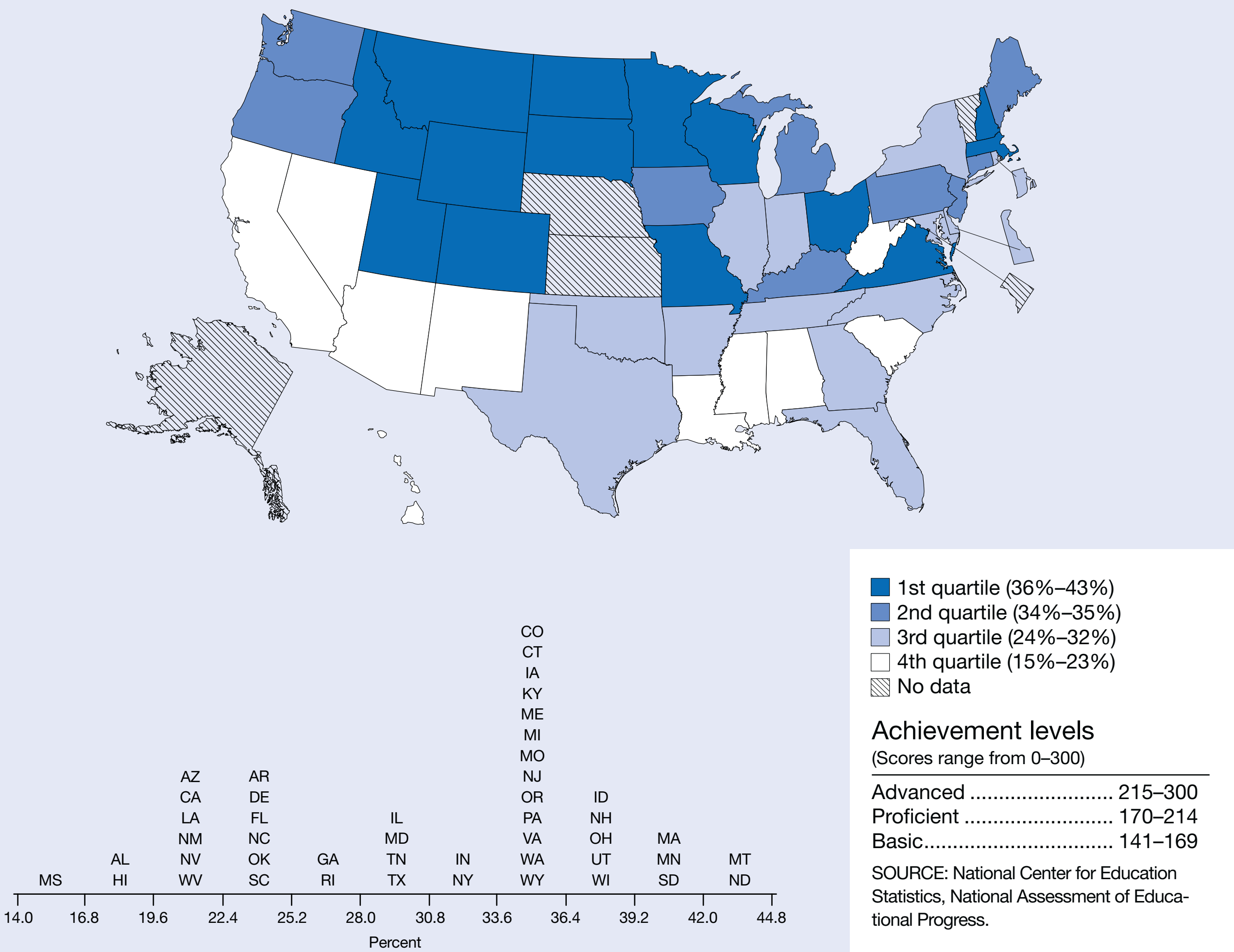
NOTES: National average for United States is reported value in National Assessment of Educational Progress (NAEP) reports. NAEP grade 8 science scores for public schools only.

SOURCE: National Center for Education Statistics, NAEP (various years).

Science and Engineering Indicators 2012

Eighth Grade Science Proficiency

Figure 8-8
Students reaching proficiency in eighth grade science: 2009
(Percentage of students scoring 170 or above)



SOURCE: National Center for Education Statistics, National Assessment of Educational Progress.

Findings

- In 2009, 29% of eighth grade public school students nationwide performed at or above the proficient level in science. Among the states, there were significant differences in the percentage of eighth grade public school students who demonstrated proficiency in science. State values for this indicator ranged from 15% to 43%.
- Nationally, the percentage of eighth grade white students demonstrating proficient performance in science was 41% compared to 12% for Hispanic students and 8% for black students.
- A gender difference was reported with 32% of male eighth grade public school students scoring at or above the proficient level in science compared to 26% of female eighth grade public school students. The range by state was 17%–47% for males and 13%–38% for females.

This indicator represents the proportion of a state's eighth grade students in public schools that has met or exceeded the proficiency standard in science.

The National Assessment Governing Board sets performance standards that provide a context for interpreting National Assessment of Educational Progress (NAEP) results. The standards define "proficiency," as well as "advanced" and "basic" accomplishment. For the eighth grade, the proficient level (scores 170–214) represents solid academic performance and demonstrates competency over challenging subject-matter knowledge. The advanced level (215–300) signifies superior performance. The basic level (141–169) denotes partial mastery of knowledge and skills that are prerequisite for proficient work. The National Center for Education Statistics has determined that achievement levels are to be used on a trial basis and should be interpreted with caution.

Approximately 151,100 eighth grade students in 6,920 schools participated in the 2009 NAEP science assessment. A designation of NA (not available) indicates that the state either did not participate in the assessment or did not meet minimum guidelines for reporting.

NAEP allows students with disabilities or limited English-language proficiency to use certain accommodations (e.g., extended time, individual testing, or small group testing). All data presented here represent scores from tests taken with accommodations offered.

Table 8-8
Students reaching proficiency in eighth grade science, by state: 2009
(Percent)

State	2009
United States	29
Alabama	19
Alaska	NA
Arizona	22
Arkansas	24
California	20
Colorado	36
Connecticut	35
Delaware	25
District of Columbia	NA
Florida	25
Georgia	27
Hawaii	17
Idaho	37
Illinois	28
Indiana	32
Iowa	35
Kansas	NA
Kentucky	34
Louisiana	20
Maine	35
Maryland	28
Massachusetts	41
Michigan	35
Minnesota	40
Mississippi	15
Missouri	36
Montana	43
Nebraska	NA
Nevada	20
New Hampshire	39
New Jersey	34
New Mexico	21
New York	31
North Carolina	24
North Dakota	42
Ohio	37
Oklahoma	25
Oregon	35
Pennsylvania	35
Rhode Island	26
South Carolina	23
South Dakota	40
Tennessee	28
Texas	29
Utah	39
Vermont	NA
Virginia	36
Washington	34
West Virginia	22
Wisconsin	38
Wyoming	36
Puerto Rico	NA

NA = not available

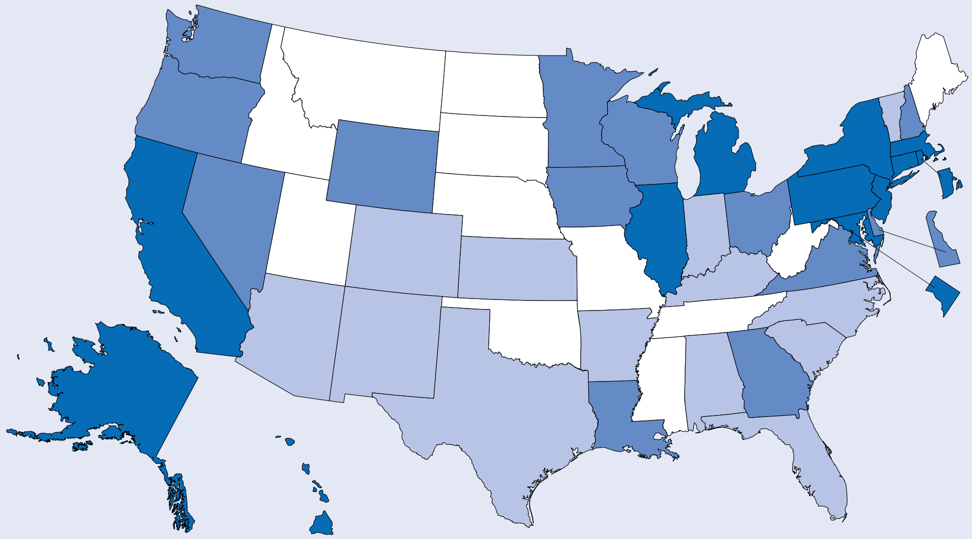
NOTES: National average for United States is reported value in National Assessment of Educational Progress (NAEP) reports. NAEP grade 8 science scores for public schools only.

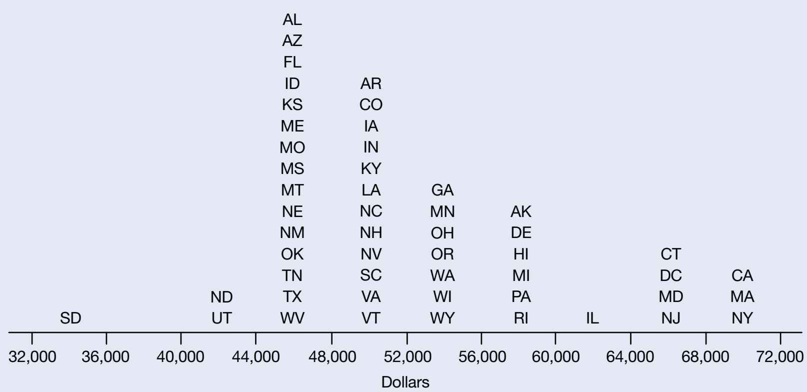
SOURCE: National Center for Education Statistics, NAEP (various years).

Science and Engineering Indicators 2012

Public School Teacher Salaries

Figure 8-9
Public school teacher salaries: 2010





SOURCE: National Center for Education Statistics, Digest of Education Statistics.

Findings

- In 2010, salaries for public school teachers nationwide averaged $52,418, ranging from a state low of $35,136 to a high of $71,470.
- Twenty states and the District of Columbia had average public school teacher salaries higher than the national average in 2010 compared to 22 states plus DC in 2000.
- Between 2000 and 2010, average teacher salaries across the nation rose by 33% in terms of current dollars. Average teacher salaries increased by 5% when expressed in constant dollars.
- States with high salaries for public school teachers do not necessarily have high student achievement scores on the NAEP mathematics and science tests.

This indicator represents the average salary of all full-time public school teachers. The year is the end date of the academic year. For example, 2010 data represent salaries for the 2009–2010 academic year. The figures (given in current dollars) include salaries for teachers with varying amounts of teaching experience and various types and levels of formal education.

Salary estimates for public elementary and secondary teachers are provided by National Education Association, *Estimates of School Statistics, 1969–70 through 2009–10.*

Public school teacher salaries may reflect a range of factors, including the value that the state places on primary and secondary education, the state's cost of living, the teachers' experience and education level, and the local supply and demand in the job market. Relatively low teacher salaries may hinder recruitment into the teaching profession.

Table 8-9
Public school teacher salaries, by state: 2000, 2005, and 2010
(Dollars)

State	2000	2005	2010
United States	39,354	45,089	52,418
Alabama	36,689	38,186	47,156
Alaska	46,462	52,424	59,729
Arizona	36,902	42,905	46,952
Arkansas	33,386	40,495	49,051
California	47,680	57,876	70,458
Colorado	38,163	43,949	49,505
Connecticut	51,780	57,737	64,350
Delaware	44,435	50,595	57,080
District of Columbia	47,076	58,456	64,548
Florida	36,722	41,590	46,912
Georgia	41,023	46,526	54,274
Hawaii	40,578	46,149	58,168
Idaho	35,547	42,122	46,283
Illinois	46,486	55,421	62,077
Indiana	41,850	46,583	49,986
Iowa	35,678	39,284	50,547
Kansas	34,981	39,345	46,957
Kentucky	36,380	40,522	48,354
Louisiana	33,109	39,022	50,349
Maine	35,561	39,610	46,106
Maryland	44,048	52,331	65,333
Massachusetts	46,580	54,679	68,000
Michigan	49,044	56,973	57,958
Minnesota	39,802	46,906	53,069
Mississippi	31,857	36,590	45,644
Missouri	35,656	39,067	45,317
Montana	32,121	38,485	45,759
Nebraska	33,237	39,456	46,080
Nevada	39,390	43,394	51,524
New Hampshire	37,734	43,941	51,365
New Jersey	52,015	56,682	64,809
New Mexico	32,554	39,391	46,401
New York	51,020	56,200	71,470
North Carolina	39,404	43,348	48,648
North Dakota	29,863	36,695	42,964
Ohio	41,436	48,692	55,931
Oklahoma	31,298	37,879	44,143
Oregon	42,336	48,330	55,224
Pennsylvania	48,321	53,258	58,124
Rhode Island	47,041	53,473	59,636
South Carolina	36,081	42,189	48,417
South Dakota	29,071	34,040	35,136
Tennessee	36,328	42,076	46,290
Texas	37,567	41,011	47,157
Utah	34,946	39,456	43,068
Vermont	37,758	44,535	49,053
Virginia	38,744	42,768	49,999
Washington	41,043	45,718	53,653
West Virginia	35,009	38,360	45,959
Wisconsin	41,153	44,299	52,644
Wyoming	34,127	40,497	55,694
Puerto Rico	NA	NA	NA

NA = not available

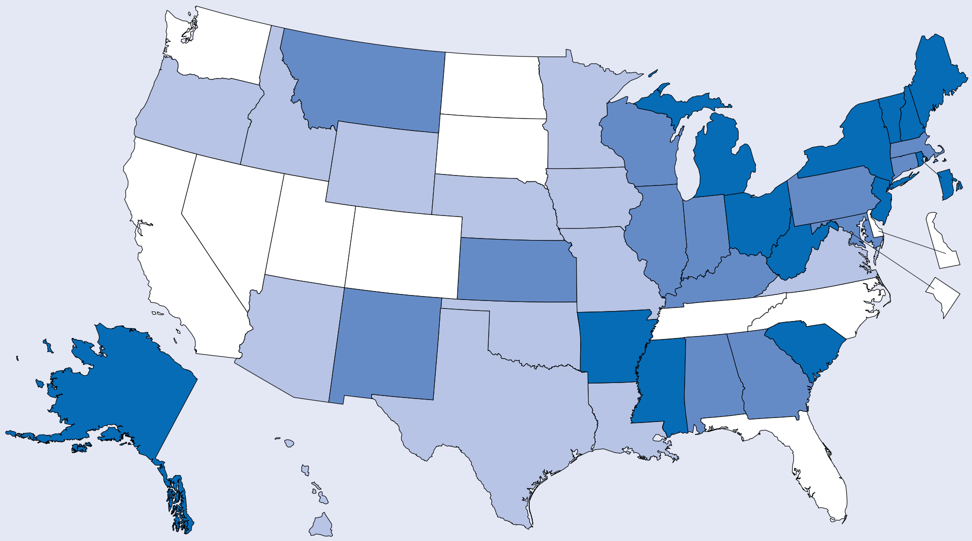
NOTES: National average for United States is reported value from *Digest of Education Statistics*. Average salaries reported in current dollars.

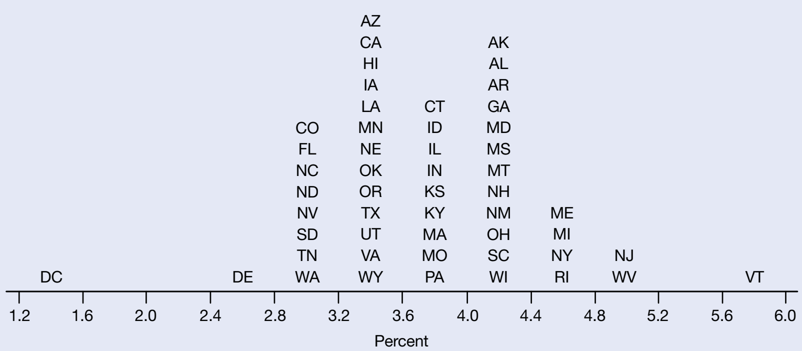
SOURCE: National Center for Education Statistics, *Digest of Education Statistics* (various years).

Science and Engineering Indicators 2012

Elementary and Secondary Public School Current Expenditures as a Percentage of Gross Domestic Product

Figure 8-10
Elementary and secondary public school current expenditures as a percentage of gross domestic product: 2009





1st quartile (4.17%–5.74%)
2nd quartile (3.72%–4.14%)
3rd quartile (3.30%–3.71%)
4th quartile (1.37%–3.27%)

SOURCES: National Center for Education Statistics (NCES), NCES Common Core of Data, National Public Education Financial Survey; Bureau of Economic Analysis, Gross Domestic Product data.

Findings

- The 2009 national average for spending on elementary and secondary education was 3.70% of the gross domestic product (GDP), an increase from 3.32% in 2000. Among individual states, the value for this indicator ranged from 2.50% to 5.74% of the state's GDP in 2009, indicating that some states were directing a much higher percentage of their resources toward elementary and secondary education.
- Spending for elementary and secondary public education as a percentage of the state's GDP decreased in 9 states during the 2000-2009 period.
- Several states spending the highest percentage of their GDP on elementary and secondary education tended to have relatively small student populations (100,000-300,000 students), indicating that some level of state spending may be required regardless of the size of the student population or the GDP.

This indicator represents the relative amount of resources that state governments expend to support public education in prekindergarten through grade 12. It is calculated by dividing a state's current expenditures for elementary and secondary public schools by the state's gross domestic product (GDP). Current expenditures include instruction and instruction-related costs, student support services, administration, and operations and exclude funds for school construction and other capital outlays, debt service, and programs outside of public elementary and secondary education. State and local support represent the largest sources of funding for elementary and secondary education.

Expenditure data on public elementary and secondary education are reported by the National Center for Education Statistics, Department of Education. They are part of the National Public Education Financial Survey and are included in the 2009 Common Core of Data, a comprehensive annual national statistical database that covers approximately 104,000 public elementary and secondary schools and 13,800 regular school districts in the United States.

Current expenditures are expressed in actual dollars and their data year is the end date of the academic year. For example, current expenditure data for 2009 represent expenditures for the 2008–09 academic year. GDP data refer to the 2009 calendar year in current dollars.

Table 8-10
Elementary and secondary public school current expenditures as a percentage of gross domestic product, by state: 2000, 2005, and 2009

	Public school expenditures ($thousands)			State GDP ($millions)			School expenditures/ GDP (%)		
State	2000	2005	2009	2000	2005	2009	2000	2005	2009
United States	323,808,910	425,047,568	518,997,426	9,884,171	12,554,535	14,014,842	3.28	3.39	3.70
Alabama	4,176,082	5,164,406	6,683,843	116,014	151,096	166,819	3.60	3.42	4.01
Alaska	1,183,499	1,442,269	2,006,114	25,913	37,824	45,861	4.57	3.81	4.37
Arizona	4,262,182	6,579,957	8,625,276	161,901	222,968	249,711	2.63	2.95	3.45
Arkansas	2,380,331	3,546,999	4,240,839	68,146	88,227	98,795	3.49	4.02	4.29
California	38,129,479	50,918,654	60,080,929	1,317,343	1,691,991	1,847,048	2.89	3.01	3.25
Colorado	4,400,888	5,994,440	7,187,267	171,930	217,412	250,664	2.56	2.76	2.87
Connecticut	5,402,868	7,080,396	8,708,294	163,943	197,055	227,550	3.30	3.59	3.83
Delaware	937,630	1,299,349	1,518,786	40,957	54,749	60,660	2.29	2.37	2.50
District of Columbia	780,192	1,067,500	1,352,905	58,269	82,837	98,892	1.34	1.29	1.37
Florida	13,885,988	19,042,877	23,328,028	481,115	680,277	732,782	2.89	2.80	3.18
Georgia	9,158,624	12,528,856	15,976,945	294,479	363,154	394,117	3.11	3.45	4.05
Hawaii	1,213,695	1,648,086	2,225,437	41,372	56,869	65,428	2.93	2.90	3.40
Idaho	1,302,817	1,618,215	1,957,740	36,091	48,675	53,661	3.61	3.32	3.65
Illinois	14,462,773	18,658,428	23,495,271	474,444	569,544	631,970	3.05	3.28	3.72
Indiana	7,110,930	9,108,931	9,680,895	198,020	239,575	259,894	3.59	3.80	3.72
Iowa	3,264,336	3,808,200	4,731,463	93,287	120,258	136,062	3.50	3.17	3.48
Kansas	2,971,814	3,718,153	4,805,310	85,742	105,164	122,544	3.47	3.54	3.92
Kentucky	3,837,794	4,812,591	5,886,890	113,108	139,336	155,789	3.39	3.45	3.78
Louisiana	4,391,214	5,554,766	7,276,651	131,430	197,163	205,117	3.34	2.82	3.55
Maine	1,604,438	2,056,266	2,350,447	36,395	45,587	50,039	4.41	4.51	4.70
Maryland	6,545,135	8,682,586	11,591,965	182,953	248,139	285,116	3.58	3.50	4.07
Massachusetts	8,511,065	11,357,857	13,942,586	272,680	323,301	360,538	3.12	3.51	3.87
Michigan	13,994,294	16,353,921	17,217,584	336,786	375,260	369,671	4.16	4.36	4.66
Minnesota	6,140,442	7,310,284	9,270,281	188,449	238,367	258,499	3.26	3.07	3.59
Mississippi	2,510,376	3,243,888	3,967,232	65,615	81,500	94,406	3.83	3.98	4.20
Missouri	5,655,531	7,115,207	8,827,224	180,982	216,633	237,955	3.12	3.28	3.71
Montana	994,770	1,193,182	1,436,062	21,629	30,088	34,999	4.60	3.97	4.10
Nebraska	1,926,500	2,512,914	3,053,575	57,233	72,504	86,411	3.37	3.47	3.53
Nevada	1,875,467	2,722,264	3,606,035	75,907	114,771	125,037	2.47	2.37	2.88
New Hampshire	1,418,503	2,021,144	2,490,623	44,067	53,653	59,086	3.22	3.77	4.22
New Jersey	13,327,645	19,669,576	23,589,224	349,334	429,985	471,946	3.82	4.57	5.00
New Mexico	1,890,274	2,554,638	3,186,252	50,262	67,776	76,871	3.76	3.77	4.14
New York	28,433,240	38,866,853	48,635,363	770,621	961,941	1,094,104	3.69	4.04	4.45
North Carolina	7,713,293	9,835,550	12,470,470	281,418	354,973	407,032	2.74	2.77	3.06
North Dakota	638,946	832,157	928,528	18,250	24,672	31,626	3.50	3.37	2.94
Ohio	12,974,575	17,167,866	19,397,511	381,175	444,715	462,015	3.40	3.86	4.20
Oklahoma	3,382,581	4,161,024	5,082,062	91,292	120,662	142,388	3.71	3.45	3.57
Oregon	3,896,287	4,458,028	5,529,831	112,974	143,349	167,481	3.45	3.11	3.30
Pennsylvania	14,120,112	18,711,100	21,831,816	395,811	482,324	546,538	3.57	3.88	3.99
Rhode Island	1,393,143	1,825,900	2,139,317	33,522	44,169	47,470	4.16	4.13	4.51
South Carolina	4,087,355	5,312,739	6,626,763	115,392	141,929	158,786	3.54	3.74	4.17
South Dakota	737,998	916,563	1,080,054	24,009	31,641	38,255	3.07	2.90	2.82
Tennessee	4,931,734	6,446,691	7,768,052	177,582	224,522	243,849	2.78	2.87	3.19
Texas	25,098,703	31,919,107	40,688,181	732,987	970,997	1,146,647	3.42	3.29	3.55
Utah	2,102,655	2,627,022	3,638,775	69,483	90,748	111,301	3.03	2.89	3.27
Vermont	870,198	1,177,478	1,413,329	18,033	22,773	24,625	4.83	5.17	5.74
Virginia	7,757,598	10,705,162	13,505,290	261,894	356,852	409,732	2.96	3.00	3.30
Washington	6,399,883	7,870,979	9,940,056	227,828	279,405	331,639	2.81	2.82	3.00
West Virginia	2,086,937	2,527,767	3,059,420	41,419	51,964	61,043	5.04	4.86	5.01
Wisconsin	6,852,178	8,435,359	9,696,228	177,638	218,923	239,613	3.86	3.85	4.05
Wyoming	683,918	863,423	1,268,407	17,047	26,238	36,760	4.01	3.29	3.45
Puerto Rico	2,086,414	2,865,945	3,502,757	69,208	86,157	NA	3.01	3.33	NA

GDP = gross domestic product; NA = not available

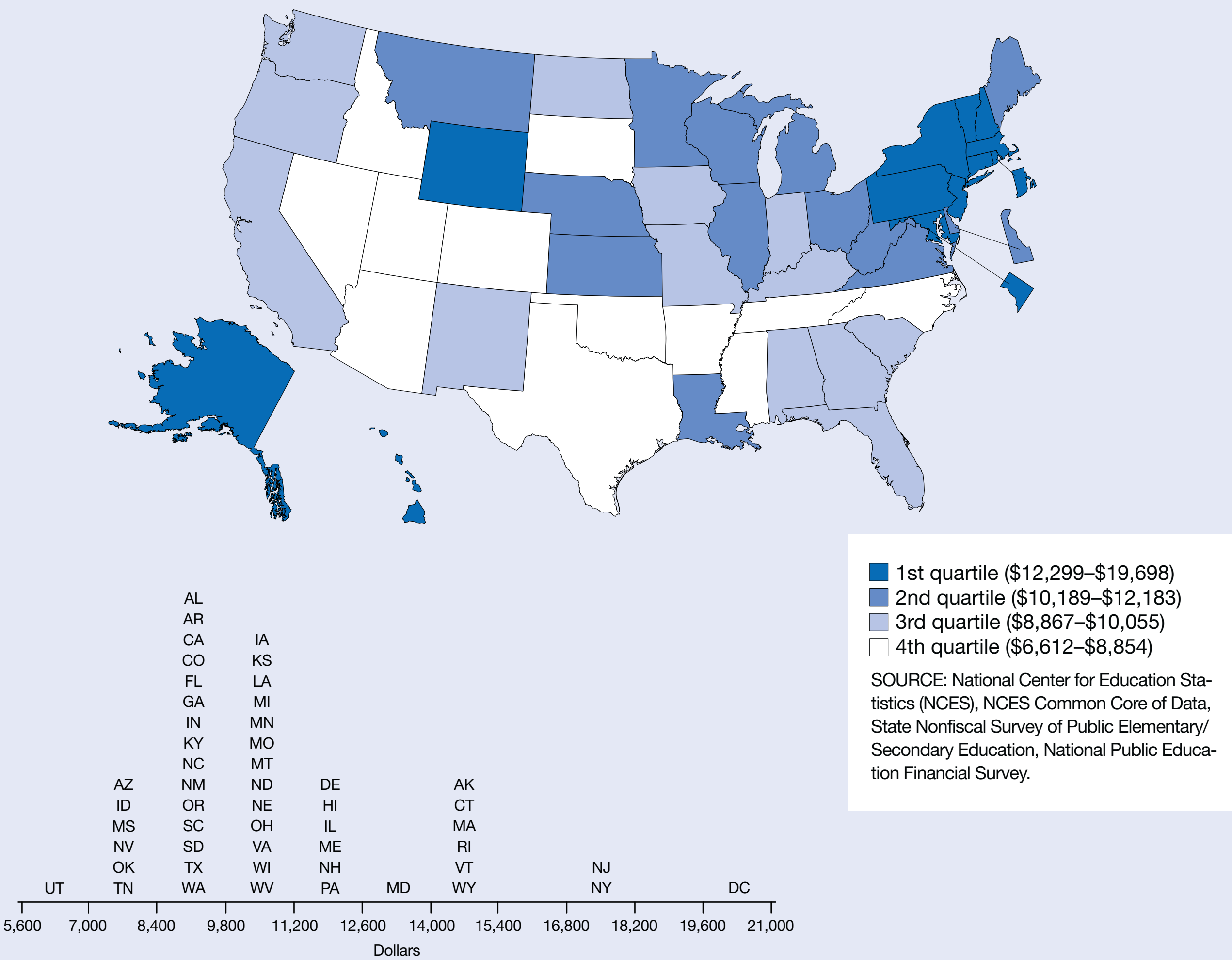
NOTE: GDP reported in current dollars.

SOURCES: National Center for Education Statistics (NCES), NCES Common Core of Data, National Public Education Financial Survey (various years); Bureau of Economic Analysis, Gross Domestic Product data (various years); Government of Puerto Rico, Office of the Governor (various years); United Nations Statistics Division.

Science and Engineering Indicators 2012

Current Expenditures per Pupil for Elementary and Secondary Public Schools

Figure 8-11
Current expenditures per pupil for elementary and secondary public schools: 2009



SOURCE: National Center for Education Statistics (NCES), NCES Common Core of Data, State Nonfiscal Survey of Public Elementary/Secondary Education, National Public Education Financial Survey.

Findings

- Per-pupil spending on day-to-day operations grew nationwide in current dollars from $6,911 in 2000 to $10,591 in 2009, an increase of 53% in unadjusted dollars. This was equivalent to an increase of approximately 23% after adjusting for inflation.
- In 2009, all states showed substantial increases in per-pupil spending relative to 2000, and only 1 state did not exceed the 2000 national average, compared with 30 states in 2000.
- Per-pupil spending in individual states varied widely, ranging from a low of $6,612 to a high of $17,746 in 2009.
- Several states that ranked in the lower two quartiles of this indicator ranked in the upper quartiles of the National Assessment of Educational Progress indicators

This indicator represents the amount that local, state, and federal governments spend on elementary and secondary education, adjusted for the size of the student body. It is calculated by dividing the current expenditures over the entire academic year for prekindergarten through grade 12 by the number of students in those grades in public schools. Current expenditures include expenditures for instruction and instruction-related costs, student support services, administration, and operations and exclude funds for school construction and other capital outlays, debt service, and programs outside of public elementary and secondary education. The number of pupils enrolled in prekindergarten through grade 12 is determined during the fall of the academic year. Expenditures represent actual spending in current dollars and have not been adjusted for inflation or for the cost of living in a state, which could affect the amount of goods and services that can be purchased.

During the 2008–09 school year, 65.8% of current expenses were used for instructional costs, 18.0% for operational costs, 10.8% for administrative costs, and 5.4% for student support services.

The year is the end date of the academic year. For example, data for 2009 represent costs for the 2008–09 academic year.

Table 8-11
Current expenditures per pupil for elementary and secondary public schools, by state: 2000, 2005, and 2009

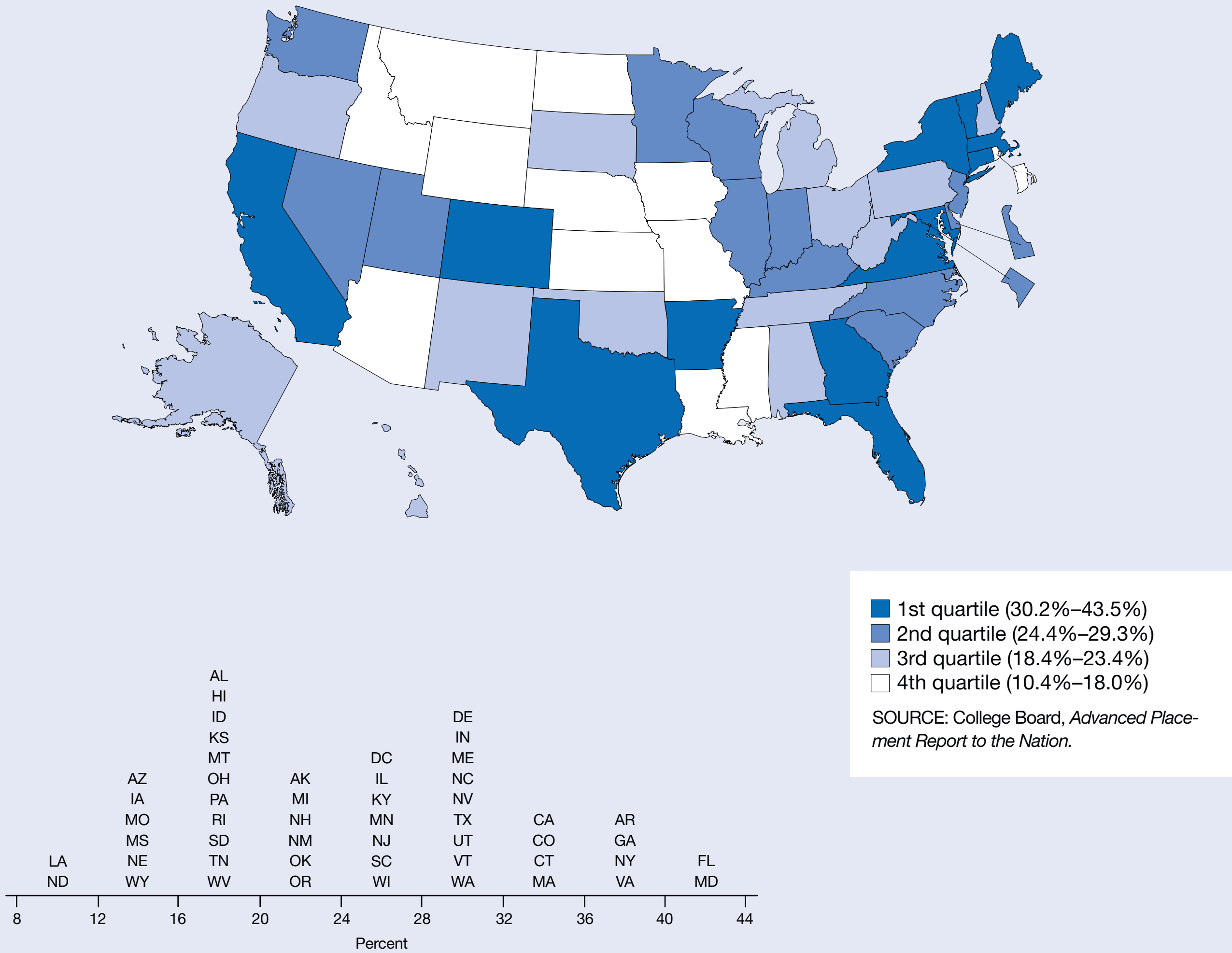
State	Public school expenditures ($thousands)			Student enrollment			Per-pupil expenditures ($)		
	2000	2005	2009	2000	2005	2009	2000	2005	2009
United States	323,808,910	425,047,568	518,997,426	46,857,149	48,794,911	49,003,001	6,911	8,711	10,591
Alabama	4,176,082	5,164,406	6,683,843	740,732	730,140	739,198	5,638	7,073	9,042
Alaska	1,183,499	1,442,269	2,006,114	134,391	132,970	130,662	8,806	10,847	15,353
Arizona	4,262,182	6,579,957	8,625,276	852,612	1,043,298	1,087,817	4,999	6,307	7,929
Arkansas	2,380,331	3,546,999	4,240,839	451,034	463,115	478,965	5,277	7,659	8,854
California	38,129,479	50,918,654	60,080,929	6,038,590	6,441,557	6,322,528	6,314	7,905	9,503
Colorado	4,400,888	5,994,440	7,187,267	708,109	765,976	818,443	6,215	7,826	8,782
Connecticut	5,402,868	7,080,396	8,708,294	553,993	577,390	567,198	9,753	12,263	15,353
Delaware	937,630	1,299,349	1,518,786	112,836	119,091	125,430	8,310	10,911	12,109
District of Columbia	780,192	1,067,500	1,352,905	77,194	76,714	68,681	10,107	13,915	19,698
Florida	13,885,988	19,042,877	23,328,028	2,381,396	2,639,336	2,631,020	5,831	7,215	8,867
Georgia	9,158,624	12,528,856	15,976,945	1,422,762	1,553,437	1,655,792	6,437	8,065	9,649
Hawaii	1,213,695	1,648,086	2,225,437	185,860	183,185	179,478	6,530	8,997	12,399
Idaho	1,302,817	1,618,215	1,957,740	245,136	256,084	275,051	5,315	6,319	7,118
Illinois	14,462,773	18,658,428	23,495,271	2,027,600	2,097,503	2,026,925	7,133	8,896	11,592
Indiana	7,110,930	9,108,931	9,680,895	988,702	1,021,348	1,046,147	7,192	8,919	9,254
Iowa	3,264,336	3,808,200	4,731,463	497,301	478,319	470,537	6,564	7,962	10,055
Kansas	2,971,814	3,718,153	4,805,310	472,188	469,136	471,060	6,294	7,926	10,201
Kentucky	3,837,794	4,812,591	5,886,890	648,180	674,796	651,370	5,921	7,132	9,038
Louisiana	4,391,214	5,554,766	7,276,651	756,579	724,281	684,873	5,804	7,669	10,625
Maine	1,604,438	2,056,266	2,350,447	209,253	198,820	192,935	7,667	10,342	12,183
Maryland	6,545,135	8,682,586	11,591,965	846,582	865,561	843,861	7,731	10,031	13,737
Massachusetts	8,511,065	11,357,857	13,942,586	971,425	975,574	958,910	8,761	11,642	14,540
Michigan	13,994,294	16,353,921	17,217,584	1,725,639	1,750,919	1,659,921	8,110	9,340	10,373
Minnesota	6,140,442	7,310,284	9,270,281	854,034	838,503	836,048	7,190	8,718	11,088
Mississippi	2,510,376	3,243,888	3,967,232	500,716	495,376	491,962	5,014	6,548	8,064
Missouri	5,655,531	7,115,207	8,827,224	914,110	905,449	892,436	6,187	7,858	9,891
Montana	994,770	1,193,182	1,436,062	157,556	146,705	140,936	6,314	8,133	10,189
Nebraska	1,926,500	2,512,914	3,053,575	288,261	285,761	281,544	6,683	8,794	10,846
Nevada	1,875,467	2,722,264	3,606,035	325,610	400,083	433,371	5,760	6,804	8,321
New Hampshire	1,418,503	2,021,144	2,490,623	206,783	206,852	197,934	6,860	9,771	12,583
New Jersey	13,327,645	19,669,576	23,589,224	1,289,256	1,393,347	1,381,420	10,337	14,117	17,076
New Mexico	1,890,274	2,554,638	3,186,252	324,495	326,102	330,245	5,825	7,834	9,648
New York	28,433,240	38,866,853	48,635,363	2,887,776	2,836,337	2,740,592	9,846	13,703	17,746
North Carolina	7,713,293	9,835,550	12,470,470	1,275,925	1,385,754	1,463,967	6,045	7,098	8,518
North Dakota	638,946	832,157	928,528	112,751	100,513	94,728	5,667	8,279	9,802
Ohio	12,974,575	17,167,866	19,397,511	1,836,554	1,840,032	1,779,290	7,065	9,330	10,902
Oklahoma	3,382,581	4,161,024	5,082,062	627,032	629,476	645,108	5,395	6,610	7,878
Oregon	3,896,287	4,458,028	5,529,831	545,033	552,322	575,393	7,149	8,071	9,611
Pennsylvania	14,120,112	18,711,100	21,831,816	1,816,716	1,828,089	1,775,029	7,772	10,235	12,299
Rhode Island	1,393,143	1,825,900	2,139,317	156,454	156,498	145,342	8,904	11,667	14,719
South Carolina	4,087,355	5,312,739	6,626,763	666,780	703,736	718,113	6,130	7,549	9,228
South Dakota	737,998	916,563	1,080,054	131,037	122,798	126,429	5,632	7,464	8,543
Tennessee	4,931,734	6,446,691	7,768,052	916,202	941,091	971,950	5,383	6,850	7,992
Texas	25,098,703	31,919,107	40,688,181	3,991,783	4,405,215	4,752,148	6,288	7,246	8,562
Utah	2,102,655	2,627,022	3,638,775	480,255	503,607	550,298	4,378	5,216	6,612
Vermont	870,198	1,177,478	1,413,329	104,559	98,352	93,625	8,323	11,972	15,096
Virginia	7,757,598	10,705,162	13,505,290	1,133,994	1,204,739	1,235,795	6,841	8,886	10,928
Washington	6,399,883	7,870,979	9,940,056	1,003,714	1,020,005	1,026,023	6,376	7,717	9,688
West Virginia	2,086,937	2,527,767	3,059,420	291,811	280,129	282,729	7,152	9,024	10,821
Wisconsin	6,852,178	8,435,359	9,696,228	877,753	864,757	867,035	7,806	9,755	11,183
Wyoming	683,918	863,423	1,268,407	92,105	84,733	86,709	7,425	10,190	14,628
Puerto Rico	2,086,414	2,865,945	3,502,757	613,019	575,648	503,635	3,404	4,979	6,955

SOURCES: National Center for Education Statistics (NCES), NCES Common Core of Data, State Nonfiscal Survey of Public Elementary/Secondary Education (various years); National Public Education Financial Survey (various years).

Science and Engineering Indicators 2012

Percentage of Public High School Students Taking Advanced Placement Exams

Figure 8-12
Percentage of public high school students taking Advanced Placement Exams: 2010



SOURCE: College Board, *Advanced Placement Report to the Nation.*

Findings

- Nationwide, the percentage of public school students who took an AP Exam rose from 15.9% of the class of 2000 to 28.3% of the class of 2010.
- The percentage of public school students taking an AP Exam varied greatly among states and ranged from 10.4% to 43.5% of the class of 2010. Forty-two states and the District of Columbia exceeded the 2000 national average in 2010, compared with 15 states and the District of Columbia that exceeded the national average in 2000.
- AP participation levels were higher for all jurisdictions in 2010 than in 2000. Arkansas showed the largest increase, with the class of 2010 exceeding the participation of the class of 2000 by more than 28 percentage points.

Participation in the Advanced Placement (AP) program provides a measure of the extent to which a rigorous curriculum is available to and used by high school students. This indicator represents the percentage of students in the graduating class who have taken one or more AP Exams.

Throughout the United States, nearly 853,000 public school students from the class of 2010 took nearly 2.5 million AP Exams during their high school careers. Generally, students who take AP Exams have completed a rigorous course of study in a specific subject area in high school with the expectation of obtaining college credit or advanced placement. AP Exams were taken most frequently in U.S. history, English literature and composition, English language and composition, calculus AB, and U.S. government and politics.

Students from the class of 2010 attended 12,705 U.S. public schools that participated in the AP program. These schools make an average of 10 different AP courses available to their students.

Table 8-12
Public high school students taking Advanced Placement Exams, by state: 2000, 2005, and 2010
(Percent)

State	2000	2005	2010
United States	15.9	22.7	28.3
Alabama	7.2	9.7	19.5
Alaska	15.4	18.8	22.3
Arizona	11.3	14.6	15.6
Arkansas	8.1	24.0	36.6
California	22.2	30.2	34.0
Colorado	18.6	26.7	34.6
Connecticut	19.1	26.0	32.2
Delaware	13.3	24.8	28.1
District of Columbia	17.3	27.0	25.1
Florida	22.7	32.9	43.5
Georgia	17.2	24.4	37.3
Hawaii	10.6	16.5	19.6
Idaho	9.6	14.3	16.3
Illinois	13.4	19.8	26.3
Indiana	11.9	18.4	29.3
Iowa	6.9	10.2	14.4
Kansas	7.0	9.8	16.0
Kentucky	10.6	17.1	24.4
Louisiana	3.2	4.9	11.4
Maine	14.8	22.3	31.6
Maryland	20.2	31.5	43.4
Massachusetts	19.6	26.2	33.2
Michigan	13.9	18.0	23.2
Minnesota	13.4	17.6	26.4
Mississippi	5.6	8.7	14.1
Missouri	5.5	9.2	13.4
Montana	10.1	15.2	18.0
Nebraska	5.0	7.3	12.4
Nevada	15.1	20.3	28.3
New Hampshire	13.3	17.6	22.7
New Jersey	17.9	23.0	25.6
New Mexico	11.1	18.0	22.3
New York	27.3	34.8	38.0
North Carolina	19.7	29.7	28.8
North Dakota	5.9	8.8	10.4
Ohio	11.3	16.4	18.9
Oklahoma	9.5	17.7	20.8
Oregon	10.5	16.4	23.4
Pennsylvania	12.4	15.7	19.7
Rhode Island	10.7	12.4	17.9
South Carolina	17.7	21.6	26.8
South Dakota	9.6	14.1	18.4
Tennessee	10.4	15.1	18.6
Texas	16.6	25.1	30.2
Utah	24.5	29.1	28.4
Vermont	16.6	22.7	31.8
Virginia	25.0	30.1	38.1
Washington	11.5	21.1	28.0
West Virginia	8.4	12.0	18.4
Wisconsin	15.2	21.1	26.3
Wyoming	6.1	11.4	15.7
Puerto Rico	NA	NA	NA

NA = not available

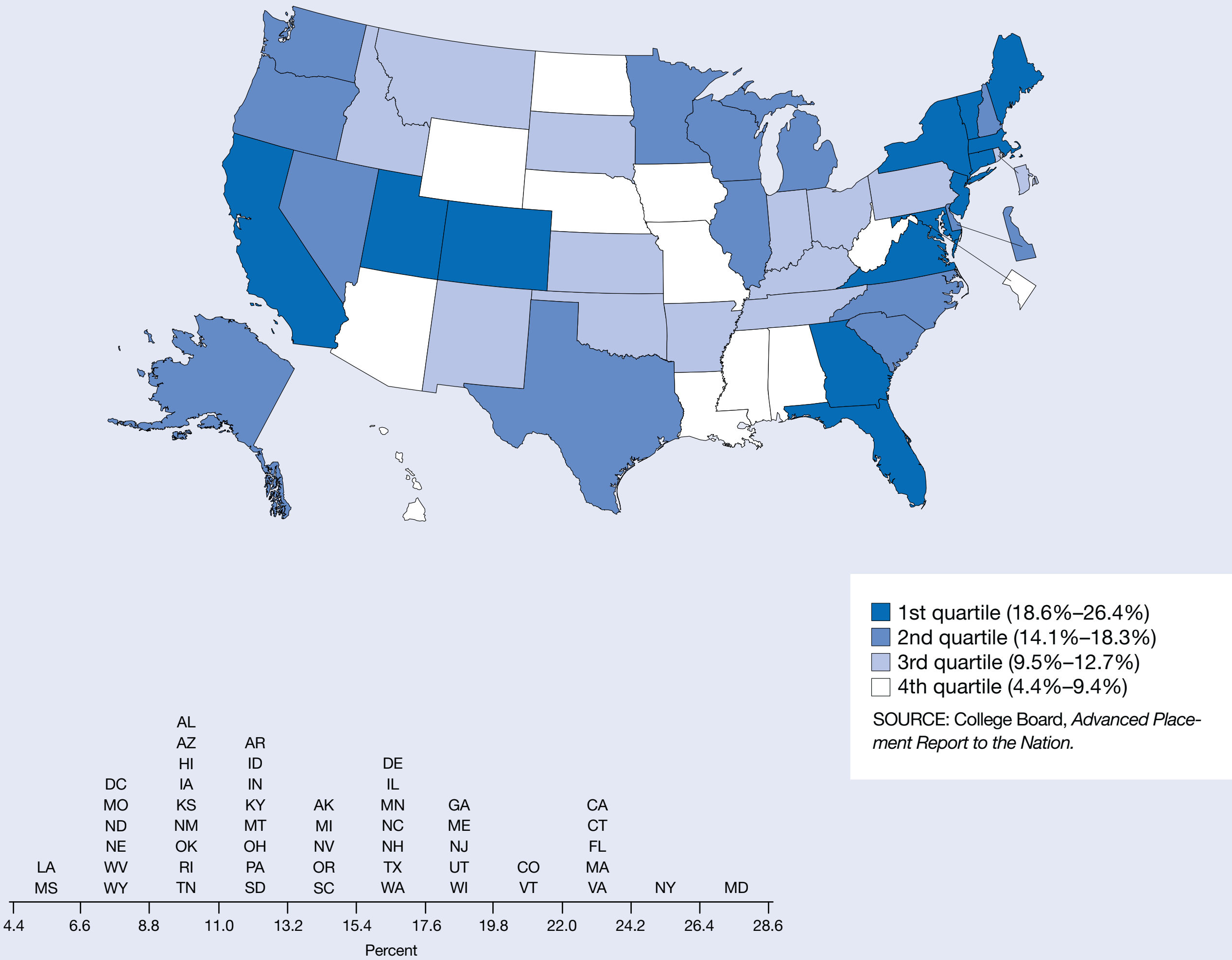
NOTE: National average for United States is reported value in *Advanced Placement Report to the Nation.*

SOURCE: College Board, *Advanced Placement Report to the Nation* (various years).

Science and Engineering Indicators 2012

Percentage of Public High School Students Scoring 3 or Higher on at Least One Advanced Placement Exam

Figure 8-13
Percentage of public high school students scoring 3 or higher on at least one Advanced Placement Exam: 2010



SOURCE: College Board, *Advanced Placement Report to the Nation.*

Findings

- Nationally, 16.9% of public school students in the class of 2010 demonstrated the ability to do college-level work by obtaining a score of 3 or higher on at least one AP Exam, a substantial increase from the 10.2% of the class of 2000 who obtained that score.
- Students from all states and the District of Columbia demonstrated greater success on AP Exams in 2010 than in 2000, but this success was not evenly distributed. In 2010, 13 states and the District of Columbia had percentages below the 2000 national average of 10.2% compared with 38 jurisdictions in 2000.
- The percentage of students who scored 3 or higher on an AP Exam varied widely among states. For the class of 2010, this percentage ranged from a low of 4.4% to a high of 26.4% across states.

This indicator represents the extent to which high school students are successfully demonstrating mastery of college-level material in specific disciplines. State scores on this indicator reflect students' access to rigorous coursework as well as their success in comprehending and using it. The indicator value is defined as the percentage of U.S. public high school graduates who have scored 3 or higher on at least one Advanced Placement (AP) Exam. Many colleges and universities grant college credit or advanced placement for AP Exam scores of 3 or higher. Students who score a 3 or higher typically experience greater academic success in college and higher graduation rates.

A total of 33 different AP Exams are offered each spring by the College Board. The exams include a multiple choice section and a free response section. To prepare for the AP Exam in a subject area, most students enroll in an AP class that employs a curriculum of high academic intensity. Performance on AP Exams has been shown in research to be one of the best predictors of success in college.

Table 8-13
Public high school students scoring 3 or higher on at least one Advanced Placement Exam, by state: 2000, 2005, and 2010
(Percent)

State	2000	2005	2010
United States	10.2	14.1	16.9
Alabama	3.9	5.3	9.0
Alaska	10.1	12.4	14.3
Arizona	7.2	9.2	8.8
Arkansas	4.3	7.7	12.5
California	15.0	19.7	22.3
Colorado	12.2	16.9	21.4
Connecticut	13.6	19.1	23.2
Delaware	7.6	12.9	15.4
District of Columbia	6.6	8.7	6.9
Florida	13.5	18.5	22.3
Georgia	9.7	13.5	19.1
Hawaii	5.8	8.2	9.4
Idaho	6.5	9.6	11.0
Illinois	9.9	14.1	17.2
Indiana	6.0	8.9	12.4
Iowa	4.9	6.7	8.8
Kansas	4.4	6.5	9.5
Kentucky	5.5	8.3	12.2
Louisiana	1.9	2.5	4.6
Maine	10.1	14.4	19.0
Maryland	14.1	21.0	26.4
Massachusetts	14.5	18.7	23.1
Michigan	8.8	11.6	15.0
Minnesota	8.1	11.5	16.8
Mississippi	2.3	3.3	4.4
Missouri	3.7	6.0	7.5
Montana	6.8	10.0	11.7
Nebraska	3.2	4.4	7.4
Nevada	9.1	12.0	15.0
New Hampshire	9.2	11.5	16.6
New Jersey	12.9	16.5	18.6
New Mexico	6.1	8.5	10.2
New York	17.9	22.8	24.6
North Carolina	11.3	17.1	17.5
North Dakota	4.4	6.0	6.8
Ohio	7.1	10.1	11.8
Oklahoma	5.4	8.2	10.3
Oregon	7.1	10.7	14.1
Pennsylvania	8.3	10.5	12.7
Rhode Island	6.9	8.1	10.9
South Carolina	10.0	12.6	15.1
South Dakota	5.9	8.8	11.0
Tennessee	6.2	8.9	9.7
Texas	9.9	13.7	15.5
Utah	17.4	20.5	19.2
Vermont	11.5	15.4	21.8
Virginia	15.9	19.3	23.7
Washington	7.6	13.2	17.1
West Virginia	4.6	5.8	7.6
Wisconsin	10.5	14.5	18.3
Wyoming	3.8	5.8	8.5
Puerto Rico	NA	NA	NA

NA = not available

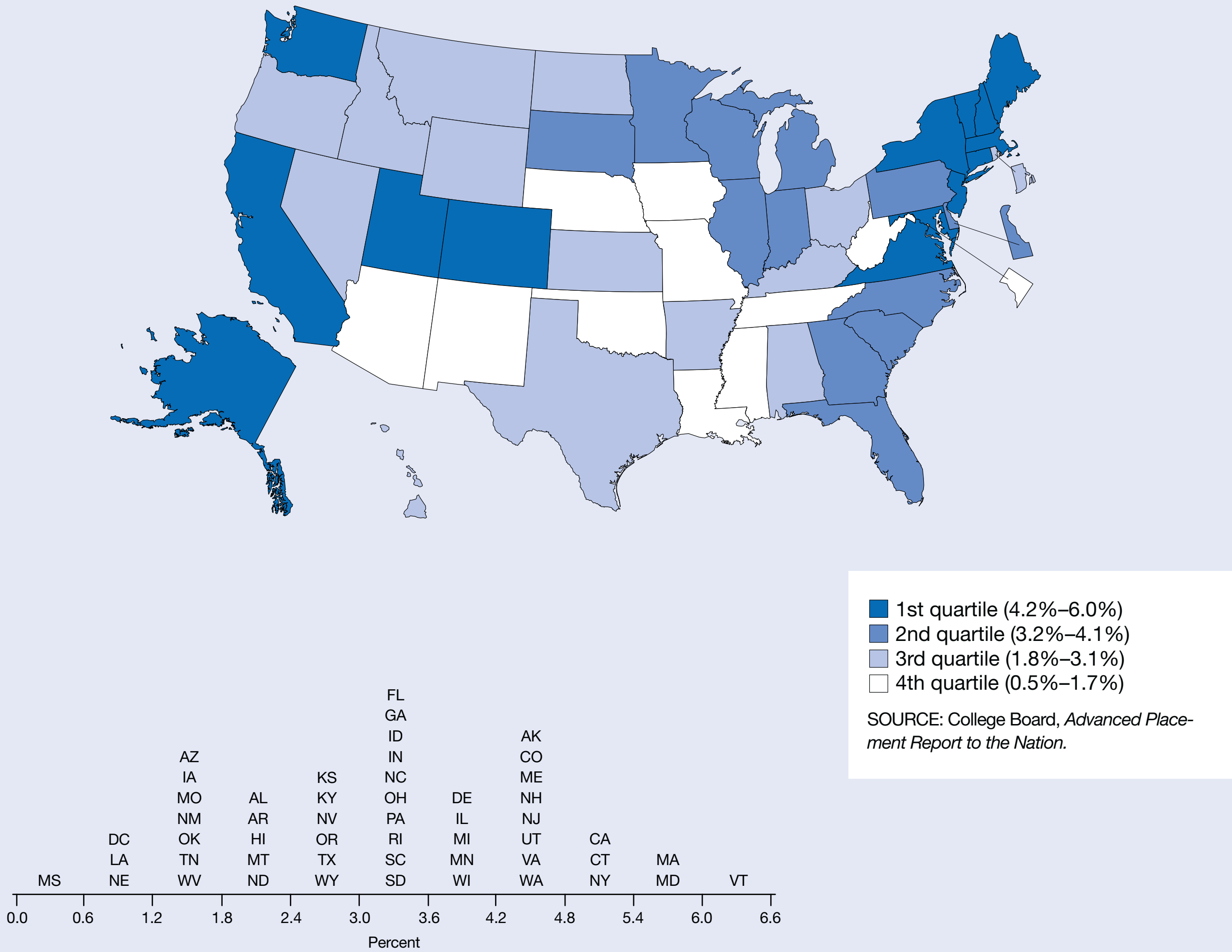
NOTE: National average for United States is reported value in *Advanced Placement Report to the Nation*.

SOURCE: College Board, *Advanced Placement Report to the Nation* (various years).

Science and Engineering Indicators 2012

Percentage of Public High School Students Scoring 3 or Higher on Advanced Placement Calculus AB Exam

Figure 8-14
Percentage of public high school students scoring 3 or higher on Advanced Placement Calculus AB Exam: 2010



SOURCE: College Board, *Advanced Placement Report to the Nation.*

Findings

- In 2010, a total of 237,000 Calculus AB exams were taken in the United States, and 137,000 were scored 3 or higher. Public school students took 200,000 Calculus AB exams and 108,000 of those were scored at 3 or above. The remaining 37,000 Calculus AB exams were taken by students who did not attend public schools, i.e., those who attended independent or religious schools, home schools, or did not identify their school.
- Nationally, the share of the graduating class that demonstrated a mastery of Calculus AB by scoring a 3 or higher on the AP Exam increased from 2.7% in 2000 to 3.5% in 2010. Values for individual states ranged from a low of 0.5% to a high of 6.0% in 2010.
- Between 2000 and 2010, nearly all states increased the percentage of high school graduates that had demonstrated their ability in Calculus AB. However, four states showed lower percentages in 2010.
- Because the percentages are small, year-to-year comparisons should be made with caution. Variability in students' course selection and level of performance can affect the numbers.

The Advanced Placement (AP) Calculus AB exam seeks to assess how well a student has mastered the concepts and techniques of differential and integral calculus. Many colleges and universities grant college credit or advanced placement for AP exam scores of 3 or higher.

AP courses in calculus consist of a full high school academic year of work and are comparable to calculus courses taught at colleges and universities. Prior to taking an AP Calculus course, students are expected to have completed four years of secondary mathematics intended for college-bound students consisting of courses in algebra, geometry, trigonometry, analytic geometry, and elementary functions. Even though a Calculus AB course may cover elementary functions, most of its topics will address differential and integral calculus. The use of a graphing calculator in AP Calculus is considered an integral part of the course, and graphing calculators are required on portions of the AP Examination.

Successful performance on the Calculus AB exam indicates that the student has a solid mathematical background and is prepared to undertake advanced training in mathematics, science, or engineering at the college or university level.

Table 8-14
Public high school students scoring 3 or higher on Advanced Placement Calculus AB Exam, by state: 2000, 2005, and 2010
(Percent)

State	2000	2005	2010
United States	2.7	3.2	3.5
Alabama	0.8	1.0	1.8
Alaska	3.2	4.0	4.6
Arizona	1.8	2.1	1.6
Arkansas	2.2	1.7	2.1
California	3.4	4.3	4.8
Colorado	2.4	3.0	4.4
Connecticut	3.4	4.0	5.0
Delaware	2.2	3.5	3.8
District of Columbia	0.7	1.7	0.8
Florida	3.2	3.2	3.3
Georgia	2.5	3.0	3.3
Hawaii	1.5	1.9	2.0
Idaho	1.6	2.8	3.0
Illinois	3.2	3.6	3.9
Indiana	2.3	2.5	3.3
Iowa	1.4	1.6	1.7
Kansas	1.2	1.8	2.4
Kentucky	1.6	0.4	2.7
Louisiana	0.4	0.3	0.8
Maine	2.7	3.4	4.3
Maryland	3.4	4.3	5.4
Massachusetts	4.0	4.6	5.6
Michigan	2.5	3.0	3.6
Minnesota	3.0	3.3	4.1
Mississippi	0.5	0.7	0.5
Missouri	0.9	1.3	1.5
Montana	1.3	1.7	2.2
Nebraska	0.6	0.9	1.1
Nevada	2.1	2.6	2.6
New Hampshire	3.0	2.8	4.2
New Jersey	3.8	3.8	4.2
New Mexico	1.4	1.7	1.6
New York	5.1	5.0	5.2
North Carolina	3.4	3.9	3.2
North Dakota	1.2	1.6	1.8
Ohio	2.3	3.0	3.0
Oklahoma	1.3	1.1	1.3
Oregon	1.8	2.2	2.9
Pennsylvania	2.4	2.8	3.2
Rhode Island	1.6	1.9	3.1
South Carolina	3.4	3.7	3.5
South Dakota	2.4	3.2	3.4
Tennessee	1.5	1.7	1.5
Texas	1.9	2.4	2.6
Utah	5.0	4.9	4.7
Vermont	3.5	3.9	6.0
Virginia	3.7	3.6	4.2
Washington	2.7	4.0	4.6
West Virginia	1.3	1.4	1.3
Wisconsin	3.1	3.7	4.0
Wyoming	1.6	1.6	2.5
Puerto Rico	NA	NA	NA

NA = not available

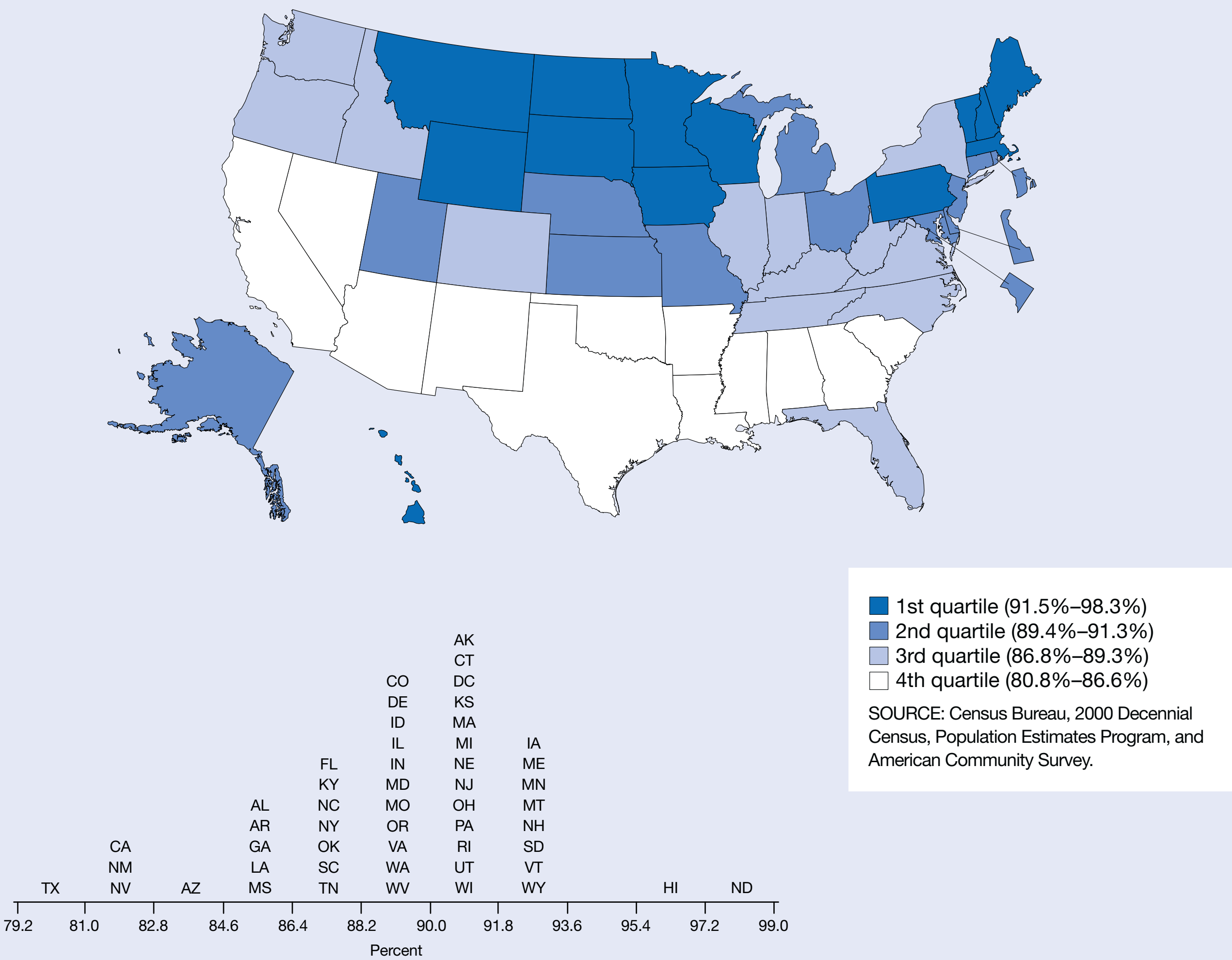
NOTE: National average for United States is reported value in *Advanced Placement Report to the Nation*.

SOURCE: College Board, *Advanced Placement Report to the Nation* (various years).

Science and Engineering Indicators 2012

High School Graduates Among Individuals 25–44 Years Old

Figure 8-15
High school graduates among individuals 25–44 years old: 2009



SOURCE: Census Bureau, 2000 Decennial Census, Population Estimates Program, and American Community Survey.

Findings

- Nationwide, 87.1% of the early- to mid-career population had at least a high school credential in 2009, a slight increase from the 85.0% who held such a credential in 2000.
- Forty-six states and the District of Columbia showed an increase in the percentage of their early- to mid-career population with at least a high school credential between 2000 and 2009. Six states had 2009 values below the 2000 national average of 85.0%, compared with 17 states and the District of Columbia in 2000.
- In 2009, the early- to mid-career population with at least a high school credential varied greatly among states, ranging from 80.8% to 98.3%. States in close proximity to the southern border of the United States tended to rank lowest on this indicator.

This indicator represents the percentage of the early- to mid-career population that has earned at least a high school credential. The indicator displays results based on where high school graduates live rather than where they were educated. High values indicate a resident population and potential workforce with widespread basic education credentials.

Estimates of educational attainment have been developed by the U.S. Census Bureau. Data from 2005 and later are derived from the American Community Survey (ACS), the largest household survey in the United States, with a sample size of about 3 million addresses. The ACS collects information on an annual basis. Data prior to 2005 were derived from the Decennial Census.

Estimates of population ages 25–44 are provided by the Census Bureau based on the 2000 Decennial Census. Estimates for states with smaller populations are generally less precise than estimates for states with larger populations.

Table 8-15
High school graduates among individuals 25–44 years old, by state: 2000, 2005, and 2009

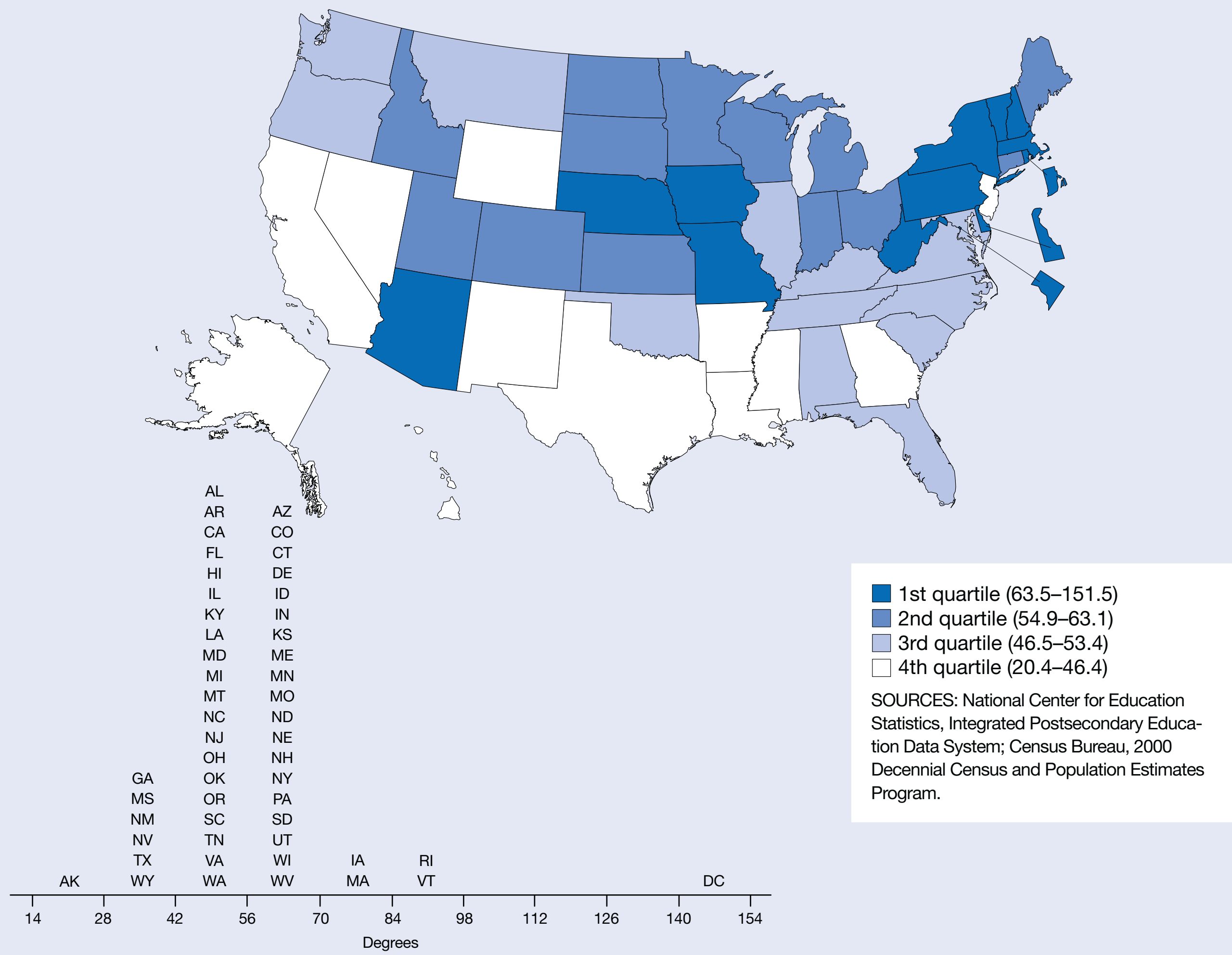
State	Graduates 25–44 years old			Population 25–44 years old			Graduates/population 25–44 years old (%)		
	2000	2005	2009	2000	2005	2009	2000	2005	2009
United States	72,241,876	71,215,646	72,337,536	85,040,251	83,257,116	83,096,278	85.0	85.5	87.1
Alabama	1,064,945	1,035,193	1,055,386	1,288,527	1,231,043	1,235,509	82.6	84.1	85.4
Alaska	186,160	162,669	179,001	203,522	191,837	197,248	91.5	84.8	90.7
Arizona	1,232,818	1,367,583	1,528,930	1,511,469	1,695,189	1,826,751	81.6	80.7	83.7
Arkansas	622,698	633,557	651,055	750,972	747,630	755,915	82.9	84.7	86.1
California	8,286,071	8,316,850	8,590,128	10,714,403	10,668,824	10,604,180	77.3	78.0	81.0
Colorado	1,242,919	1,240,697	1,279,279	1,400,850	1,388,046	1,445,400	88.7	89.4	88.5
Connecticut	926,614	852,932	820,616	1,032,689	951,020	899,649	89.7	89.7	91.2
Delaware	207,799	206,583	209,049	236,441	234,823	232,837	87.9	88.0	89.8
District of Columbia	157,077	163,027	180,722	189,439	190,118	197,983	82.9	85.8	91.3
Florida	3,840,710	4,000,762	4,170,014	4,569,347	4,787,948	4,789,059	84.1	83.6	87.1
Georgia	2,238,995	2,368,999	2,418,543	2,652,764	2,746,294	2,830,740	84.4	86.3	85.4
Hawaii	333,762	308,637	344,834	362,336	354,560	360,037	92.1	87.0	95.8
Idaho	316,815	327,870	355,984	362,401	375,247	400,329	87.4	87.4	88.9
Illinois	3,265,416	3,200,557	3,146,716	3,795,544	3,611,958	3,544,995	86.0	88.6	88.8
Indiana	1,567,100	1,500,650	1,502,416	1,791,828	1,716,726	1,689,050	87.5	87.4	89.0
Iowa	740,397	713,525	685,787	808,259	746,659	734,622	91.6	95.6	93.4
Kansas	687,268	656,920	649,026	769,204	713,752	717,645	89.3	92.0	90.4
Kentucky	1,009,246	993,094	1,014,340	1,210,773	1,172,770	1,162,402	83.4	84.7	87.3
Louisiana	1,044,255	1,026,229	1,022,069	1,293,128	1,217,593	1,186,325	80.8	84.3	86.2
Maine	339,227	317,653	301,407	370,597	344,295	322,409	91.5	92.3	93.5
Maryland	1,487,216	1,399,879	1,398,327	1,664,677	1,611,882	1,557,085	89.3	86.8	89.8
Massachusetts	1,795,438	1,690,234	1,635,794	1,989,783	1,857,726	1,787,350	90.2	91.0	91.5
Michigan	2,630,713	2,455,339	2,293,446	2,960,544	2,743,365	2,536,880	88.9	89.5	90.4
Minnesota	1,395,170	1,345,742	1,299,949	1,497,320	1,420,387	1,394,305	93.2	94.7	93.2
Mississippi	650,242	648,458	644,971	807,170	771,676	761,785	80.6	84.0	84.7
Missouri	1,426,806	1,378,001	1,388,876	1,626,302	1,566,374	1,554,391	87.7	88.0	89.4
Montana	225,105	216,509	214,586	245,220	226,076	231,769	91.8	95.8	92.6
Nebraska	441,527	421,008	412,126	487,107	453,659	451,666	90.6	92.8	91.2
Nevada	508,173	585,942	631,069	628,572	719,501	769,608	80.8	81.4	82.0
New Hampshire	350,744	330,926	310,704	381,240	357,080	333,694	92.0	92.7	93.1
New Jersey	2,313,820	2,165,296	2,135,875	2,624,146	2,485,721	2,363,679	88.2	87.1	90.4
New Mexico	425,745	411,608	430,512	516,100	510,063	523,059	82.5	80.7	82.3
New York	4,926,064	4,786,794	4,697,650	5,831,622	5,548,409	5,351,598	84.5	86.3	87.8
North Carolina	2,117,289	2,148,501	2,217,822	2,500,535	2,485,963	2,553,673	84.7	86.4	86.8
North Dakota	164,893	155,297	150,983	174,891	151,681	153,582	94.3	102.4	98.3
Ohio	2,965,744	2,759,770	2,716,279	3,325,210	3,122,259	2,998,151	89.2	88.4	90.6
Oklahoma	836,030	807,209	828,944	975,169	929,451	957,235	85.7	86.8	86.6
Oregon	861,602	872,276	907,376	997,269	988,164	1,028,645	86.4	88.3	88.2
Pennsylvania	3,136,195	2,908,593	2,922,659	3,508,562	3,280,173	3,187,617	89.4	88.7	91.7
Rhode Island	265,033	264,154	247,679	310,636	296,463	274,622	85.3	89.1	90.2
South Carolina	990,207	999,627	1,036,562	1,185,955	1,172,501	1,200,366	83.5	85.3	86.4
South Dakota	188,052	180,013	180,578	206,399	194,122	196,143	91.1	92.7	92.1
Tennessee	1,439,729	1,459,559	1,502,094	1,718,428	1,698,113	1,710,134	83.8	86.0	87.8
Texas	5,115,457	5,248,281	5,709,404	6,484,321	6,665,252	7,064,651	78.9	78.7	80.8
Utah	555,513	646,632	700,665	626,600	686,668	775,481	88.7	94.2	90.4
Vermont	162,109	150,073	138,869	176,456	158,184	148,584	91.9	94.9	93.5
Virginia	1,962,040	1,896,614	1,959,386	2,237,655	2,194,670	2,194,699	87.7	86.4	89.3
Washington	1,617,766	1,592,550	1,654,322	1,816,217	1,783,093	1,855,094	89.1	89.3	89.2
West Virginia	420,900	411,155	408,715	501,343	468,846	459,606	84.0	87.7	88.9
Wisconsin	1,429,331	1,367,667	1,326,456	1,581,690	1,495,775	1,449,006	90.4	91.4	91.5
Wyoming	126,931	117,952	129,556	138,619	127,487	139,035	91.6	92.5	93.2
Puerto Rico	794,579	868,650	879,051	1,049,995	1,076,844	1,084,239	75.7	80.7	81.1

SOURCES: Census Bureau, 2000 Decennial Census, Population Estimates Program (various years), and American Community Survey (various years).

Science and Engineering Indicators 2012

Bachelor's Degrees Conferred per 1,000 Individuals 18–24 Years Old

Figure 8-16
Bachelor's degrees conferred per 1,000 individuals 18–24 years old: 2009



SOURCES: National Center for Education Statistics, Integrated Postsecondary Education Data System; Census Bureau, 2000 Decennial Census and Population Estimates Program.

Findings

- In 2009, over 1.6 million bachelor's degrees were conferred nationally in all fields, which is up from 1.2 million in 2000 and represents an increase of 29%. Between 2000 and 2009, the number of bachelor's degrees conferred per 1,000 individuals 18–24 years old in the population has increased by nearly 16% nationwide.
- In 2009, state values on this indicator varied greatly. They ranged from 20.4 to 91.8 bachelor's degrees conferred per 1,000 individuals 18–24 years old.
- The number of bachelor's degrees conferred per 1,000 individuals 18–24 years old increased in all but 4 states between 2000 and 2009.

Educational attainment gives people greater opportunities to work in higher-paying jobs than are generally available to those with less education. Earning a bachelor's degree also prepares them for advanced education.

Educational attainment varies by several demographic characteristics including age. The cohort 18–24 years old was chosen to approximate the age range of most students who are pursuing an undergraduate degree. This indicator represents the extent the 18–24 year old population has earned a bachelor's degree.

The number of bachelor's degrees awarded is based on an actual count provided by the National Center of Education Statistics. Estimates of the population ages 18–24 years are provided by the U.S. Census Bureau. Small differences in the indicator value between states or across time generally are not meaningful.

A high value for this indicator may suggest the successful provision of educational opportunity at this level. Student mobility after graduation is not accounted for which may make this indicator less meaningful in predicting the qualifications of a state's future workforce. A state's value for this indicator may also be high when its higher education system draws a large percentage of out-of-state students, a situation that sometimes occurs in states with small resident populations and the District of Columbia.

Table 8-16
Bachelor's degrees conferred per 1,000 individuals 18–24 years old, by state: 2000, 2005, and 2009

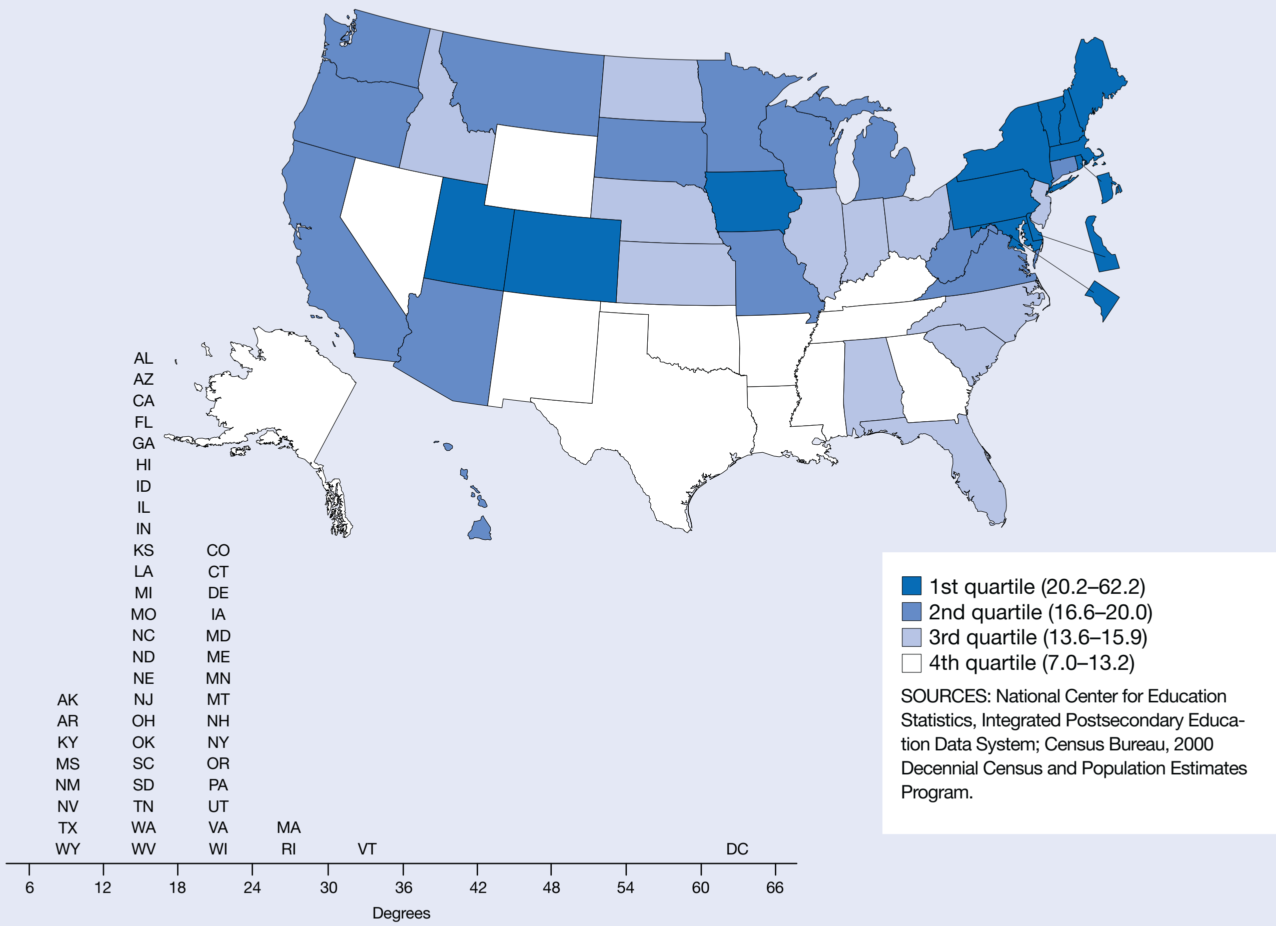
State	Bachelor's degrees			Population 18–24 years old			Degrees/1,000 individuals 18–24 years old		
	2000	2005	2009	2000	2005	2009	2000	2005	2009
United States	1,237,875	1,439,264	1,601,368	27,316,537	29,404,797	30,412,035	45.3	48.9	52.7
Alabama	21,293	21,616	24,245	442,009	453,363	465,249	48.2	47.7	52.1
Alaska	1,364	1,427	1,626	57,724	78,831	79,696	23.6	18.1	20.4
Arizona	20,865	29,133	39,898	519,381	570,206	610,920	40.2	51.1	65.3
Arkansas	9,405	11,191	12,027	263,326	269,720	273,263	35.7	41.5	44.0
California	121,546	146,959	160,930	3,389,475	3,601,422	3,746,026	35.9	40.8	43.0
Colorado	22,485	26,142	29,879	434,165	479,582	500,695	51.8	54.5	59.7
Connecticut	15,072	16,833	19,178	273,000	315,265	340,550	55.2	53.4	56.3
Delaware	4,665	5,247	5,472	75,857	79,909	83,522	61.5	65.7	65.5
District of Columbia	6,806	9,199	10,957	72,867	67,720	72,339	93.4	135.8	151.5
Florida	51,333	65,839	80,275	1,340,658	1,583,393	1,667,090	38.3	41.6	48.2
Georgia	29,219	35,515	40,461	844,924	912,133	979,688	34.6	38.9	41.3
Hawaii	5,091	5,300	5,797	115,683	128,311	124,841	44.0	41.3	46.4
Idaho	4,711	7,295	9,066	140,017	157,526	161,387	33.6	46.3	56.2
Illinois	55,036	63,913	69,339	1,217,816	1,273,336	1,298,744	45.2	50.2	53.4
Indiana	31,970	36,655	39,583	618,463	637,074	643,920	51.7	57.5	61.5
Iowa	18,750	20,786	26,239	299,438	320,586	321,355	62.6	64.8	81.7
Kansas	14,291	16,267	17,521	277,164	306,834	307,284	51.6	53.0	57.0
Kentucky	15,643	17,862	19,996	404,146	417,504	416,470	38.7	42.8	48.0
Louisiana	19,844	21,494	21,425	475,946	496,032	477,506	41.7	43.3	44.9
Maine	5,672	6,500	6,909	104,527	117,289	118,353	54.3	55.4	58.4
Maryland	22,089	25,990	27,909	454,129	515,830	547,538	48.6	50.4	51.0
Massachusetts	42,308	45,769	50,106	582,619	621,142	668,112	72.6	73.7	75.0
Michigan	45,754	51,207	54,641	937,626	997,376	995,230	48.8	51.3	54.9
Minnesota	23,175	28,275	31,275	473,816	523,797	526,091	48.9	54.0	59.4
Mississippi	10,988	11,681	12,430	312,663	317,707	313,729	35.1	36.8	39.6
Missouri	29,978	34,306	38,370	538,883	586,404	592,454	55.6	58.5	64.8
Montana	5,171	5,177	5,252	86,241	103,362	104,243	60.0	50.1	50.4
Nebraska	10,747	11,999	12,575	175,359	197,081	196,793	61.3	60.9	63.9
Nevada	4,245	5,608	7,119	181,984	210,962	228,809	23.3	26.6	31.1
New Hampshire	7,776	8,107	8,879	104,064	123,750	130,242	74.7	65.5	68.2
New Jersey	26,939	31,987	34,625	679,702	716,880	756,033	39.6	44.6	45.8
New Mexico	6,727	7,342	7,875	177,978	202,397	202,276	37.8	36.3	38.9
New York	95,558	111,201	122,186	1,772,439	1,839,901	1,923,887	53.9	60.4	63.5
North Carolina	35,257	39,303	44,834	814,485	855,830	942,328	43.3	45.9	47.6
North Dakota	4,877	5,161	5,604	73,371	89,501	88,808	66.5	57.7	63.1
Ohio	49,849	56,969	60,048	1,062,062	1,084,194	1,084,493	46.9	52.5	55.4
Oklahoma	15,578	18,266	19,634	358,410	387,237	386,532	43.5	47.2	50.8
Oregon	14,428	16,867	17,918	330,074	351,657	364,365	43.7	48.0	49.2
Pennsylvania	66,273	77,765	84,692	1,099,275	1,169,151	1,219,844	60.3	66.5	69.4
Rhode Island	8,402	9,417	10,291	107,100	109,690	112,088	78.5	85.9	91.8
South Carolina	16,033	18,795	21,058	410,784	427,535	452,903	39.0	44.0	46.5
South Dakota	4,494	4,771	5,031	78,087	87,891	87,586	57.6	54.3	57.4
Tennessee	22,958	26,032	29,388	552,177	570,664	585,173	41.6	45.6	50.2
Texas	75,834	88,757	102,157	2,213,346	2,429,659	2,523,258	34.3	36.5	40.5
Utah	17,058	20,799	21,504	320,147	342,610	341,926	53.3	60.7	62.9
Vermont	4,832	4,892	5,788	56,918	66,960	68,869	84.9	73.1	84.0
Virginia	33,599	36,970	42,483	686,011	776,170	814,917	49.0	47.6	52.1
Washington	24,002	28,265	30,091	563,091	617,519	644,616	42.6	45.8	46.7
West Virginia	8,545	9,574	11,366	173,092	172,766	169,767	49.4	55.4	67.0
Wisconsin	27,543	31,144	33,651	523,861	585,387	590,593	52.6	53.2	57.0
Wyoming	1,797	1,695	1,765	50,157	57,751	59,634	35.8	29.4	29.6
Puerto Rico	16,164	16,646	17,116	429,220	406,548	394,800	37.7	40.9	43.4

SOURCES: National Center for Education Statistics, Integrated Postsecondary Education Data System (various years); Census Bureau, 2000 Decennial Census and Population Estimates Program (various years).

Science and Engineering Indicators 2012

Bachelor's Degrees in Science and Engineering Conferred per 1,000 Individuals 18–24 Years Old

Figure 8-17
Bachelor's degrees in science and engineering conferred per 1,000 individuals 18–24 years old: 2009



SOURCES: National Center for Education Statistics, Integrated Postsecondary Education Data System; Census Bureau, 2000 Decennial Census and Population Estimates Program.

Findings

- In 2009, more than 501,000 bachelor's degrees in S&E fields were conferred nationally, which is up from 394,000 in 2000 and represents an increase of 27%. Between 2000 and 2009, the number of bachelor's degrees in S&E fields conferred per 1,000 individuals 18–24 years old in the population increased by nearly 15% nationwide.
- In 2009, state values on this indicator varied greatly. They ranged from 7.0 to 31.4 bachelor's degrees in S&E fields conferred per 1,000 individuals 18–24 years old.
- The number of bachelor's degrees in S&E fields conferred per 1,000 individuals 18–24 years old decreased in 7 states between 2000 and 2009.
- The states producing the largest numbers of S&E bachelor's degrees were the same as those producing the largest numbers of bachelor's degrees in natural science and engineering (NS&E). However, in terms of educational output adjusted for population, the concentration of S&E bachelor's degrees was highest in the northeastern states unlike NS&E bachelor's degrees that were concentrated in the north central states.

Educational attainment in an S&E field gives people greater opportunities to work in higher-paying technical jobs than are generally available to those in other fields of study. Earning a bachelor's degree in an S&E field also prepares an individual for advanced technical education.

Educational attainment varies by several demographic characteristics including age. The cohort 18–24 years old was chosen to approximate the age range of most students who are pursuing an undergraduate degree. This indicator represents the extent to which a state provides bachelor's level training in S&E fields, controlling for the size of its college-age population.

The number of bachelor's degrees awarded in S&E fields is based on an actual count provided by the National Center of Education Statistics. Estimates of the population ages 18–24 years are provided by the U.S. Census Bureau. Small differences in the indicator value between states or across time generally are not meaningful.

A high value for this indicator may suggest the successful provision of undergraduate training in S&E fields. Student mobility after graduation is not accounted for, which may make this indicator less meaningful in predicting the qualifications of a state's future technical workforce. A state's value for this indicator may also be high when its higher education system draws a large percentage of out-of-state students, a situation that sometimes occurs in states with small resident populations and the District of Columbia.

Table 8-17
Bachelor's degrees in science and engineering conferred per 1,000 individuals 18–24 years old, by state: 2000, 2005, and 2009

	S&E bachelor's degrees			Population 18–24 years old			Degrees/1,000 individuals 18–24 years old		
State	2000	2005	2009	2000	2005	2009	2000	2005	2009
EPSCoR states	61,035	67,202	71,999	4,702,607	5,059,909	5,109,850	13.0	13.3	14.1
Non-EPSCoR states	330,351	394,690	424,576	22,541,063	24,277,168	25,229,846	14.7	16.3	16.8
Average EPSCoR state value	na	na	na	na	na	na	15.1	14.7	15.7
Average non-EPSCoR state value	na	na	na	na	na	na	15.6	17.1	17.8
United States	394,301	466,065	501,076	27,316,537	29,404,797	30,412,035	14.4	15.8	16.5
Alabama	5,575	5,767	6,490	442,009	453,363	465,249	12.6	12.7	13.9
Alaska	393	440	559	57,724	78,831	79,696	6.8	5.6	7.0
Arizona	5,154	7,741	10,173	519,381	570,206	610,920	9.9	13.6	16.7
Arkansas	2,392	2,748	2,751	263,326	269,720	273,263	9.1	10.2	10.1
California	46,406	58,536	63,381	3,389,475	3,601,422	3,746,026	13.7	16.3	16.9
Colorado	8,822	10,375	10,865	434,165	479,582	500,695	20.3	21.6	21.7
Connecticut	5,139	5,945	6,803	273,000	315,265	340,550	18.8	18.9	20.0
Delaware	1,546	1,656	1,688	75,857	79,909	83,522	20.4	20.7	20.2
District of Columbia	2,915	4,173	4,501	72,867	67,720	72,339	40.0	61.6	62.2
Florida	14,094	19,400	22,608	1,340,658	1,583,393	1,667,090	10.5	12.3	13.6
Georgia	8,990	11,354	11,782	844,924	912,133	979,688	10.6	12.4	12.0
Hawaii	1,660	1,854	2,074	115,683	128,311	124,841	14.3	14.4	16.6
Idaho	1,492	1,960	2,340	140,017	157,526	161,387	10.7	12.4	14.5
Illinois	15,960	18,943	19,471	1,217,816	1,273,336	1,298,744	13.1	14.9	15.0
Indiana	8,921	10,477	10,211	618,463	637,074	643,920	14.4	16.4	15.9
Iowa	5,556	6,117	7,656	299,438	320,586	321,355	18.6	19.1	23.8
Kansas	4,157	4,713	4,599	277,164	306,834	307,284	15.0	15.4	15.0
Kentucky	4,153	4,537	4,944	404,146	417,504	416,470	10.3	10.9	11.9
Louisiana	5,568	6,076	5,782	475,946	496,032	477,506	11.7	12.2	12.1
Maine	2,117	2,354	2,518	104,527	117,289	118,353	20.3	20.1	21.3
Maryland	8,598	11,057	11,393	454,129	515,830	547,538	18.9	21.4	20.8
Massachusetts	16,062	17,589	18,463	582,619	621,142	668,112	27.6	28.3	27.6
Michigan	13,642	15,591	16,873	937,626	997,376	995,230	14.5	15.6	17.0
Minnesota	7,434	9,271	10,060	473,816	523,797	526,091	15.7	17.7	19.1
Mississippi	2,769	2,784	3,036	312,663	317,707	313,729	8.9	8.8	9.7
Missouri	8,169	9,532	9,908	538,883	586,404	592,454	15.2	16.3	16.7
Montana	1,734	1,807	1,874	86,241	103,362	104,243	20.1	17.5	18.0
Nebraska	2,657	3,039	3,133	175,359	197,081	196,793	15.2	15.4	15.9
Nevada	1,050	1,481	2,039	181,984	210,962	228,809	5.8	7.0	8.9
New Hampshire	2,788	2,826	2,929	104,064	123,750	130,242	26.8	22.8	22.5
New Jersey	10,822	11,856	12,028	679,702	716,880	756,033	15.9	16.5	15.9
New Mexico	1,939	2,188	2,308	177,978	202,397	202,276	10.9	10.8	11.4
New York	32,141	37,642	39,595	1,772,439	1,839,901	1,923,887	18.1	20.5	20.6
North Carolina	12,021	13,488	14,833	814,485	855,830	942,328	14.8	15.8	15.7
North Dakota	1,329	1,305	1,326	73,371	89,501	88,808	18.1	14.6	14.9
Ohio	13,874	15,485	16,257	1,062,062	1,084,194	1,084,493	13.1	14.3	15.0
Oklahoma	4,001	4,718	4,878	358,410	387,237	386,532	11.2	12.2	12.6
Oregon	5,381	6,261	6,545	330,074	351,657	364,365	16.3	17.8	18.0
Pennsylvania	21,115	24,723	26,514	1,099,275	1,169,151	1,219,844	19.2	21.1	21.7
Rhode Island	2,503	2,837	3,082	107,100	109,690	112,088	23.4	25.9	27.5
South Carolina	4,996	5,784	6,151	410,784	427,535	452,903	12.2	13.5	13.6
South Dakota	1,506	1,494	1,571	78,087	87,891	87,586	19.3	17.0	17.9
Tennessee	6,532	7,156	7,727	552,177	570,664	585,173	11.8	12.5	13.2
Texas	20,831	25,294	27,723	2,213,346	2,429,659	2,523,258	9.4	10.4	11.0
Utah	5,245	6,870	6,986	320,147	342,610	341,926	16.4	20.1	20.4
Vermont	1,821	1,992	2,349	56,918	66,960	68,869	32.0	29.7	34.1
Virginia	12,933	13,748	15,158	686,011	776,170	814,917	18.9	17.7	18.6
Washington	7,905	10,121	10,692	563,091	617,519	644,616	14.0	16.4	16.6
West Virginia	2,204	2,285	2,929	173,092	172,766	169,767	12.7	13.2	17.3
Wisconsin	8,604	10,118	10,871	523,861	585,387	590,593	16.4	17.3	18.4
Wyoming	685	557	649	50,157	57,751	59,634	13.7	9.6	10.9
Puerto Rico	4,187	4,042	4,237	429,220	406,548	394,800	9.8	9.9	10.7

na = not applicable

EPSCoR = Experimental Program to Stimulate Competitive Research

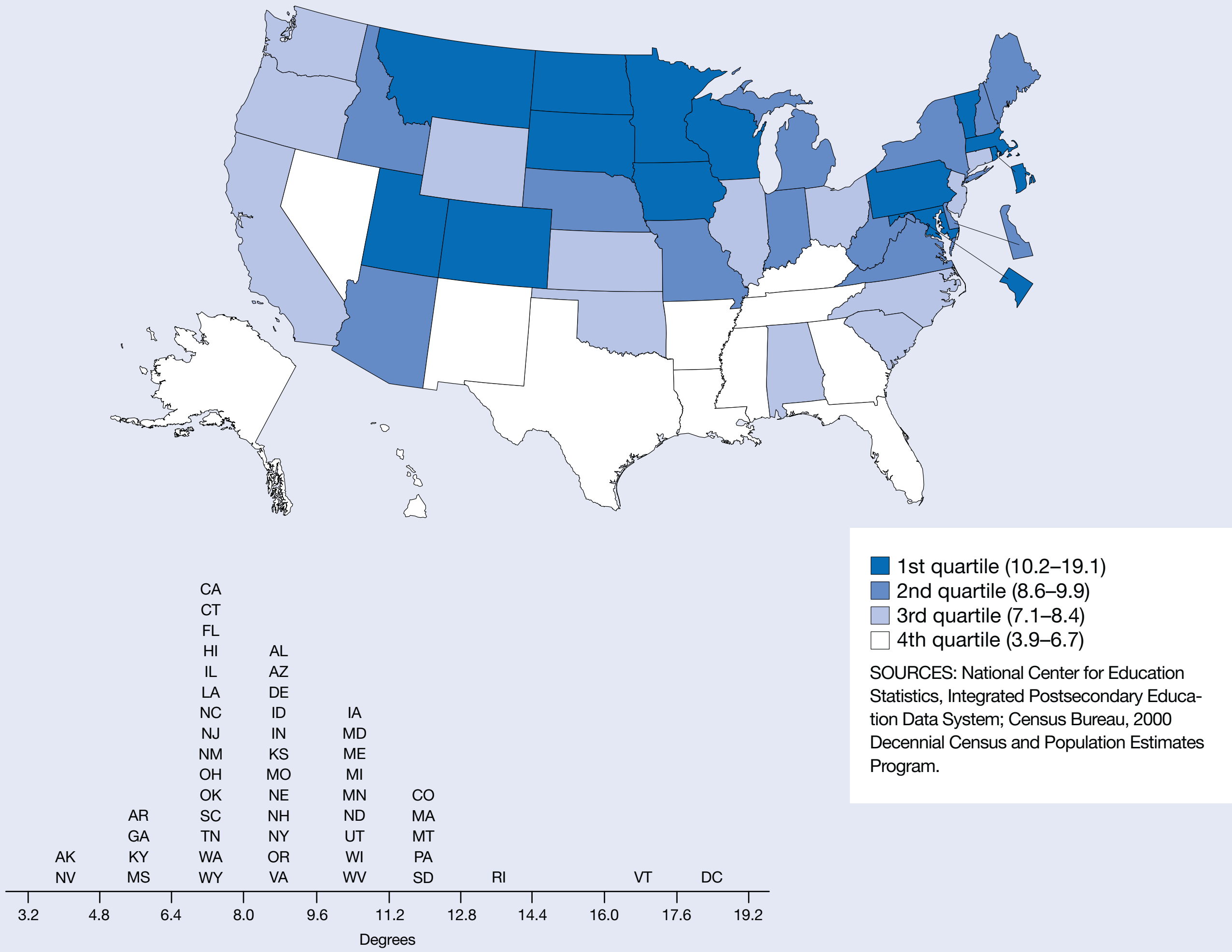
NOTE: For explanation of EPSCoR and non-EPSCoR averages, see chapter introduction.

SOURCES: National Center for Education Statistics, Integrated Postsecondary Education Data System (various years); Census Bureau, 2000 Decennial Census and Population Estimates Program (various years).

Science and Engineering Indicators 2012

Bachelor's Degrees in Natural Sciences and Engineering Conferred per 1,000 Individuals 18–24 Years Old

Figure 8-18
Bachelor's degrees in natural sciences and engineering conferred per 1,000 individuals 18–24 years old: 2009



SOURCES: National Center for Education Statistics, Integrated Postsecondary Education Data System; Census Bureau, 2000 Decennial Census and Population Estimates Program.

Findings

- Between 2000 and 2009, the value of this indicator did not change appreciably.
- In 2009, the value of this indicator ranged from 3.9 to16.0 natural sciences and engineering (NS&E) bachelor's degrees conferred per 1,000 individuals 18–24 years old for individual states.
- The states conferring the largest number of bachelor's degrees in NS&E fields were California, New York, Texas, and Pennsylvania.
- States that ranked in the top 2 quartiles on this indicator were generally the same as those in the top 2 quartiles for the number of bachelor's degrees conferred per 1,000 individuals 18–24 years old.

Natural sciences and engineering (NS&E) fields include the physical, earth, ocean, atmospheric, biological, agricultural, and computer sciences; mathematics; and engineering. NS&E fields do not include social sciences and psychology. This indicator is the ratio of new NS&E bachelor's degrees to the population ages18–24 years and represents the extent to which a state prepares young people to enter technology-intensive occupations that are fundamental to a knowledge-based, technology-driven economy. In addition, the presence of higher education institutions that produce such degrees may generate resources for the state. The cohort 18–24 years old was chosen to approximate the age range of most students who are pursing an undergraduate degree.

The number of NS&E bachelor's degrees awarded is based on an actual count provided by the National Center for Education Statistics. Estimates of the population ages 18–24 years are provided by the U.S. Census Bureau. Small differences in the value of the indicator between states or across time generally are not meaningful.

Because students often relocate after graduation, this measure does not necessarily indicate the qualifications of a state's future workforce. A state's value for this indicator may also be high when its higher education system draws a large number of out-of-state students who study NS&E fields, a situation that occurs in the District of Columbia and some states with small resident populations.

Table 8-18
Bachelor's degrees in natural sciences and engineering conferred per 1,000 individuals 18–24 years old, by state: 2000, 2005, and 2009

	NS&E bachelor's degrees			Population 18–24 years old			Degrees/1,000 individuals 18–24 years old		
State	2000	2005	2009	2000	2005	2009	2000	2005	2009
EPSCoR states	35,201	37,177	38,960	4,702,607	5,059,909	5,109,850	7.5	7.3	7.6
Non-EPSCoR states	171,285	198,206	209,080	22,541,063	24,277,168	25,229,846	7.6	8.2	8.3
Average EPSCoR state value	na	na	na	na	na	na	8.5	8.0	8.4
Average non-EPSCoR state value	na	na	na	na	na	na	8.1	8.6	8.8
United States	207,375	236,700	249,420	27,316,537	29,404,797	30,412,035	7.6	8.0	8.2
Alabama	3,556	3,511	3,891	442,009	453,363	465,249	8.0	7.7	8.4
Alaska	240	248	313	57,724	78,831	79,696	4.2	3.1	3.9
Arizona	2,928	5,069	5,284	519,381	570,206	610,920	5.6	8.9	8.6
Arkansas	1,440	1,630	1,563	263,326	269,720	273,263	5.5	6.0	5.7
California	22,036	26,786	28,386	3,389,475	3,601,422	3,746,026	6.5	7.4	7.6
Colorado	4,742	5,475	5,714	434,165	479,582	500,695	10.9	11.4	11.4
Connecticut	1,852	2,116	2,540	273,000	315,265	340,550	6.8	6.7	7.5
Delaware	696	694	740	75,857	79,909	83,522	9.2	8.7	8.9
District of Columbia	889	1,317	1,380	72,867	67,720	72,339	12.2	19.4	19.1
Florida	7,353	9,097	10,769	1,340,658	1,583,393	1,667,090	5.5	5.7	6.5
Georgia	5,190	6,063	6,190	844,924	912,133	979,688	6.1	6.6	6.3
Hawaii	719	754	842	115,683	128,311	124,841	6.2	5.9	6.7
Idaho	1,013	1,234	1,437	140,017	157,526	161,387	7.2	7.8	8.9
Illinois	8,971	11,002	10,080	1,217,816	1,273,336	1,298,744	7.4	8.6	7.8
Indiana	5,113	5,797	5,573	618,463	637,074	643,920	8.3	9.1	8.7
Iowa	3,135	3,249	3,563	299,438	320,586	321,355	10.5	10.1	11.1
Kansas	2,436	2,637	2,463	277,164	306,834	307,284	8.8	8.6	8.0
Kentucky	2,266	2,293	2,503	404,146	417,504	416,470	5.6	5.5	6.0
Louisiana	3,395	3,600	3,216	475,946	496,032	477,506	7.1	7.3	6.7
Maine	1,091	1,136	1,172	104,527	117,289	118,353	10.4	9.7	9.9
Maryland	4,422	5,911	5,669	454,129	515,830	547,538	9.7	11.5	10.4
Massachusetts	7,328	7,623	8,215	582,619	621,142	668,112	12.6	12.3	12.3
Michigan	8,315	9,174	9,620	937,626	997,376	995,230	8.9	9.2	9.7
Minnesota	4,067	4,861	5,346	473,816	523,797	526,091	8.6	9.3	10.2
Mississippi	1,733	1,630	1,757	312,663	317,707	313,729	5.5	5.1	5.6
Missouri	4,767	5,350	5,329	538,883	586,404	592,454	8.8	9.1	9.0
Montana	1,173	1,127	1,223	86,241	103,362	104,243	13.6	10.9	11.7
Nebraska	1,581	1,642	1,782	175,359	197,081	196,793	9.0	8.3	9.1
Nevada	548	739	989	181,984	210,962	228,809	3.0	3.5	4.3
New Hampshire	1,281	1,130	1,186	104,064	123,750	130,242	12.3	9.1	9.1
New Jersey	5,249	5,354	5,376	679,702	716,880	756,033	7.7	7.5	7.1
New Mexico	1,243	1,392	1,306	177,978	202,397	202,276	7.0	6.9	6.5
New York	14,451	16,705	17,096	1,772,439	1,839,901	1,923,887	8.2	9.1	8.9
North Carolina	6,172	6,774	7,308	814,485	855,830	942,328	7.6	7.9	7.8
North Dakota	893	913	929	73,371	89,501	88,808	12.2	10.2	10.5
Ohio	7,828	8,106	8,504	1,062,062	1,084,194	1,084,493	7.4	7.5	7.8
Oklahoma	2,491	2,636	2,727	358,410	387,237	386,532	7.0	6.8	7.1
Oregon	2,440	2,831	3,068	330,074	351,657	364,365	7.4	8.1	8.4
Pennsylvania	11,671	13,719	14,453	1,099,275	1,169,151	1,219,844	10.6	11.7	11.8
Rhode Island	1,236	1,531	1,566	107,100	109,690	112,088	11.5	14.0	14.0
South Carolina	2,684	3,130	3,199	410,784	427,535	452,903	6.5	7.3	7.1
South Dakota	981	1,039	996	78,087	87,891	87,586	12.6	11.8	11.4
Tennessee	3,455	3,541	3,921	552,177	570,664	585,173	6.3	6.2	6.7
Texas	11,868	13,692	15,185	2,213,346	2,429,659	2,523,258	5.4	5.6	6.0
Utah	2,817	3,412	3,766	320,147	342,610	341,926	8.8	10.0	11.0
Vermont	840	865	1,102	56,918	66,960	68,869	14.8	12.9	16.0
Virginia	6,414	6,310	7,096	686,011	776,170	814,917	9.3	8.1	8.7
Washington	3,850	4,615	4,985	563,091	617,519	644,616	6.8	7.5	7.7
West Virginia	1,208	1,288	1,637	173,092	172,766	169,767	7.0	7.5	9.6
Wisconsin	4,851	5,574	6,044	523,861	585,387	590,593	9.3	9.5	10.2
Wyoming	457	378	421	50,157	57,751	59,634	9.1	6.5	7.1
Puerto Rico	3,013	2,848	3,039	429,220	406,548	394,800	7.0	7.0	7.7

na = not applicable

EPSCoR = Experimental Program to Stimulate Competitive Research; NS&E = natural sciences and engineering

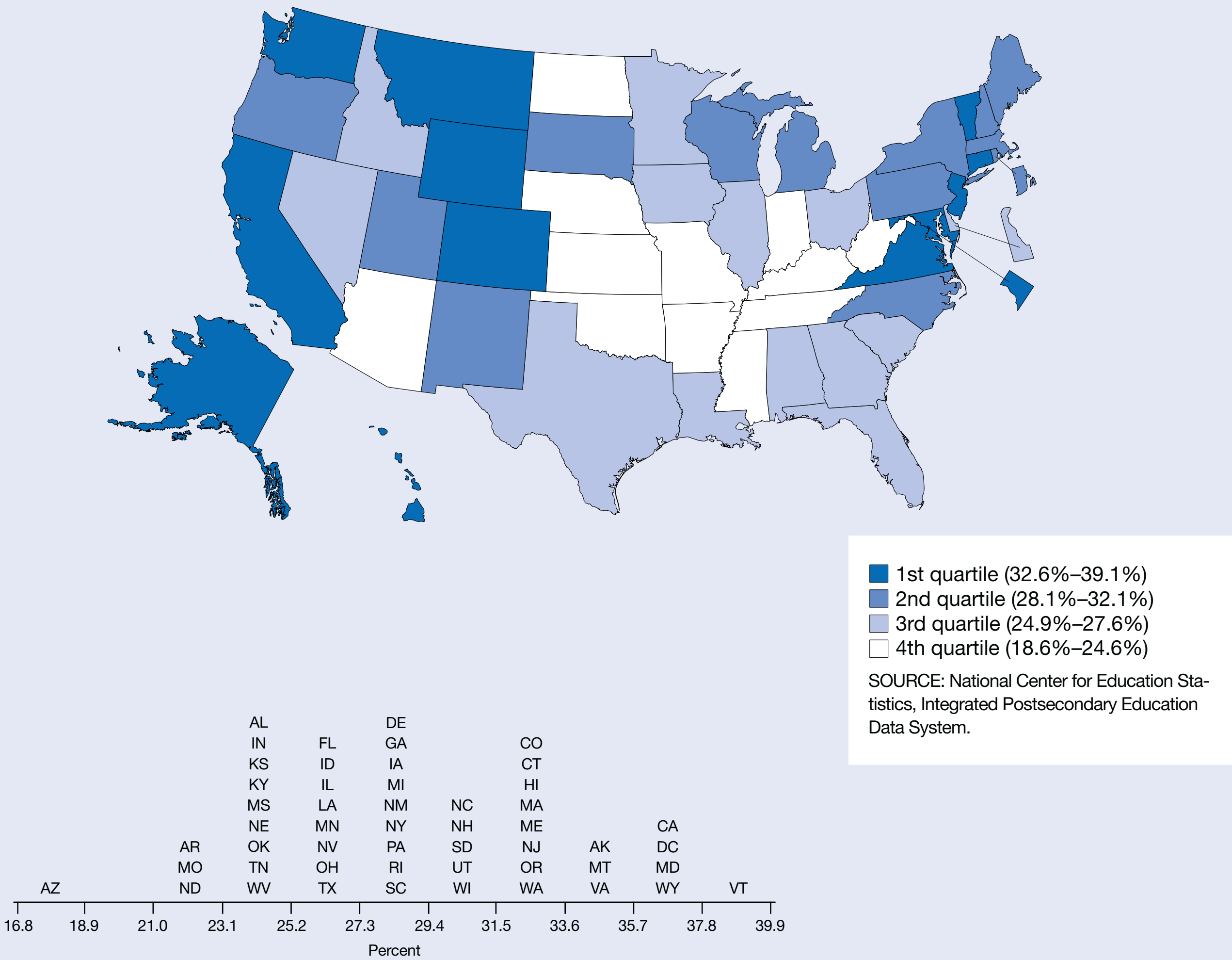
NOTE: For explanation of EPSCoR and non-EPSCoR averages, see chapter introduction.

SOURCES: National Center for Education Statistics, Integrated Postsecondary Education Data System (various years); Census Bureau, 2000 Decennial Census and Population Estimates Program (various years).

Science and Engineering Indicators 2012

Science and Engineering Degrees as a Percentage of Higher Education Degrees Conferred

Figure 8-19
Science and engineering degrees as a percentage of higher education degrees conferred: 2009



SOURCE: National Center for Education Statistics, Integrated Postsecondary Education Data System.

Findings

- In 2009, nearly 668,000 S&E bachelor's, master's, and doctoral degrees were conferred nationwide, an increase of 30% since 2000.
- Nationally, the proportion of S&E degrees as a share of total degrees conferred decreased by 3% between 2005 and 2009.
- There are noteworthy differences in the proportions of S&E higher education degrees conferred in different states. In some states, only about 20% of higher education degrees were awarded in S&E fields. In others, nearly 40% of higher education degrees were awarded in S&E fields.
- The District of Columbia has a high value because of the large number of programs in political science and public administration at several of its academic institutions.

This indicator represents the extent to which a state's higher education programs are concentrated in S&E fields. S&E fields include the physical, life, earth, ocean, atmospheric, computer, and social sciences; mathematics; engineering; and psychology. Counts of both S&E degrees and higher education degrees conferred include bachelor's, master's, and doctoral degrees; associate's degrees are not included.

Degree data reflect the location of the degree-granting institution, not the state where degree-earning students permanently reside. The year indicates the end date of the academic year. For example, data for 2009 represent degrees conferred during the 2008–09 academic year. All degree data are actual counts.

Table 8-19
Science and engineering degrees as a percentage of higher education degrees conferred, by state: 2000, 2005, and 2009

	All S&E degrees			All higher education degrees			All S&E degrees/all higher education degrees (%)		
State	2000	2005	2009	2000	2005	2009	2000	2005	2009
United States	515,298	614,694	667,790	1,739,739	2,066,513	2,322,054	29.6	29.7	28.8
Alabama	7,512	8,038	8,899	29,848	32,180	35,725	25.2	25.0	24.9
Alaska	578	676	802	1,901	2,107	2,267	30.4	32.1	35.4
Arizona	6,890	9,613	13,432	31,863	49,921	72,140	21.6	19.3	18.6
Arkansas	2,828	3,306	3,390	11,916	14,291	16,089	23.7	23.1	21.1
California	61,903	77,557	84,579	171,337	207,416	230,605	36.1	37.4	36.7
Colorado	11,733	13,745	14,280	31,689	38,125	43,834	37.0	36.1	32.6
Connecticut	6,887	8,154	9,615	23,703	26,359	29,078	29.1	30.9	33.1
Delaware	1,940	2,163	2,241	6,296	7,512	8,118	30.8	28.8	27.6
District of Columbia	5,740	7,490	8,469	14,433	18,348	22,525	39.8	40.8	37.6
Florida	18,293	24,845	29,004	71,408	92,917	112,165	25.6	26.7	25.9
Georgia	11,754	14,807	15,775	40,661	49,851	57,165	28.9	29.7	27.6
Hawaii	2,235	2,412	2,656	6,986	7,497	8,001	32.0	32.2	33.2
Idaho	1,823	2,384	2,797	5,943	9,057	10,816	30.7	26.3	25.9
Illinois	22,464	27,237	28,725	84,112	102,657	111,875	26.7	26.5	25.7
Indiana	11,404	13,317	13,251	41,655	49,048	54,032	27.4	27.2	24.5
Iowa	6,611	7,378	9,079	23,165	25,774	33,315	28.5	28.6	27.3
Kansas	5,317	6,068	5,920	19,617	22,348	24,284	27.1	27.2	24.4
Kentucky	5,091	6,088	6,481	20,865	24,937	28,070	24.4	24.4	23.1
Louisiana	6,998	7,849	7,199	26,338	28,930	28,256	26.6	27.1	25.5
Maine	2,302	2,550	2,749	6,916	8,188	8,717	33.3	31.1	31.5
Maryland	12,235	15,675	16,514	33,753	40,381	44,369	36.2	38.8	37.2
Massachusetts	22,662	25,251	26,712	69,410	76,108	83,467	32.6	33.2	32.0
Michigan	18,430	21,335	22,804	67,567	75,675	78,332	27.3	28.2	29.1
Minnesota	9,043	11,915	13,887	31,839	42,566	52,323	28.4	28.0	26.5
Mississippi	3,397	3,577	3,937	14,598	15,931	17,023	23.3	22.5	23.1
Missouri	10,965	12,984	13,464	43,783	52,849	59,466	25.0	24.6	22.6
Montana	2,102	2,254	2,298	6,187	6,416	6,559	34.0	35.1	35.0
Nebraska	3,304	3,847	4,193	14,008	16,427	17,411	23.6	23.4	24.1
Nevada	1,365	1,963	2,585	5,813	7,776	9,884	23.5	25.2	26.2
New Hampshire	3,342	3,460	3,684	10,330	11,025	12,375	32.4	31.4	29.8
New Jersey	13,940	15,667	16,535	37,278	45,515	49,544	37.4	34.4	33.4
New Mexico	2,636	3,065	3,255	9,664	10,874	11,366	27.3	28.2	28.6
New York	42,901	51,470	54,412	146,896	176,054	193,777	29.2	29.2	28.1
North Carolina	14,651	16,665	18,671	46,045	52,192	60,854	31.8	31.9	30.7
North Dakota	1,519	1,539	1,610	5,798	6,454	7,128	26.2	23.8	22.6
Ohio	18,123	20,287	21,129	68,854	79,349	83,813	26.3	25.6	25.2
Oklahoma	5,982	6,342	6,384	21,374	24,398	25,995	28.0	26.0	24.6
Oregon	6,608	7,805	7,975	19,647	23,492	24,858	33.6	33.2	32.1
Pennsylvania	26,563	31,478	34,537	90,495	107,174	119,761	29.4	29.4	28.8
Rhode Island	3,012	3,447	3,783	10,524	11,883	13,002	28.6	29.0	29.1
South Carolina	5,953	6,855	7,279	20,995	24,268	26,666	28.4	28.2	27.3
South Dakota	1,813	1,966	1,990	5,456	6,077	6,377	33.2	32.4	31.2
Tennessee	8,029	8,749	9,601	31,502	35,453	40,553	25.5	24.7	23.7
Texas	27,962	34,612	38,196	103,283	124,122	142,321	27.1	27.9	26.8
Utah	6,289	8,153	8,339	20,866	25,382	27,003	30.1	32.1	30.9
Vermont	2,230	2,508	3,144	6,350	6,638	8,031	35.1	37.8	39.1
Virginia	16,299	17,810	20,822	45,870	51,210	60,840	35.5	34.8	34.2
Washington	9,720	12,449	13,215	32,085	37,831	40,136	30.3	32.9	32.9
West Virginia	2,750	2,945	3,772	11,144	12,522	15,787	24.7	23.5	23.9
Wisconsin	10,260	12,187	12,881	35,426	40,806	43,694	29.0	29.9	29.5
Wyoming	910	757	839	2,247	2,202	2,262	40.5	34.4	37.1
Puerto Rico	4,807	4,817	5,293	19,261	21,111	23,501	25.0	22.8	22.5

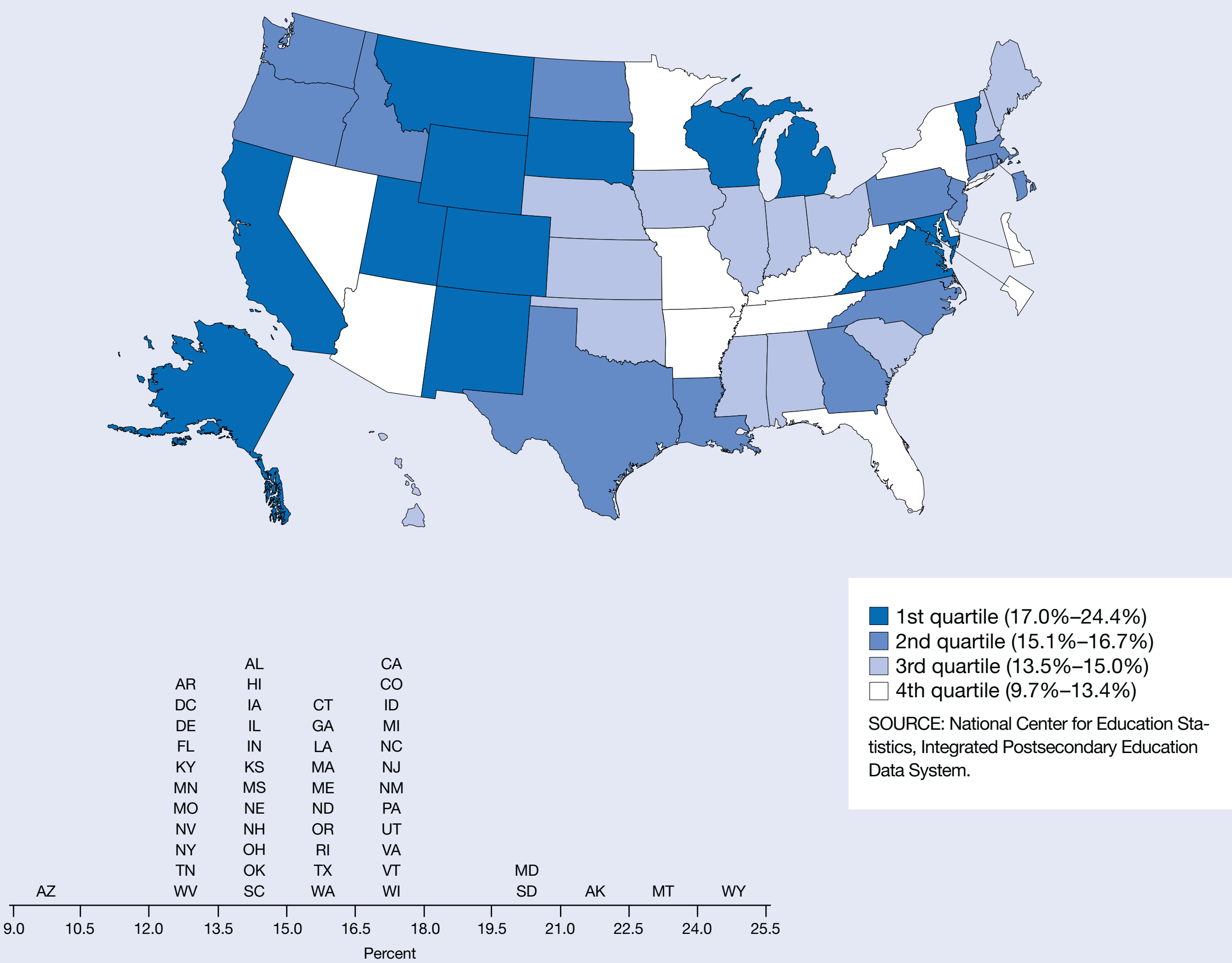
NOTES: All S&E degrees include bachelor's, master's, and doctorate. All S&E degrees include physical, computer, agricultural, biological, earth, atmospheric, ocean, and social sciences; psychology; mathematics; and engineering. All higher education degrees include bachelor's, master's, and doctorate.

SOURCE: National Center for Education Statistics, Integrated Postsecondary Education Data System (various years).

Science and Engineering Indicators 2012

Natural Sciences and Engineering Degrees as a Percentage of Higher Education Degrees Conferred

Figure 8-20
Natural sciences and engineering degrees as a percentage of higher education degrees conferred: 2009



SOURCE: National Center for Education Statistics, Integrated Postsecondary Education Data System.

Findings

- In 2009, nearly 354,000 NS&E bachelor's, master's, and doctoral degrees were conferred nationwide, an increase of 25% since 2000.
- The proportion of NS&E degrees as a share of total degrees conferred showed a decline of 5% between 2005 and 2009.
- There are noteworthy differences in the proportions of natural sciences and engineering higher education degrees conferred in different states. In 2009, the proportions ranged between 9.7% and 24.4%.
- Nationally, over half, 53%, of all S&E degrees were in NS&E fields in 2009, down from 55% of all S&E degrees in 2000.
- States with the highest percentage of higher education degrees in natural science or engineering fields tended to be located in the western United States, and four of the top five are EPSCoR states.

This indicator represents the extent to which a state's higher education programs are concentrated in natural sciences and engineering (NS&E) fields. The indicator is expressed as the percentage of higher education degrees that were conferred in NS&E fields.

NS&E fields include the physical, life, earth, ocean, atmospheric, and computer sciences; mathematics; and engineering. Social sciences such as anthropology, economics, political science and public administration; psychology; and sociology are not included. Counts of both NS&E degrees and higher education degrees conferred include bachelor's, master's, and doctoral degrees; associate's degrees are not included.

Degree data reflect the location of the degree-granting institution, not the state in which degree-earning students permanently reside. The year reflects the end date of the academic year. For example, data for 2009 represent degrees conferred during the 2008–09 academic year. All degree data are actual counts.

Table 8-20
Natural sciences and engineering degrees as a percentage of higher education degrees conferred, by state: 2000, 2005, and 2009

	NS&E degrees			All higher education degrees			NS&E/higher education degrees (%)		
State	2000	2005	2009	2000	2005	2009	2000	2005	2009
United States	283,371	331,247	353,509	1,739,739	2,066,513	2,322,054	16.3	16.0	15.2
Alabama	4,464	4,732	5,261	29,848	32,180	35,725	15.0	14.7	14.7
Alaska	360	419	475	1,901	2,107	2,267	18.9	19.9	21.0
Arizona	4,063	6,343	6,989	31,863	49,921	72,140	12.8	12.7	9.7
Arkansas	1,734	2,022	1,970	11,916	14,291	16,089	14.6	14.1	12.2
California	30,833	38,181	40,990	171,337	207,416	230,605	18.0	18.4	17.8
Colorado	6,823	7,663	7,827	31,689	38,125	43,834	21.5	20.1	17.9
Connecticut	3,007	3,634	4,624	23,703	26,359	29,078	12.7	13.8	15.9
Delaware	917	980	1,069	6,296	7,512	8,118	14.6	13.0	13.2
District of Columbia	2,091	2,561	2,949	14,433	18,348	22,525	14.5	14.0	13.1
Florida	9,942	12,636	15,036	71,408	92,917	112,165	13.9	13.6	13.4
Georgia	7,099	8,354	9,025	40,661	49,851	57,165	17.5	16.8	15.8
Hawaii	1,004	1,011	1,109	6,986	7,497	8,001	14.4	13.5	13.9
Idaho	1,272	1,568	1,797	5,943	9,057	10,816	21.4	17.3	16.6
Illinois	13,053	16,027	15,937	84,112	102,657	111,875	15.5	15.6	14.2
Indiana	6,723	7,637	7,493	41,655	49,048	54,032	16.1	15.6	13.9
Iowa	3,939	4,205	4,633	23,165	25,774	33,315	17.0	16.3	13.9
Kansas	3,196	3,557	3,290	19,617	22,348	24,284	16.3	15.9	13.5
Kentucky	2,819	3,215	3,392	20,865	24,937	28,070	13.5	12.9	12.1
Louisiana	4,357	4,895	4,260	26,338	28,930	28,256	16.5	16.9	15.1
Maine	1,228	1,272	1,305	6,916	8,188	8,717	17.8	15.5	15.0
Maryland	6,854	9,110	9,142	33,753	40,381	44,369	20.3	22.6	20.6
Massachusetts	11,309	12,222	13,219	69,410	76,108	83,467	16.3	16.1	15.8
Michigan	11,873	13,474	13,861	67,567	75,675	78,332	17.6	17.8	17.7
Minnesota	5,056	6,333	6,873	31,839	42,566	52,323	15.9	14.9	13.1
Mississippi	2,195	2,225	2,427	14,598	15,931	17,023	15.0	14.0	14.3
Missouri	5,974	6,935	7,182	43,783	52,849	59,466	13.6	13.1	12.1
Montana	1,458	1,455	1,529	6,187	6,416	6,559	23.6	22.7	23.3
Nebraska	1,958	2,212	2,393	14,008	16,427	17,411	14.0	13.5	13.7
Nevada	756	1,035	1,326	5,813	7,776	9,884	13.0	13.3	13.4
New Hampshire	1,656	1,563	1,730	10,330	11,025	12,375	16.0	14.2	14.0
New Jersey	7,469	7,859	8,283	37,278	45,515	49,544	20.0	17.3	16.7
New Mexico	1,704	2,015	1,982	9,664	10,874	11,366	17.6	18.5	17.4
New York	20,638	24,534	25,832	146,896	176,054	193,777	14.0	13.9	13.3
North Carolina	8,070	9,084	10,110	46,045	52,192	60,854	17.5	17.4	16.6
North Dakota	1,026	1,087	1,147	5,798	6,454	7,128	17.7	16.8	16.1
Ohio	10,671	11,425	11,767	68,854	79,349	83,813	15.5	14.4	14.0
Oklahoma	3,366	3,821	3,740	21,374	24,398	25,995	15.7	15.7	14.4
Oregon	3,224	3,852	3,947	19,647	23,492	24,858	16.4	16.4	15.9
Pennsylvania	15,119	18,344	19,701	90,495	107,174	119,761	16.7	17.1	16.5
Rhode Island	1,589	1,914	1,988	10,524	11,883	13,002	15.1	16.1	15.3
South Carolina	3,417	3,971	3,967	20,995	24,268	26,666	16.3	16.4	14.9
South Dakota	1,142	1,324	1,253	5,456	6,077	6,377	20.9	21.8	19.6
Tennessee	4,430	4,560	5,083	31,502	35,453	40,553	14.1	12.9	12.5
Texas	17,004	20,489	22,601	103,283	124,122	142,321	16.5	16.5	15.9
Utah	3,541	4,327	4,699	20,866	25,382	27,003	17.0	17.0	17.4
Vermont	1,008	1,097	1,365	6,350	6,638	8,031	15.9	16.5	17.0
Virginia	8,627	8,689	10,456	45,870	51,210	60,840	18.8	17.0	17.2
Washington	5,009	5,981	6,415	32,085	37,831	40,136	15.6	15.8	16.0
West Virginia	1,571	1,764	2,042	11,144	12,522	15,787	14.1	14.1	12.9
Wisconsin	6,105	7,124	7,466	35,426	40,806	43,694	17.2	17.5	17.1
Wyoming	628	510	552	2,247	2,202	2,262	27.9	23.2	24.4
Puerto Rico	3,314	3,244	3,586	19,261	21,111	23,501	17.2	15.4	15.3

NS&E = natural sciences and engineering

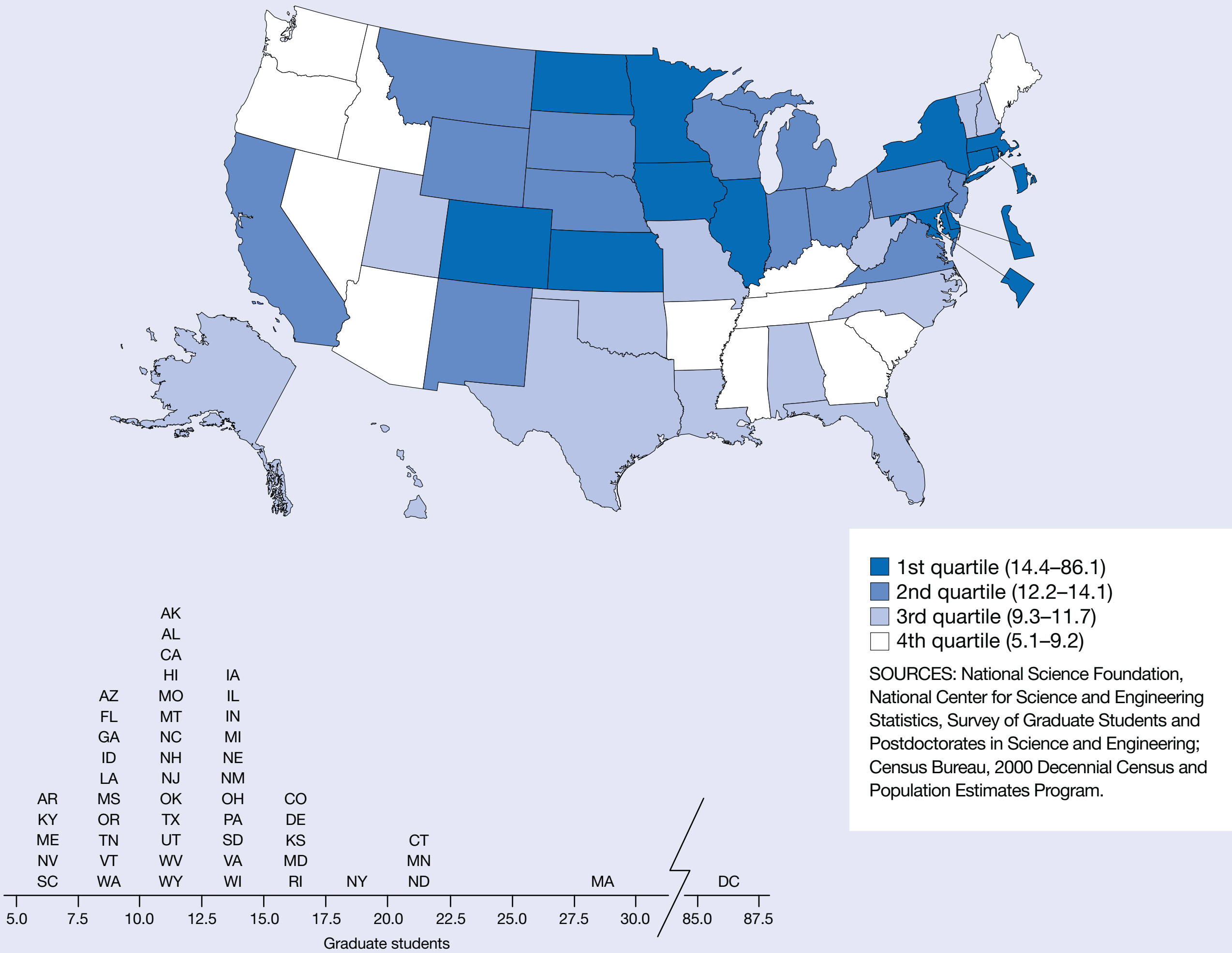
NOTES: NS&E degrees include bachelor's, master's, and doctorate. NS&E degrees include physical, computer, agricultural, biological, earth, atmospheric, and ocean sciences; mathematics; and engineering. All higher education degrees include bachelor's, master's, and doctorate.

SOURCE: National Center for Education Statistics, Integrated Postsecondary Education Data System (various years).

Science and Engineering Indicators 2012

Science and Engineering Graduate Students per 1,000 Individuals 25–34 Years Old

Figure 8-21
Science and engineering graduate students per 1,000 individuals 25–34 years old: 2009



SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Graduate Students and Postdoctorates in Science and Engineering; Census Bureau, 2000 Decennial Census and Population Estimates Program.

Findings

- The number of S&E graduate students in the United States grew from approximately 411,000 in 2000 to 523,000 in 2009, a 27% increase.
- Among the 50 states, the value of this indicator ranged from 5.1 to 29.4.
- Growth in the number of S&E graduate students was most significant in California during this period. Other states with sizeable increases included Texas, New York, Minnesota, and Florida.

Graduate students in S&E fields may become the technical leaders of the future. This indicator is a relative measure of a state's population with graduate training in S&E and is defined as the ratio of S&E graduate students to a state's population ages 25–34.

Graduate students are counted on the basis of their university enrollment and include state residents, residents of other states, and noncitizens. The cohort includes all state residents ages 25–34 and was chosen to approximate the age of most graduate students.

Data on S&E graduate students are counts obtained from all academic institutions in the United States that offer doctoral or master's degree programs in any S&E field, including the physical, life, earth, ocean, atmospheric, computer, and social sciences; mathematics; engineering; and psychology. Graduate students enrolled in schools of nursing, public health, dentistry, veterinary medicine, and other health-related disciplines are not included.

Estimates of the population ages 25–34 years old are provided by the U.S. Census Bureau. Small differences in the value of the indicator between states or across years generally are not meaningful.

Table 8-21
Science and engineering graduate students per 1,000 individuals 25–34 years old, by state: 2000, 2005, and 2009

State	S&E graduate students			Population 25–34 years old			S&E graduate students/1,000 individuals 25–34 years old		
	2000	2005	2009	2000	2005	2009	2000	2005	2009
United States	410,505	474,550	522,511	39,825,518	39,712,639	41,566,322	10.3	11.9	12.6
Alabama	5,161	6,232	6,562	600,351	593,380	619,371	8.6	10.5	10.6
Alaska	597	806	1,064	89,013	92,286	106,145	6.7	8.7	10.0
Arizona	6,477	6,976	8,161	744,892	864,337	956,944	8.7	8.1	8.5
Arkansas	1,958	2,447	2,799	351,690	368,207	389,042	5.6	6.6	7.2
California	53,437	63,837	66,695	5,233,641	5,223,518	5,385,409	10.2	12.2	12.4
Colorado	8,688	8,997	11,000	665,276	676,923	734,263	13.1	13.3	15.0
Connecticut	6,266	6,973	8,660	450,434	405,974	411,196	13.9	17.2	21.1
Delaware	1,414	1,760	1,907	108,699	110,244	115,495	13.0	16.0	16.5
District of Columbia	7,126	8,662	9,700	101,272	102,601	112,704	70.4	84.4	86.1
Florida	15,463	19,126	22,486	2,084,041	2,229,778	2,357,049	7.4	8.6	9.5
Georgia	8,809	10,675	11,151	1,300,057	1,329,899	1,392,988	6.8	8.0	8.0
Hawaii	1,412	1,892	2,013	170,502	176,998	191,254	8.3	10.7	10.5
Idaho	1,309	2,013	1,933	169,287	186,405	209,877	7.7	10.8	9.2
Illinois	22,964	23,387	25,617	1,806,793	1,745,946	1,783,102	12.7	13.4	14.4
Indiana	7,931	9,648	10,489	828,362	817,981	838,888	9.6	11.8	12.5
Iowa	4,646	5,020	5,463	361,434	345,064	367,097	12.9	14.5	14.9
Kansas	5,740	5,804	5,574	347,757	337,097	368,979	16.5	17.2	15.1
Kentucky	3,390	4,625	4,076	566,024	562,610	579,199	6.0	8.2	7.0
Louisiana	5,496	4,809	5,824	597,966	593,933	624,512	9.2	8.1	9.3
Maine	588	684	760	156,941	148,575	149,643	3.7	4.6	5.1
Maryland	8,995	11,228	12,453	746,862	729,811	756,962	12.0	15.4	16.5
Massachusetts	19,536	22,638	25,120	924,695	843,944	855,592	21.1	26.8	29.4
Michigan	15,080	15,454	16,072	1,357,578	1,261,427	1,202,738	11.1	12.3	13.4
Minnesota	6,749	10,685	14,484	671,894	653,869	699,621	10.0	16.3	20.7
Mississippi	2,628	3,175	3,246	380,294	379,067	393,163	6.9	8.4	8.3
Missouri	5,947	7,278	8,369	736,623	739,026	785,730	8.1	9.8	10.7
Montana	1,199	1,454	1,468	102,764	104,944	120,074	11.7	13.9	12.2
Nebraska	2,452	2,811	3,272	222,460	216,423	232,221	11.0	13.0	14.1
Nevada	1,423	1,992	2,137	308,307	357,001	394,105	4.6	5.6	5.4
New Hampshire	1,340	1,448	1,544	159,784	149,554	149,648	8.4	9.7	10.3
New Jersey	11,135	12,267	13,580	1,186,931	1,112,730	1,110,420	9.4	11.0	12.2
New Mexico	3,109	3,762	3,792	233,360	250,621	277,897	13.3	15.0	13.6
New York	37,782	42,399	46,786	2,749,299	2,602,535	2,649,054	13.7	16.3	17.7
North Carolina	10,034	12,167	14,457	1,212,550	1,187,546	1,235,447	8.3	10.2	11.7
North Dakota	1,053	1,512	1,811	76,253	71,313	81,735	13.8	21.2	22.2
Ohio	16,092	19,054	19,580	1,513,069	1,470,729	1,478,233	10.6	13.0	13.2
Oklahoma	3,478	4,274	5,095	449,552	456,812	504,985	7.7	9.4	10.1
Oregon	3,815	4,387	4,737	469,904	483,361	525,411	8.1	9.1	9.0
Pennsylvania	18,300	20,209	21,542	1,552,979	1,489,438	1,538,441	11.8	13.6	14.0
Rhode Island	1,709	1,971	2,127	140,153	134,692	131,818	12.2	14.6	16.1
South Carolina	3,185	3,339	3,499	559,245	565,038	598,990	5.7	5.9	5.8
South Dakota	866	930	1,452	90,667	91,888	102,810	9.6	10.1	14.1
Tennessee	5,366	6,585	6,431	813,532	820,169	848,633	6.6	8.0	7.6
Texas	27,855	32,788	37,774	3,164,710	3,339,356	3,647,847	8.8	9.8	10.4
Utah	3,821	4,884	4,929	327,177	381,597	441,598	11.7	12.8	11.2
Vermont	627	644	655	74,260	67,274	69,085	8.4	9.6	9.5
Virginia	11,552	12,566	14,624	1,035,588	1,027,412	1,084,710	11.2	12.2	13.5
Washington	5,905	6,570	7,534	839,575	851,102	948,773	7.0	7.7	7.9
West Virginia	2,024	2,247	2,273	227,512	224,330	225,178	8.9	10.0	10.1
Wisconsin	7,822	8,572	8,817	704,005	675,890	707,393	11.1	12.7	12.5
Wyoming	754	887	917	59,504	61,984	74,853	12.7	14.3	12.3
Puerto Rico	2,944	3,661	3,068	534,332	550,170	556,543	5.5	6.7	5.5

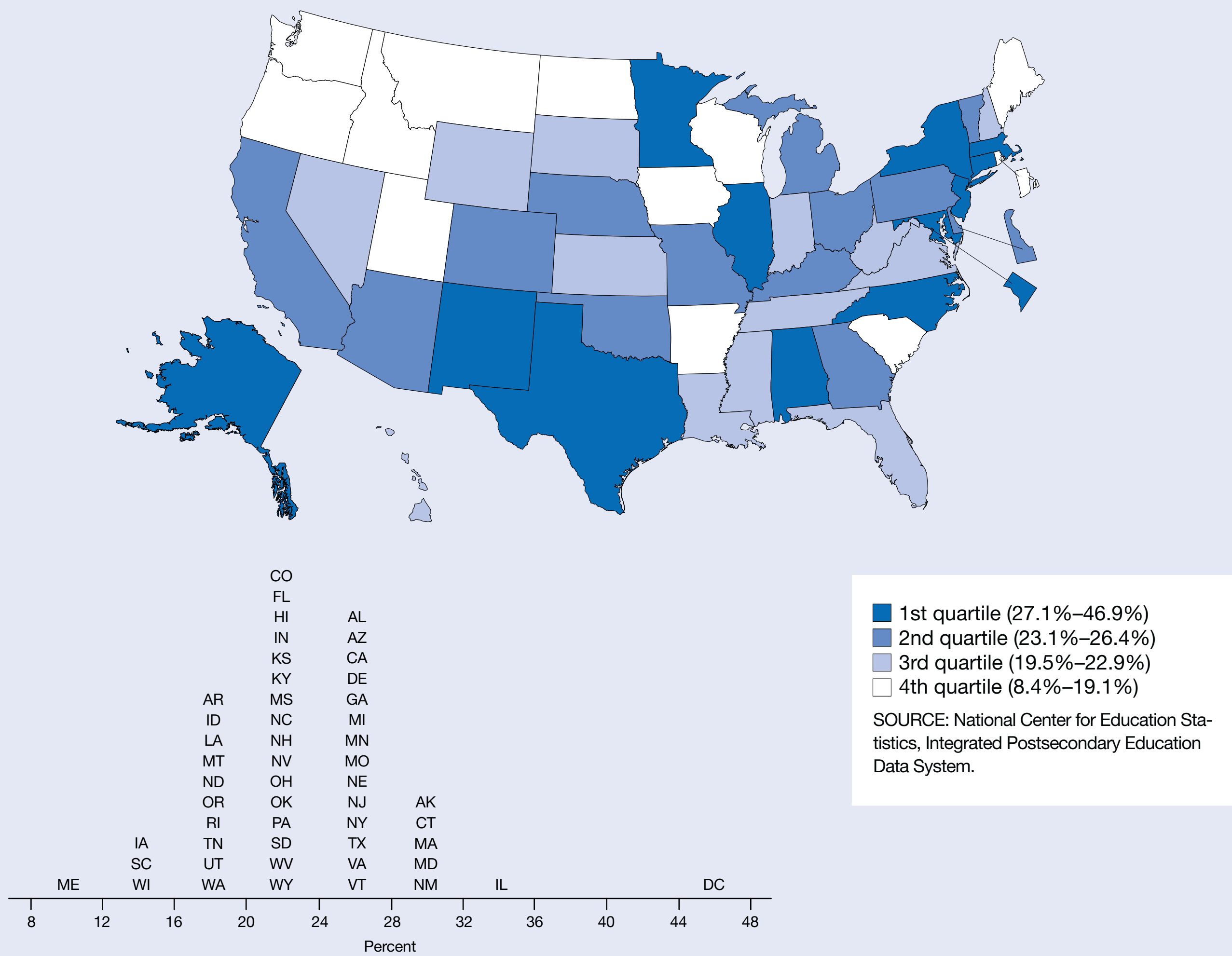
NOTE: S&E graduate students include students pursuing graduate degrees in physical, computer, agricultural, biological, earth, atmospheric, ocean, and social sciences; psychology; mathematics; and engineering.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Graduate Students and Postdoctorates in Science Engineering; Census Bureau, 2000 Decennial Census and Population Estimates Program (various years).

Science and Engineering Indicators 2012

Advanced Science and Engineering Degrees as a Percentage of S&E Degrees Conferred

Figure 8-22
Advanced science and engineering degrees as a percentage of S&E degrees conferred: 2009



SOURCE: National Center for Education Statistics, Integrated Postsecondary Education Data System.

Findings

- In 2009, nearly 167,000 advanced S&E degrees were awarded nationwide, 38% more degrees than were awarded in 2000. The share of advanced degrees as a percentage of all S&E degrees conferred increased by 6% between 2000 and 2009.
- In 2009, the value of this indicator for individual states ranged from 8.4 % to 32.2% of S&E graduates completing training at the master's or doctoral level. California produced the largest number of advanced S&E degrees, consistent over the decade and approximately 110 times the number produced in Wyoming.
- Between 2000 and 2009, 33 states showed increases in the share of their S&E graduates completing training at the master's or doctoral level and 16 states and the District of Columbia showed decreases.
- In states with few S&E graduate programs, the number of advanced S&E degrees conferred varies considerably from year to year. Readers should use caution when making annual comparisons for those states with small numbers of S&E graduate students.

This indicator represents the extent to which a state's higher education programs in S&E are concentrated at the graduate level. S&E fields include the physical, life, earth, ocean, atmospheric, computer, and social sciences; mathematics; engineering; and psychology. Advanced S&E degrees include master's and doctoral degrees. Total S&E degrees include bachelor's, master's, and doctoral degrees but exclude associate's degrees.

The indicator value is computed by dividing the number of advanced S&E degrees by the total number of S&E degrees awarded by the higher education institutions within the state. The number of degrees are actual counts provided by the National Center of Education Statistics.

Table 8-22
Advanced science and engineering degrees as a percentage of S&E degrees conferred, by state: 2000, 2005, and 2009

State	Advanced S&E degrees			All S&E degrees			Advanced S&E/ all S&E degrees (%)		
	2000	2005	2009	2000	2005	2009	2000	2005	2009
United States	120,997	148,629	166,714	515,298	614,694	667,790	23.5	24.2	25.0
Alabama	1,937	2,271	2,409	7,512	8,038	8,899	25.8	28.3	27.1
Alaska	185	236	243	578	676	802	32.0	34.9	30.3
Arizona	1,736	1,872	3,259	6,890	9,613	13,432	25.2	19.5	24.3
Arkansas	436	558	639	2,828	3,306	3,390	15.4	16.9	18.8
California	15,497	19,021	21,198	61,903	77,557	84,579	25.0	24.5	25.1
Colorado	2,911	3,370	3,415	11,733	13,745	14,280	24.8	24.5	23.9
Connecticut	1,748	2,209	2,812	6,887	8,154	9,615	25.4	27.1	29.2
Delaware	394	507	553	1,940	2,163	2,241	20.3	23.4	24.7
District of Columbia	2,825	3,317	3,968	5,740	7,490	8,469	49.2	44.3	46.9
Florida	4,199	5,445	6,396	18,293	24,845	29,004	23.0	21.9	22.1
Georgia	2,764	3,453	3,993	11,754	14,807	15,775	23.5	23.3	25.3
Hawaii	575	558	582	2,235	2,412	2,656	25.7	23.1	21.9
Idaho	331	424	457	1,823	2,384	2,797	18.2	17.8	16.3
Illinois	6,504	8,294	9,254	22,464	27,237	28,725	29.0	30.5	32.2
Indiana	2,483	2,840	3,040	11,404	13,317	13,251	21.8	21.3	22.9
Iowa	1,055	1,261	1,423	6,611	7,378	9,079	16.0	17.1	15.7
Kansas	1,160	1,355	1,321	5,317	6,068	5,920	21.8	22.3	22.3
Kentucky	938	1,551	1,537	5,091	6,088	6,481	18.4	25.5	23.7
Louisiana	1,430	1,773	1,417	6,998	7,849	7,199	20.4	22.6	19.7
Maine	185	196	231	2,302	2,550	2,749	8.0	7.7	8.4
Maryland	3,637	4,618	5,121	12,235	15,675	16,514	29.7	29.5	31.0
Massachusetts	6,600	7,662	8,249	22,662	25,251	26,712	29.1	30.3	30.9
Michigan	4,788	5,744	5,931	18,430	21,335	22,804	26.0	26.9	26.0
Minnesota	1,609	2,644	3,827	9,043	11,915	13,887	17.8	22.2	27.6
Mississippi	628	793	901	3,397	3,577	3,937	18.5	22.2	22.9
Missouri	2,796	3,452	3,556	10,965	12,984	13,464	25.5	26.6	26.4
Montana	368	447	424	2,102	2,254	2,298	17.5	19.8	18.5
Nebraska	647	808	1,060	3,304	3,847	4,193	19.6	21.0	25.3
Nevada	315	482	546	1,365	1,963	2,585	23.1	24.6	21.1
New Hampshire	554	634	755	3,342	3,460	3,684	16.6	18.3	20.5
New Jersey	3,118	3,811	4,507	13,940	15,667	16,535	22.4	24.3	27.3
New Mexico	697	877	947	2,636	3,065	3,255	26.4	28.6	29.1
New York	10,760	13,828	14,817	42,901	51,470	54,412	25.1	26.9	27.2
North Carolina	2,630	3,177	3,838	14,651	16,665	18,671	18.0	19.1	20.6
North Dakota	190	234	284	1,519	1,539	1,610	12.5	15.2	17.6
Ohio	4,249	4,802	4,872	18,123	20,287	21,129	23.4	23.7	23.1
Oklahoma	1,981	1,624	1,506	5,982	6,342	6,384	33.1	25.6	23.6
Oregon	1,227	1,544	1,430	6,608	7,805	7,975	18.6	19.8	17.9
Pennsylvania	5,448	6,755	8,023	26,563	31,478	34,537	20.5	21.5	23.2
Rhode Island	509	610	701	3,012	3,447	3,783	16.9	17.7	18.5
South Carolina	957	1,071	1,128	5,953	6,855	7,279	16.1	15.6	15.5
South Dakota	307	472	419	1,813	1,966	1,990	16.9	24.0	21.1
Tennessee	1,497	1,593	1,874	8,029	8,749	9,601	18.6	18.2	19.5
Texas	7,131	9,318	10,473	27,962	34,612	38,196	25.5	26.9	27.4
Utah	1,044	1,283	1,353	6,289	8,153	8,339	16.6	15.7	16.2
Vermont	409	516	795	2,230	2,508	3,144	18.3	20.6	25.3
Virginia	3,366	4,062	5,664	16,299	17,810	20,822	20.7	22.8	27.2
Washington	1,815	2,328	2,523	9,720	12,449	13,215	18.7	18.7	19.1
West Virginia	546	660	843	2,750	2,945	3,772	19.9	22.4	22.3
Wisconsin	1,656	2,069	2,010	10,260	12,187	12,881	16.1	17.0	15.6
Wyoming	225	200	190	910	757	839	24.7	26.4	22.6
Puerto Rico	620	775	1,056	4,807	4,817	5,293	12.9	16.1	20.0

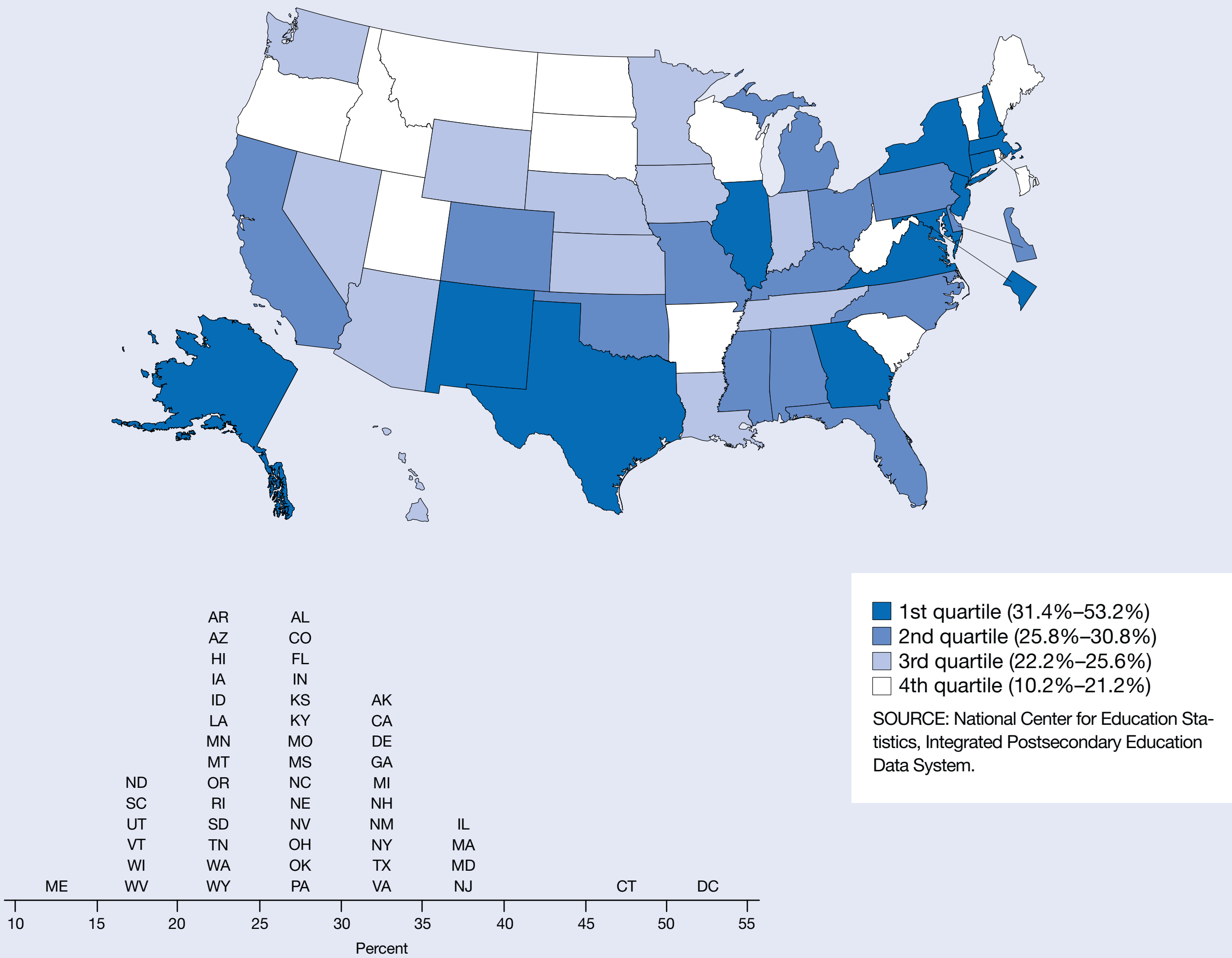
NOTES: Advanced S&E degrees include only master's and doctorate. All S&E degrees include bachelor's, master's, and doctorate. S&E degrees include physical, computer, agricultural, biological, earth, atmospheric, ocean, and social sciences; psychology; mathematics; and engineering.

SOURCE: National Center for Education Statistics, Integrated Postsecondary Education Data System (various years).

Science and Engineering Indicators 2012

Advanced Natural Sciences and Engineering Degrees as a Percentage of NS&E Degrees Conferred

Figure 8-23
Advanced natural sciences and engineering degrees as a percentage of NS&E degrees conferred: 2009



SOURCE: National Center for Education Statistics, Integrated Postsecondary Education Data System.

Findings

- In 2009, more than 104,000 advanced natural sciences and engineering (NS&E) degrees were awarded nationwide. This total represented approximately 37% more than were awarded in 2000. The share of advanced degrees as a percentage of all NS&E degrees conferred rose by 10% between 2000 and 2009.
- In 2009, the value of this indicator ranged from a low of 10.2% to a high of 45.1% of NS&E graduates completing training at the master's or doctoral level.
- Nationally, about 62% of all advanced S&E degrees were in NS&E fields in 2009, nearly unchanged from a decade ago in 2000.
- In states with few NS&E graduate programs, the number of advanced NS&E degrees conferred varies considerably from year to year. Readers should use caution when making annual comparisons for those states with small numbers of NS&E graduate students.

This indicator represents the extent to which a state's higher education programs in natural sciences and engineering (NS&E) are concentrated at the graduate level. NS&E fields include the physical, life, earth, ocean, atmospheric, and computer sciences; mathematics; and engineering. The social sciences, including anthropology, economics, political science and public administration, psychology, and sociology, are not included. Advanced NS&E degrees include master's and doctoral degrees. Total NS&E degrees include bachelor's, master's, and doctoral degrees but exclude associate's degrees.

The indicator value is computed by dividing the number of advanced NS&E degrees by the total number of NS&E degrees awarded by the higher education institutions within the state.

The number of degrees are actual counts provided by the National Center of Education Statistics.

Table 8-23
Advanced natural sciences and engineering degrees as a percentage of NS&E degrees conferred, by state: 2000, 2005, and 2009

State	Advanced NS&E degrees			NS&E degrees conferred			Advanced NS&E degrees/ NS&E degrees conferred (%)		
	2000	2005	2009	2000	2005	2009	2000	2005	2009
United States	75,996	94,547	104,089	283,371	331,247	353,509	26.8	28.5	29.4
Alabama	908	1,221	1,370	4,464	4,732	5,261	20.3	25.8	26.0
Alaska	120	171	162	360	419	475	33.3	40.8	34.1
Arizona	1,135	1,274	1,705	4,063	6,343	6,989	27.9	20.1	24.4
Arkansas	294	392	407	1,734	2,022	1,970	17.0	19.4	20.7
California	8,797	11,395	12,604	30,833	38,181	40,990	28.5	29.8	30.7
Colorado	2,081	2,188	2,113	6,823	7,663	7,827	30.5	28.6	27.0
Connecticut	1,155	1,518	2,084	3,007	3,634	4,624	38.4	41.8	45.1
Delaware	221	286	329	917	980	1,069	24.1	29.2	30.8
District of Columbia	1,202	1,244	1,569	2,091	2,561	2,949	57.5	48.6	53.2
Florida	2,589	3,539	4,267	9,942	12,636	15,036	26.0	28.0	28.4
Georgia	1,909	2,291	2,835	7,099	8,354	9,025	26.9	27.4	31.4
Hawaii	285	257	267	1,004	1,011	1,109	28.4	25.4	24.1
Idaho	259	334	360	1,272	1,568	1,797	20.4	21.3	20.0
Illinois	4,082	5,025	5,857	13,053	16,027	15,937	31.3	31.4	36.8
Indiana	1,610	1,840	1,920	6,723	7,637	7,493	23.9	24.1	25.6
Iowa	804	956	1,070	3,939	4,205	4,633	20.4	22.7	23.1
Kansas	760	920	827	3,196	3,557	3,290	23.8	25.9	25.1
Kentucky	553	922	889	2,819	3,215	3,392	19.6	28.7	26.2
Louisiana	962	1,295	1,044	4,357	4,895	4,260	22.1	26.5	24.5
Maine	137	136	133	1,228	1,272	1,305	11.2	10.7	10.2
Maryland	2,432	3,199	3,473	6,854	9,110	9,142	35.5	35.1	38.0
Massachusetts	3,981	4,599	5,004	11,309	12,222	13,219	35.2	37.6	37.9
Michigan	3,558	4,300	4,241	11,873	13,474	13,861	30.0	31.9	30.6
Minnesota	989	1,472	1,527	5,056	6,333	6,873	19.6	23.2	22.2
Mississippi	462	595	670	2,195	2,225	2,427	21.0	26.7	27.6
Missouri	1,207	1,585	1,853	5,974	6,935	7,182	20.2	22.9	25.8
Montana	285	328	306	1,458	1,455	1,529	19.5	22.5	20.0
Nebraska	377	570	611	1,958	2,212	2,393	19.3	25.8	25.5
Nevada	208	296	337	756	1,035	1,326	27.5	28.6	25.4
New Hampshire	375	433	544	1,656	1,563	1,730	22.6	27.7	31.4
New Jersey	2,220	2,505	2,907	7,469	7,859	8,283	29.7	31.9	35.1
New Mexico	461	623	676	1,704	2,015	1,982	27.1	30.9	34.1
New York	6,187	7,829	8,736	20,638	24,534	25,832	30.0	31.9	33.8
North Carolina	1,898	2,310	2,802	8,070	9,084	10,110	23.5	25.4	27.7
North Dakota	133	174	218	1,026	1,087	1,147	13.0	16.0	19.0
Ohio	2,843	3,319	3,263	10,671	11,425	11,767	26.6	29.1	27.7
Oklahoma	875	1,185	1,013	3,366	3,821	3,740	26.0	31.0	27.1
Oregon	784	1,021	879	3,224	3,852	3,947	24.3	26.5	22.3
Pennsylvania	3,448	4,625	5,248	15,119	18,344	19,701	22.8	25.2	26.6
Rhode Island	353	383	422	1,589	1,914	1,988	22.2	20.0	21.2
South Carolina	733	841	768	3,417	3,971	3,967	21.5	21.2	19.4
South Dakota	161	285	257	1,142	1,324	1,253	14.1	21.5	20.5
Tennessee	975	1,019	1,162	4,430	4,560	5,083	22.0	22.3	22.9
Texas	5,136	6,797	7,416	17,004	20,489	22,601	30.2	33.2	32.8
Utah	724	915	933	3,541	4,327	4,699	20.4	21.1	19.9
Vermont	168	232	263	1,008	1,097	1,365	16.7	21.1	19.3
Virginia	2,213	2,379	3,360	8,627	8,689	10,456	25.7	27.4	32.1
Washington	1,159	1,366	1,430	5,009	5,981	6,415	23.1	22.8	22.3
West Virginia	363	476	405	1,571	1,764	2,042	23.1	27.0	19.8
Wisconsin	1,254	1,550	1,422	6,105	7,124	7,466	20.5	21.8	19.0
Wyoming	171	132	131	628	510	552	27.2	25.9	23.7
Puerto Rico	301	396	547	3,314	3,244	3,586	9.1	12.2	15.3

NS&E = natural sciences and engineering

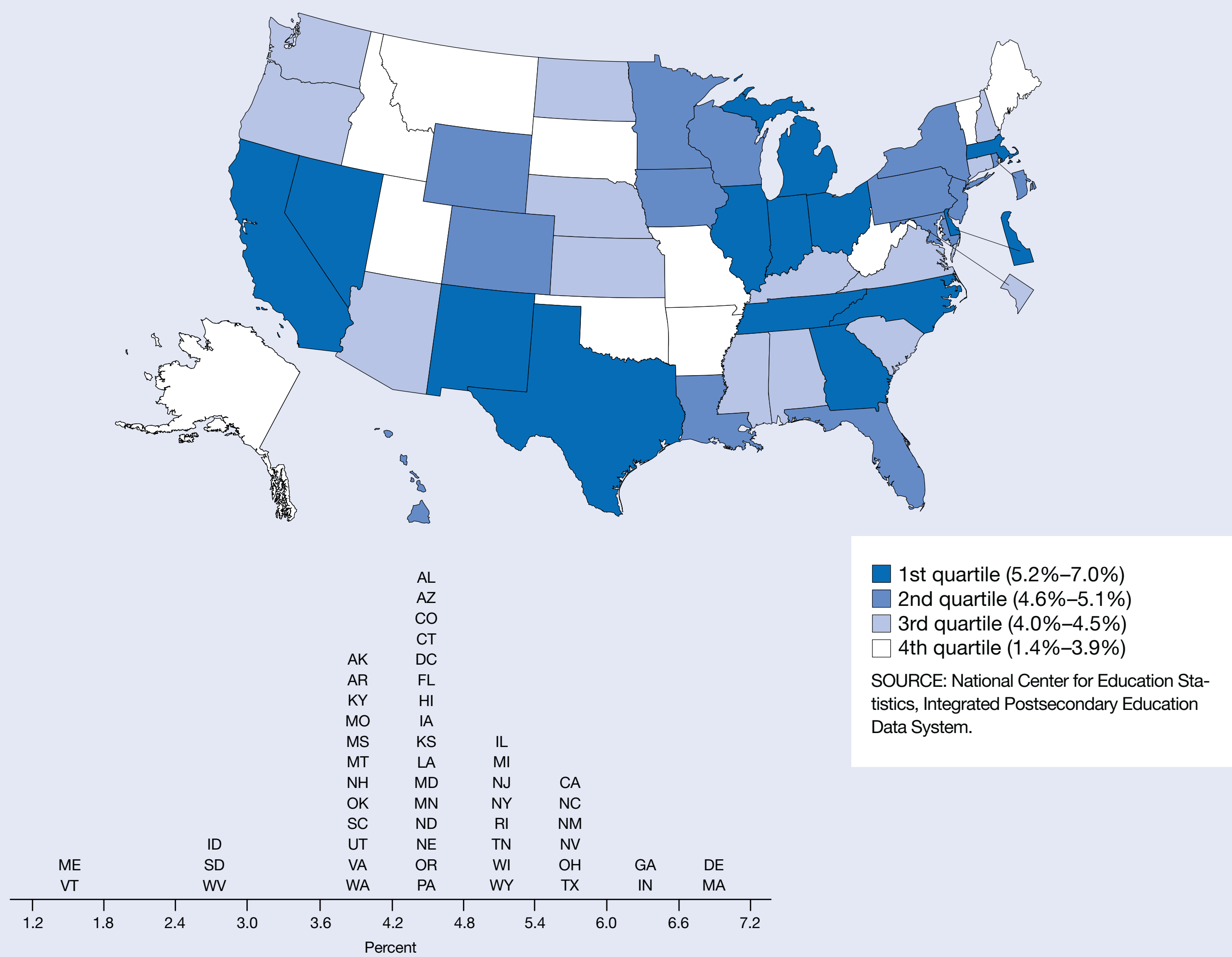
NOTES: Advanced NS&E degrees include only master's and doctorate. NS&E degrees conferred includes bachelor's, master's, and doctorate. NS&E degrees include physical, computer, agricultural, biological, earth, atmospheric, and ocean sciences; mathematics; and engineering.

SOURCE: National Center for Education Statistics, Integrated Postsecondary Education Data System (various years).

Science and Engineering Indicators 2012

Science and Engineering Doctoral Degrees as a Percentage of S&E Degrees Conferred

Figure 8-24
Science and engineering doctoral degrees as a percentage of S&E degrees conferred: 2009



SOURCE: National Center for Education Statistics, Integrated Postsecondary Education Data System.

Findings

- The number of S&E doctoral degrees awarded nationwide rose from 25,000 in 2000 to 33,000 in 2009, an increase of 31%. California showed the largest increase in the number of S&E doctorates awarded during this period.
- Nationally, about 5% of the S&E degrees awarded have been doctoral degrees. In 2009, the value of this indicator for individual states ranged from a low of 1.4% to a high of 7.0% of S&E graduates completing training at the doctorate level.
- In states with a small number of S&E graduate programs, the number of S&E doctoral degrees awarded varies considerably from year to year. Readers should use caution when making annual comparisons for those states with small numbers of S&E doctorates.

This indicator represents the extent to which a state's higher education programs in S&E are focused on producing individuals with the highest level of technical expertise. The academic and technical leaders of the future are often drawn from individuals receiving S&E doctoral degrees. S&E fields include the physical, life, earth, ocean, atmospheric, computer, and social sciences; mathematics; engineering; and psychology. Total S&E degrees conferred include bachelor's, master's, and doctoral degrees but exclude associate's degrees.

The indicator value is computed by dividing the number of doctoral degrees awarded in S&E fields by the total number of S&E degrees awarded by the higher education institutions within the state. The number of degrees are counts provided by the National Center of Education Statistics.

Table 8-24
Science and engineering doctoral degrees as a percentage of S&E degrees conferred, by state: 2000, 2005, and 2009

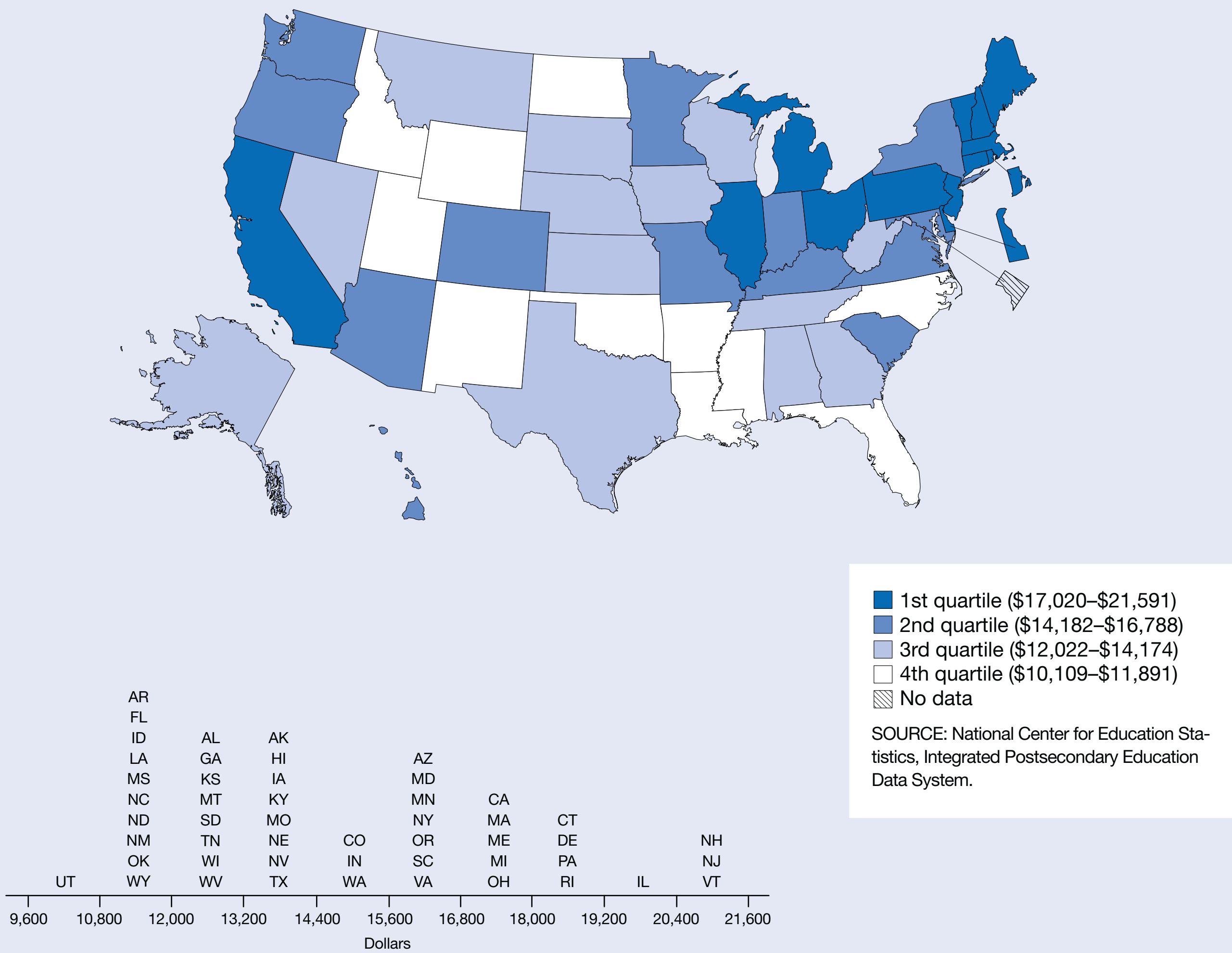
State	S&E doctoral degrees			S&E degrees conferred			S&E doctoral degrees/ S&E degrees conferred (%)		
	2000	2005	2009	2000	2005	2009	2000	2005	2009
United States	25,350	28,398	33,137	515,298	614,694	667,790	4.9	4.6	5.0
Alabama	281	322	384	7,512	8,038	8,899	3.7	4.0	4.3
Alaska	13	20	29	578	676	802	2.2	3.0	3.6
Arizona	431	466	598	6,890	9,613	13,432	6.3	4.8	4.5
Arkansas	67	111	127	2,828	3,306	3,390	2.4	3.4	3.7
California	3,553	3,939	4,724	61,903	77,557	84,579	5.7	5.1	5.6
Colorado	527	708	659	11,733	13,745	14,280	4.5	5.2	4.6
Connecticut	413	433	435	6,887	8,154	9,615	6.0	5.3	4.5
Delaware	112	116	151	1,940	2,163	2,241	5.8	5.4	6.7
District of Columbia	355	364	385	5,740	7,490	8,469	6.2	4.9	4.5
Florida	878	1,112	1,342	18,293	24,845	29,004	4.8	4.5	4.6
Georgia	552	719	964	11,754	14,807	15,775	4.7	4.9	6.1
Hawaii	126	114	121	2,235	2,412	2,656	5.6	4.7	4.6
Idaho	56	49	73	1,823	2,384	2,797	3.1	2.1	2.6
Illinois	1,438	1,470	1,534	22,464	27,237	28,725	6.4	5.4	5.3
Indiana	646	659	850	11,404	13,317	13,251	5.7	4.9	6.4
Iowa	319	321	428	6,611	7,378	9,079	4.8	4.4	4.7
Kansas	223	230	260	5,317	6,068	5,920	4.2	3.8	4.4
Kentucky	188	241	256	5,091	6,088	6,481	3.7	4.0	4.0
Louisiana	345	312	330	6,998	7,849	7,199	4.9	4.0	4.6
Maine	39	24	42	2,302	2,550	2,749	1.7	0.9	1.5
Maryland	567	688	783	12,235	15,675	16,514	4.6	4.4	4.7
Massachusetts	1,433	1,562	1,877	22,662	25,251	26,712	6.3	6.2	7.0
Michigan	941	1,019	1,200	18,430	21,335	22,804	5.1	4.8	5.3
Minnesota	463	609	645	9,043	11,915	13,887	5.1	5.1	4.6
Mississippi	144	140	161	3,397	3,577	3,937	4.2	3.9	4.1
Missouri	415	491	495	10,965	12,984	13,464	3.8	3.8	3.7
Montana	41	65	83	2,102	2,254	2,298	2.0	2.9	3.6
Nebraska	142	154	182	3,304	3,847	4,193	4.3	4.0	4.3
Nevada	78	92	142	1,365	1,963	2,585	5.7	4.7	5.5
New Hampshire	102	150	149	3,342	3,460	3,684	3.1	4.3	4.0
New Jersey	650	641	808	13,940	15,667	16,535	4.7	4.1	4.9
New Mexico	136	159	184	2,636	3,065	3,255	5.2	5.2	5.7
New York	2,237	2,440	2,605	42,901	51,470	54,412	5.2	4.7	4.8
North Carolina	652	790	1,010	14,651	16,665	18,671	4.5	4.7	5.4
North Dakota	41	42	68	1,519	1,539	1,610	2.7	2.7	4.2
Ohio	963	1,022	1,146	18,123	20,287	21,129	5.3	5.0	5.4
Oklahoma	205	205	251	5,982	6,342	6,384	3.4	3.2	3.9
Oregon	254	272	336	6,608	7,805	7,975	3.8	3.5	4.2
Pennsylvania	1,135	1,432	1,633	26,563	31,478	34,537	4.3	4.5	4.7
Rhode Island	153	167	193	3,012	3,447	3,783	5.1	4.8	5.1
South Carolina	198	234	294	5,953	6,855	7,279	3.3	3.4	4.0
South Dakota	26	38	49	1,813	1,966	1,990	1.4	1.9	2.5
Tennessee	356	354	496	8,029	8,749	9,601	4.4	4.0	5.2
Texas	1,495	1,727	2,116	27,962	34,612	38,196	5.3	5.0	5.5
Utah	238	251	303	6,289	8,153	8,339	3.8	3.1	3.6
Vermont	40	38	43	2,230	2,508	3,144	1.8	1.5	1.4
Virginia	668	758	863	16,299	17,810	20,822	4.1	4.3	4.1
Washington	365	490	544	9,720	12,449	13,215	3.8	3.9	4.1
West Virginia	80	97	93	2,750	2,945	3,772	2.9	3.3	2.5
Wisconsin	520	508	650	10,260	12,187	12,881	5.1	4.2	5.0
Wyoming	50	33	43	910	757	839	5.5	4.4	5.1
Puerto Rico	73	163	147	4,807	4,817	5,293	1.5	3.4	2.8

SOURCE: National Center for Education Statistics, Integrated Postsecondary Education Data System (various years).

Science and Engineering Indicators 2012

Average Undergraduate Charge at Public 4-Year Institutions

Figure 8-25
Average undergraduate charge at public 4-year institutions: 2010



SOURCE: National Center for Education Statistics, Integrated Postsecondary Education Data System.

Findings

- During 2010, the total annual nominal charge for a full-time undergraduate student to attend a public 4-year institution averaged $15,014 nationally, an increase of 82% since 2000 in current dollars. This was equivalent to an increase of approximately 43% after adjusting for inflation.
- All states showed major increases in undergraduate charges at public institutions in 2010, compared with 2000. In several states, undergraduate charges more than doubled during this period.
- In 2010, the state average for a year of undergraduate education at a public 4-year institution ranged from a low of $10,109 to a high of $21,591.
- Tuition and required fees averaged 45% of the total charges at public 4-year institutions in 2010, but individual states had different cost structures.

The average annual charge for an undergraduate student to attend a public 4-year academic institution is one indicator of how accessible higher education is to a state's students. The annual charge includes standard in-state charges for tuition, required fees, room, and board for a full-time undergraduate student who is a resident of that state. These charges were weighted by the number of full-time undergraduates attending each public institution within the state. The total charge for all public 4-year institutions in the state was divided by the total number of full-time undergraduates attending all public 4-year institutions in the state. The year is the end date of the academic year. For example, data for 2010 represent costs for the 2009–10 academic year.

To improve educational attainment, the federal government, state governments, and academic institutions provide various kinds of financial aid that reduce the charge to students. The data in this indicator do not include any adjustments for such financial aid.

Table 8-25
Average undergraduate charge at public 4-year institutions, by state: 2000, 2005, and 2010
(Dollars)

State	2000	2005	2010
United States	8,265	11,441	15,014
Alabama	6,742	9,819	13,052
Alaska	8,333	9,936	13,281
Arizona	7,362	10,863	15,710
Arkansas	6,416	8,734	11,841
California	9,183	13,356	17,652
Colorado	7,994	10,243	15,056
Connecticut	10,136	13,824	18,331
Delaware	9,876	13,353	18,383
District of Columbia	NA	NA	NA
Florida	7,474	9,335	11,659
Georgia	7,295	9,439	12,552
Hawaii	8,056	9,131	14,182
Idaho	6,323	9,066	10,895
Illinois	9,002	12,803	19,355
Indiana	8,845	12,240	15,590
Iowa	7,210	11,541	14,174
Kansas	6,324	9,397	12,578
Kentucky	6,481	9,400	14,228
Louisiana	5,910	7,973	10,873
Maine	9,089	11,826	17,020
Maryland	10,345	14,108	16,407
Massachusetts	9,212	13,687	17,819
Michigan	9,513	12,658	17,852
Minnesota	7,665	11,958	15,730
Mississippi	6,456	9,019	11,583
Missouri	8,185	11,356	14,368
Montana	7,463	9,867	12,399
Nebraska	7,258	10,704	13,265
Nevada	7,812	10,464	13,682
New Hampshire	11,052	14,651	20,492
New Jersey	11,450	16,349	21,591
New Mexico	6,600	8,675	11,809
New York	9,998	12,441	16,147
North Carolina	6,483	9,450	11,874
North Dakota	6,994	9,011	11,891
Ohio	9,900	15,256	17,133
Oklahoma	5,735	8,451	11,444
Oregon	9,065	12,177	15,629
Pennsylvania	10,534	14,771	19,017
Rhode Island	10,595	13,541	18,509
South Carolina	7,703	12,165	16,788
South Dakota	6,520	8,944	12,022
Tennessee	6,555	9,445	12,748
Texas	7,497	10,233	13,764
Utah	6,299	8,348	10,109
Vermont	12,478	15,658	20,735
Virginia	8,619	11,616	15,616
Washington	8,314	11,902	15,189
West Virginia	7,105	9,450	12,426
Wisconsin	7,268	9,872	13,190
Wyoming	7,091	8,514	10,952
Puerto Rico	NA	NA	NA

NA = not available

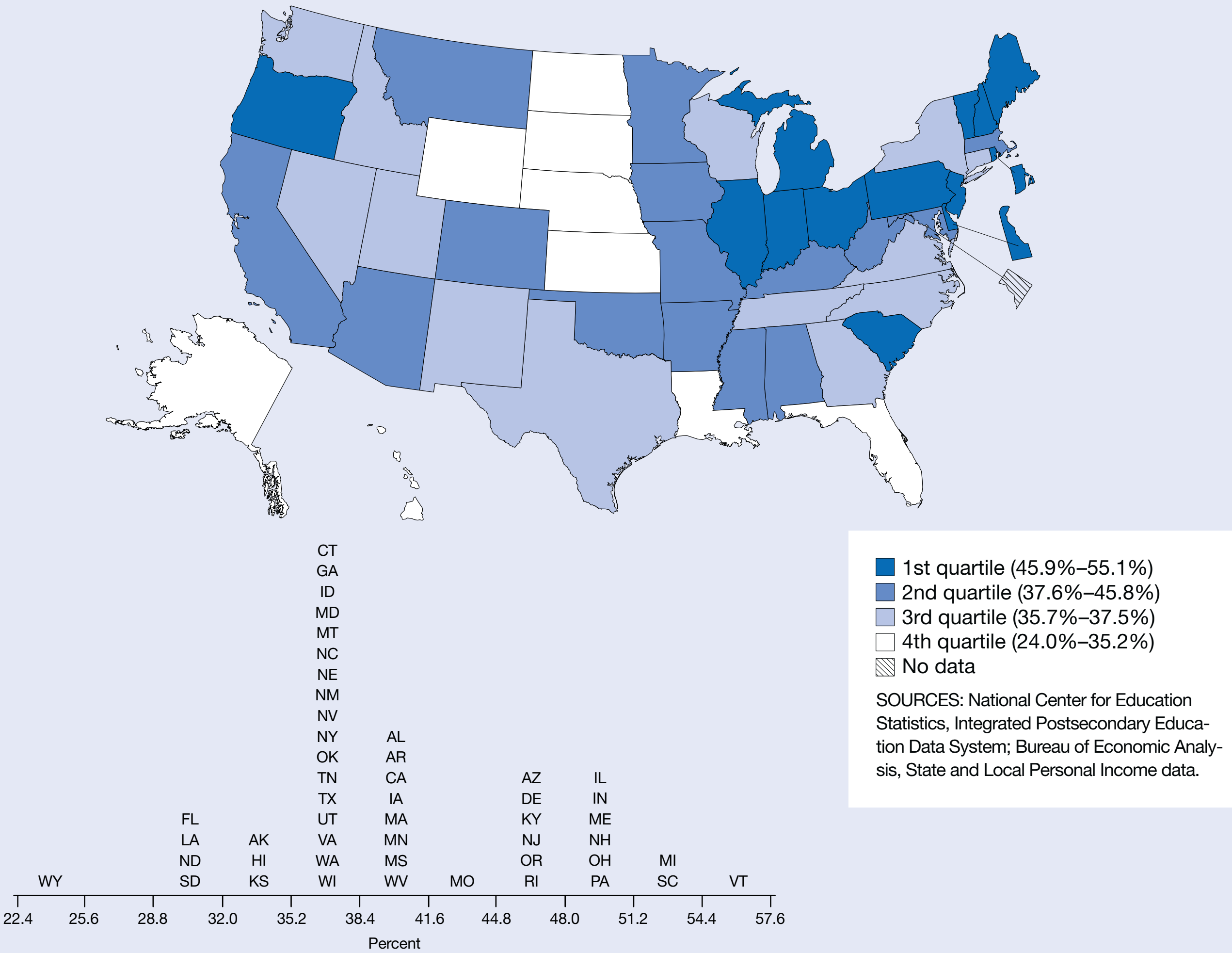
NOTES: National average for United States from *Digest of Education Statistics* data tables. Average charges for entire academic year (reported in current dollars). Tuition and fees weighted by number of full-time-equivalent undergraduates but not adjusted to reflect student residency. Room and board based on full-time students.

SOURCE: National Center for Education Statistics, Integrated Postsecondary Education Data System (various years).

Science and Engineering Indicators 2012

Average Undergraduate Charge at Public 4-Year Institutions as a Percentage of Disposable Personal Income

Figure 8-26
Average undergraduate charge at public 4-year institutions as a percentage of disposable personal income: 2009



SOURCES: National Center for Education Statistics, Integrated Postsecondary Education Data System; Bureau of Economic Analysis, State and Local Personal Income data.

Findings

- In 2009, a year of undergraduate education at a state institution would have consumed, on average, 39.7% of a resident's disposable income, an increase from the 31.8% it would have consumed in 2000.
- The cost of a year of undergraduate education at a public institution was equivalent to one-quarter to one-half of the per capita disposable income for residents of most states in 2009.
- Wyoming is the only state to show a decrease in this indicator between 2000 and 2009.
- Residents in 14 states experienced major increases in the cost of a year of undergraduate education relative to their purchasing power (in excess of 10% of their per capita disposable income) between 2000 and 2009.

This indicator represents a broad measure of how affordable higher education at a public institution is for the average resident. It is calculated by dividing the average undergraduate charge at all public 4-year institutions in the state by the per capita disposable personal income of state residents. The average undergraduate charge includes standard in-state tuition, room, board, and required fees for a student who is a resident of the state. The year is the end date of the academic year. For example, data for 2009 represent costs for the 2008–09 academic year.

Disposable personal income is the income available to state residents for spending or saving. It is calculated as personal income minus personal current taxes paid to federal, state, and local governments.

High values indicate that a year of undergraduate education consumes a high percentage of the disposable personal income of state residents. However, the data in this indicator do not include any adjustment for financial aid that a student might receive.

Table 8-26
Average undergraduate charge at public 4-year institutions as a percentage of disposable personal income, by state: 2000, 2005, and 2009

State	Average undergraduate charge ($)			Per capita disposable personal income ($)			Undergraduate charge/disposable personal income (%)		
	2000	2005	2009	2000	2005	2009	2000	2005	2009
United States	8,265	11,441	14,256	25,955	31,342	35,916	31.8	36.5	39.7
Alabama	6,742	9,819	12,183	21,357	27,031	30,758	31.6	36.3	39.6
Alaska	8,333	9,936	12,970	27,101	33,573	39,620	30.7	29.6	32.7
Arizona	7,362	10,863	14,098	22,939	28,159	30,807	32.1	38.6	45.8
Arkansas	6,416	8,734	11,708	20,034	25,344	29,861	32.0	34.5	39.2
California	9,183	13,356	15,679	27,664	33,810	38,300	33.2	39.5	40.9
Colorado	7,994	10,243	14,250	28,857	34,160	37,899	27.7	30.0	37.6
Connecticut	10,136	13,824	17,358	33,837	40,689	47,797	30.0	34.0	36.3
Delaware	9,876	13,353	17,199	26,427	32,252	36,130	37.4	41.4	47.6
District of Columbia	NA	NA	NA	33,459	47,478	60,751	NA	NA	NA
Florida	7,474	9,335	11,487	25,392	31,726	36,031	29.4	29.4	31.9
Georgia	7,295	9,439	11,532	24,606	28,653	31,096	29.6	32.9	37.1
Hawaii	8,056	9,131	13,358	25,495	31,764	38,556	31.6	28.7	34.6
Idaho	6,323	9,066	10,403	21,575	26,572	29,171	29.3	34.1	35.7
Illinois	9,002	12,803	18,228	27,877	32,972	37,913	32.3	38.8	48.1
Indiana	8,845	12,240	14,976	23,983	28,016	30,983	36.9	43.7	48.3
Iowa	7,210	11,541	13,828	24,136	29,298	34,385	29.9	39.4	40.2
Kansas	6,324	9,397	11,999	24,841	29,714	35,714	25.5	31.6	33.6
Kentucky	6,481	9,400	13,213	21,726	25,512	29,526	29.8	36.8	44.8
Louisiana	5,910	7,973	10,380	21,073	27,557	34,249	28.0	28.9	30.3
Maine	9,089	11,826	16,162	23,227	28,675	33,359	39.1	41.2	48.4
Maryland	10,345	14,108	16,112	29,231	36,787	42,902	35.4	38.4	37.6
Massachusetts	9,212	13,687	17,103	30,786	37,546	43,884	29.9	36.5	39.0
Michigan	9,513	12,658	17,034	25,285	28,924	31,475	37.6	43.8	54.1
Minnesota	7,665	11,958	15,097	27,780	33,302	37,583	27.6	35.9	40.2
Mississippi	6,456	9,019	11,093	19,491	24,795	28,387	33.1	36.4	39.1
Missouri	8,185	11,356	14,056	24,335	28,884	32,781	33.6	39.3	42.9
Montana	7,463	9,867	11,970	20,781	27,192	31,853	35.9	36.3	37.6
Nebraska	7,258	10,704	12,652	25,070	30,967	35,939	29.0	34.6	35.2
Nevada	7,812	10,464	12,824	26,882	33,743	34,914	29.1	31.0	36.7
New Hampshire	11,052	14,651	19,228	29,273	34,591	39,124	37.8	42.4	49.1
New Jersey	11,450	16,349	20,727	32,333	38,127	44,416	35.4	42.9	46.7
New Mexico	6,600	8,675	11,261	20,200	26,242	30,721	32.7	33.1	36.7
New York	9,998	12,441	14,878	28,623	34,598	40,348	34.9	36.0	36.9
North Carolina	6,483	9,450	11,354	24,253	28,546	31,635	26.7	33.1	35.9
North Dakota	6,994	9,011	11,426	23,121	29,667	37,286	30.2	30.4	30.6
Ohio	9,900	15,256	16,567	24,757	28,721	32,445	40.0	53.1	51.1
Oklahoma	5,735	8,451	12,355	21,723	27,435	32,831	26.4	30.8	37.6
Oregon	9,065	12,177	15,183	24,536	28,493	32,717	36.9	42.7	46.4
Pennsylvania	10,534	14,771	18,147	25,999	30,808	36,255	40.5	47.9	50.1
Rhode Island	10,595	13,541	17,289	25,340	32,140	37,636	41.8	42.1	45.9
South Carolina	7,703	12,165	16,137	22,165	26,368	29,900	34.8	46.1	54.0
South Dakota	6,520	8,944	11,357	23,881	30,611	35,662	27.3	29.2	31.8
Tennessee	6,555	9,445	12,057	24,011	28,810	32,135	27.3	32.8	37.5
Texas	7,497	10,233	13,222	25,166	30,175	35,472	29.8	33.9	37.3
Utah	6,299	8,348	10,301	21,454	25,554	28,856	29.4	32.7	35.7
Vermont	12,478	15,658	19,688	24,523	29,914	35,703	50.9	52.3	55.1
Virginia	8,619	11,616	14,850	26,780	34,039	39,606	32.2	34.1	37.5
Washington	8,314	11,902	14,153	27,951	33,216	39,699	29.7	35.8	35.7
West Virginia	7,105	9,450	12,128	19,815	24,249	29,416	35.9	39.0	41.2
Wisconsin	7,268	9,872	12,400	25,078	29,864	33,857	29.0	33.1	36.6
Wyoming	7,091	8,514	10,556	25,330	35,371	43,929	28.0	24.1	24.0
Puerto Rico	NA	NA	NA	NA	NA	NA	NA	NA	NA

NA = not available

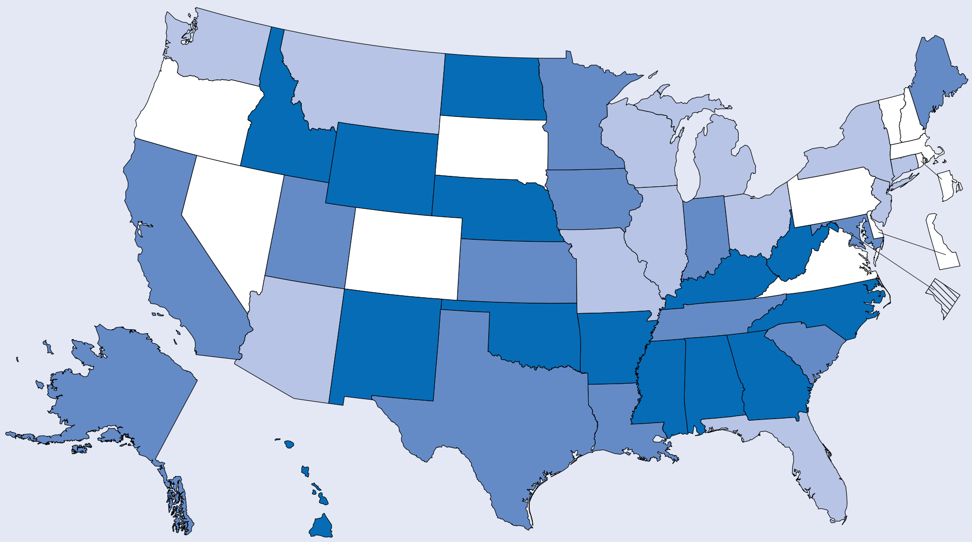
NOTES: National average undergraduate charge for United States from *Digest of Education Statistics* data tables. Average charges for entire academic year (reported in current dollars). Tuition and fees weighted by number of full-time-equivalent undergraduates but not adjusted to reflect student residency. Room and board based on full-time students. National value for disposable personal income is value reported by Bureau of Economic Analysis.

SOURCES: National Center for Education Statistics, Integrated Postsecondary Education Data System (various years); Bureau of Economic Analysis, State and Local Personal Income data.

Science and Engineering Indicators 2012

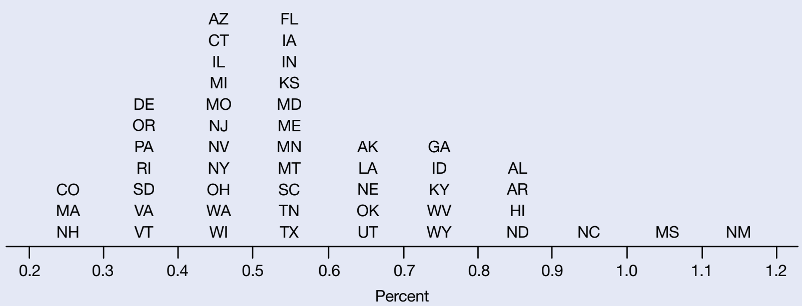
Appropriations of State Tax Funds for Operating Expenses of Higher Education as a Percentage of Gross Domestic Product

Figure 8-27
Appropriations of state tax funds for operating expenses of higher education as a percentage of gross domestic product: 2010



1st quartile (0.69%–1.10%)
2nd quartile (0.51%–0.68%)
3rd quartile (0.41%–0.50%)
4th quartile (0.22%–0.40%)
No data

SOURCES: State Higher Education Executive Officers/College Board, State Higher Education Finance; Bureau of Economic Analysis, Gross Domestic Product data; United Nations Statistics Division.



Findings

- Nationally, state appropriations for operating expenses of higher education as a share of gross domestic product decreased from 0.57% in 2000 to 0.52% in 2010 but has remained unchanged since 2005.
- In 2010, the value of this indicator ranges from 0.22% to 1.10% across the states.
- Between 2000 and 2010, most states increased their appropriations for higher education in terms of current dollars. Notable exceptions were Michigan, Massachusetts, Iowa, Ohio, and Colorado which decreased their appropriations.
- While many states reduced the percentage of their gross domestic product that was allocated to higher education, the states of Georgia and North Carolina made significant increases between 2000 and 2010.

This indicator represents the extent of state spending for higher education operating expenses as a proportion of its gross domestic product. A higher value on this indicator indicates that a state has made financial support of its higher education system more of a priority.

Because of decreases in state tax collections in FY 2009 and FY 2010, state monies allocated to higher education decreased in many states. This decrease was offset to a degree by federal stimulus funds that were used to restore the level of state support for public higher education. The state monies used to calculate this indicator do not include federal stimulus funds for education stabilization or government funds for the modernization, renovation, or repair of higher education facilities.

Table 8-27
Appropriations of state tax funds for operating expenses of higher education as a percentage of gross domestic product, by state: 2000, 2005, and 2010

State	Appropriations of state tax funds for operating expenses of higher education ($millions)			State GDP ($millions)			Appropriations of state tax funds for operating expenses of higher education/state GDP (%)		
	2000	2005	2010	2000	2005	2010	2000	2005	2010
United States	56,682	65,140	75,182	9,884,171	12,554,535	14,551,782	0.57	0.52	0.52
Alabama	1,095	1,215	1,449	116,014	151,096	172,567	0.94	0.80	0.84
Alaska	176	235	333	25,913	37,824	49,120	0.68	0.62	0.68
Arizona	866	987	1,104	161,901	222,968	253,609	0.53	0.44	0.44
Arkansas	605	655	905	68,146	88,227	102,566	0.89	0.74	0.88
California	7,684	9,067	10,793	1,317,343	1,691,991	1,901,088	0.58	0.54	0.57
Colorado	719	598	680	171,930	217,412	257,641	0.42	0.28	0.26
Connecticut	699	788	1,032	163,943	197,055	237,261	0.43	0.40	0.43
Delaware	176	203	227	40,957	54,749	62,280	0.43	0.37	0.36
District of Columbia	NA	NA	NA	58,269	82,837	103,288	NA	NA	NA
Florida	2,786	3,581	3,714	481,115	680,277	747,735	0.58	0.53	0.50
Georgia	1,560	2,467	2,977	294,479	363,154	403,070	0.53	0.68	0.74
Hawaii	342	410	575	41,372	56,869	66,760	0.83	0.72	0.86
Idaho	279	351	389	36,091	48,675	55,435	0.77	0.72	0.70
Illinois	2,554	2,686	3,040	474,444	569,544	651,518	0.54	0.47	0.47
Indiana	1,227	1,417	1,564	198,020	239,575	275,676	0.62	0.59	0.57
Iowa	827	743	722	93,287	120,258	142,698	0.89	0.62	0.51
Kansas	622	728	754	85,742	105,164	127,170	0.73	0.69	0.59
Kentucky	924	1,077	1,204	113,108	139,336	163,269	0.82	0.77	0.74
Louisiana	885	1,288	1,411	131,430	197,163	218,853	0.67	0.65	0.64
Maine	213	241	264	36,395	45,587	51,643	0.59	0.53	0.51
Maryland	1,043	1,185	1,669	182,953	248,139	295,304	0.57	0.48	0.57
Massachusetts	1,047	1,131	842	272,680	323,301	378,729	0.38	0.35	0.22
Michigan	2,074	1,948	1,837	336,786	375,260	384,171	0.62	0.52	0.48
Minnesota	1,281	1,273	1,427	188,449	238,367	270,039	0.68	0.53	0.53
Mississippi	917	761	1,006	65,615	81,500	97,461	1.40	0.93	1.03
Missouri	978	925	1,036	180,982	216,633	244,016	0.54	0.43	0.42
Montana	138	153	179	21,629	30,088	36,067	0.64	0.51	0.50
Nebraska	474	520	623	57,233	72,504	89,786	0.83	0.72	0.69
Nevada	306	502	501	75,907	114,771	125,650	0.40	0.44	0.40
New Hampshire	96	115	138	44,067	53,653	60,283	0.22	0.22	0.23
New Jersey	1,520	1,890	2,010	349,334	429,985	487,335	0.43	0.44	0.41
New Mexico	544	762	877	50,262	67,776	79,678	1.08	1.12	1.10
New York	3,127	3,642	4,879	770,621	961,941	1,159,540	0.41	0.38	0.42
North Carolina	2,293	2,781	3,848	281,418	354,973	424,935	0.81	0.78	0.91
North Dakota	187	202	301	18,250	24,672	34,685	1.03	0.82	0.87
Ohio	2,061	2,102	1,968	381,175	444,715	477,699	0.54	0.47	0.41
Oklahoma	739	787	1,018	91,292	120,662	147,543	0.81	0.65	0.69
Oregon	650	586	663	112,974	143,349	174,151	0.58	0.41	0.38
Pennsylvania	1,880	2,016	2,039	395,811	482,324	569,679	0.47	0.42	0.36
Rhode Island	151	188	163	33,522	44,169	49,234	0.45	0.43	0.33
South Carolina	813	977	924	115,392	141,929	164,445	0.70	0.69	0.56
South Dakota	130	163	152	24,009	31,641	39,893	0.54	0.51	0.38
Tennessee	985	1,302	1,474	177,582	224,522	254,806	0.55	0.58	0.58
Texas	4,093	5,110	6,543	732,987	970,997	1,207,494	0.56	0.53	0.54
Utah	547	647	687	69,483	90,748	114,538	0.79	0.71	0.60
Vermont	63	78	91	18,033	22,773	25,620	0.35	0.34	0.36
Virginia	1,480	1,481	1,576	261,894	356,852	423,860	0.57	0.41	0.37
Washington	1,238	1,412	1,576	227,828	279,405	340,460	0.54	0.51	0.46
West Virginia	373	426	503	41,419	51,964	64,642	0.90	0.82	0.78
Wisconsin	1,075	1,122	1,192	177,638	218,923	248,265	0.61	0.51	0.48
Wyoming	140	218	305	17,047	26,238	38,527	0.82	0.83	0.79
Puerto Rico	NA	NA	NA	69,208	86,157	NA	NA	NA	NA

NA = not available

GDP = gross domestic product

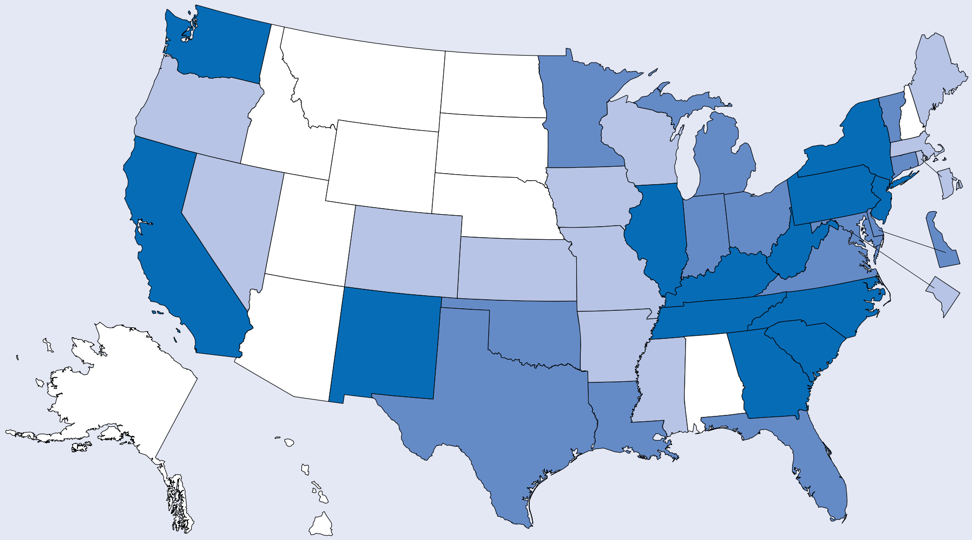
NOTE: FY 2010 appropriations figures represent initial allocations or estimates as of 10 February 2010 and are subject to change; appropriations and GDP reported in current dollars.

SOURCES: State Higher Education Executive Officers College Board, State Higher Education Finance (various years); Bureau of Economic Analysis, Gross Domestic Product data; United Nations Statistics Division.

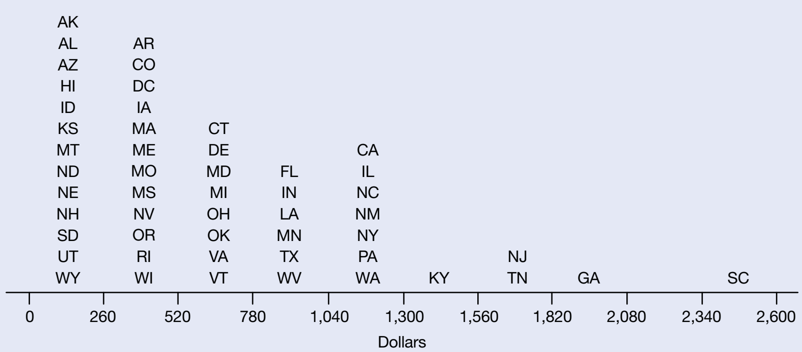
Science and Engineering Indicators 2012

State Expenditures on Student Aid per Full-Time Undergraduate Student

Figure 8-28
State expenditures on student aid per full-time undergraduate student: 2008



1st quartile ($988–$2,577)
2nd quartile ($585–$980)
3rd quartile ($200–$503)
4th quartile ($12–$191)



SOURCES: National Association of State Student Grant and Aid Programs, Annual Survey Report; National Center for Education Statistics, Integrated Postsecondary Education Data System.

Findings

- The total amount of state financial aid from grants provided to undergraduates nearly doubled nationwide increasing from $4.0 billion in 2000 to $7.9 billion in 2008.
- On a per-student basis, state funding for student grants across the United States increased from $553 per undergraduate in 2000 to $839 per undergraduate in 2008 (in current dollars).
- There are major differences in the amount of state aid provided to undergraduate students in different states. State values for this indicator ranged from $12 to $2,577 in 2008. Eight jurisdictions averaged less than $100 per undergraduate student, while 12 provided more than $1,000 per student.
- Eight states reported spending less, in current dollars, per student for student financial aid in 2008 than in 2000, even though the cost of undergraduate education rose rapidly during this period.

The cost of an undergraduate education can be reduced with financial assistance from the state or federal government or from an academic institution. This indicator is calculated by dividing the amount of financial support from state grants by the number of full-time undergraduate students who attend both public and private institutions in the state. A high value is one indicator of state efforts to provide access to higher education at a time of escalating undergraduate costs. The actual distribution of state grants to individual students may be affected by the percentage of undergraduates who are state residents.

This indicator should be viewed relative to the tuition charged to undergraduates in a state, as some states have chosen to subsidize tuition for all students at public institutions rather than provide grants. Other differences between states, such as the amount of scholarship aid available from other sources, the percentage of students attending out-of-state institutions, and their eligibility for state funding, mean that readers should exercise caution when making comparisons between states and examining changes over time.

Total state grant expenditures for financial aid include need-based and non-need-based grants. State assistance through subsidized or unsubsidized loans and awards to students at the graduate and first professional degree levels is not included. The year is the end date of the academic year. For example, data for 2008 represent costs for the 2007–08 academic year.

Table 8-28
State expenditures on student aid per full-time undergraduate student, by state: 2000, 2004, and 2008

State	State expenditures on student aid ($thousands)			Undergraduate enrollment at 4-year institutions			State expenditures on student aid/ undergraduate ($)		
	2000	2004	2008	2000	2004	2008	2000	2004	2008
United States	3,975,263	5,688,877	7,864,532	7,193,814	8,220,306	9,379,112	553	692	839
Alabama	7,487	5,084	19,841	130,189	139,033	183,162	58	37	108
Alaska	NA	NA	670	24,573	27,377	27,132	NA	NA	25
Arizona	2,727	2,865	12,179	111,429	192,819	378,866	24	15	32
Arkansas	30,936	29,705	33,774	70,538	79,007	86,667	439	376	390
California	369,785	654,549	813,374	599,658	679,920	750,965	617	963	1,083
Colorado	54,151	60,266	75,259	133,500	154,427	181,904	406	390	414
Connecticut	37,401	36,771	64,475	85,143	90,774	96,753	439	405	666
Delaware	1,293	12,703	16,980	25,761	27,996	28,438	50	454	597
District of Columbia	743	27,571	33,496	40,703	59,930	76,586	18	460	437
Florida	225,553	326,468	533,073	288,143	457,808	587,097	783	713	908
Georgia	240,458	431,951	497,667	188,383	234,213	266,808	1,276	1,844	1,865
Hawaii	490	408	408	26,290	30,956	34,471	19	13	12
Idaho	1,127	4,982	6,221	39,343	55,877	59,010	29	89	105
Illinois	360,177	347,565	415,298	276,559	298,037	343,104	1,302	1,166	1,210
Indiana	106,169	161,263	223,676	217,294	230,454	259,489	489	700	862
Iowa	51,823	49,285	59,573	97,241	110,724	166,514	533	445	358
Kansas	12,397	14,073	19,090	84,620	91,803	95,529	147	153	200
Kentucky	48,444	143,338	186,988	109,981	121,518	130,274	440	1,180	1,435
Louisiana	68,391	111,602	137,347	146,259	157,201	140,163	468	710	980
Maine	10,360	12,561	17,916	42,093	44,104	43,462	246	285	412
Maryland	45,683	50,390	99,726	117,720	130,334	140,784	388	387	708
Massachusetts	103,301	79,735	86,342	235,263	238,366	256,937	439	335	336
Michigan	91,109	162,225	189,078	287,233	314,782	323,385	317	515	585
Minnesota	113,750	119,641	156,433	142,734	164,791	183,329	797	726	853
Mississippi	20,163	21,367	22,923	61,043	65,345	67,127	330	327	341
Missouri	39,504	41,233	109,998	180,799	203,040	218,700	218	203	503
Montana	2,953	2,542	4,367	32,393	33,615	33,391	91	76	131
Nebraska	5,645	8,742	12,537	58,789	62,427	65,693	96	140	191
Nevada	6,083	34,535	39,109	32,012	76,669	92,307	190	450	424
New Hampshire	1,506	3,651	3,732	40,367	43,821	45,831	37	83	81
New Jersey	189,294	225,282	292,500	156,867	167,863	183,112	1,207	1,342	1,597
New Mexico	33,872	29,821	67,781	43,089	50,348	52,659	786	592	1,287
New York	611,167	875,299	824,174	569,260	609,027	678,593	1,074	1,437	1,215
North Carolina	109,004	156,604	286,773	191,117	215,536	243,631	570	727	1,177
North Dakota	2,431	1,756	3,778	28,462	34,010	38,778	85	52	97
Ohio	163,994	200,787	254,785	302,681	326,174	353,284	542	616	721
Oklahoma	26,595	28,841	75,823	98,512	114,090	117,799	270	253	644
Oregon	17,891	21,782	35,036	76,071	89,212	96,641	235	244	363
Pennsylvania	280,402	360,816	460,451	377,646	409,046	438,118	742	882	1,051
Rhode Island	61,722	12,296	15,336	49,484	52,831	55,312	1,247	233	277
South Carolina	33,198	225,297	295,627	92,074	103,533	114,705	361	2,176	2,577
South Dakota	857	NA	2,416	32,310	37,315	38,420	27	NA	63
Tennessee	21,383	42,395	279,300	139,743	154,060	171,186	153	275	1,632
Texas	93,814	156,529	484,807	432,747	495,259	554,233	217	316	875
Utah	2,735	4,081	10,705	120,151	138,646	151,316	23	29	71
Vermont	48,840	17,149	18,804	25,972	27,166	30,393	1,880	631	619
Virginia	70,717	110,621	173,813	180,573	202,472	239,213	392	546	727
Washington	76,581	134,280	205,891	105,470	122,495	159,407	726	1,096	1,292
West Virginia	18,982	52,087	82,487	68,435	67,215	83,509	277	775	988
Wisconsin	52,020	75,920	102,533	168,547	177,251	205,226	309	428	500
Wyoming	155	163	162	8,550	9,589	9,699	18	17	17
Puerto Rico	34,004	30,999	31,891	149,699	165,293	173,409	227	188	184

NA = not available

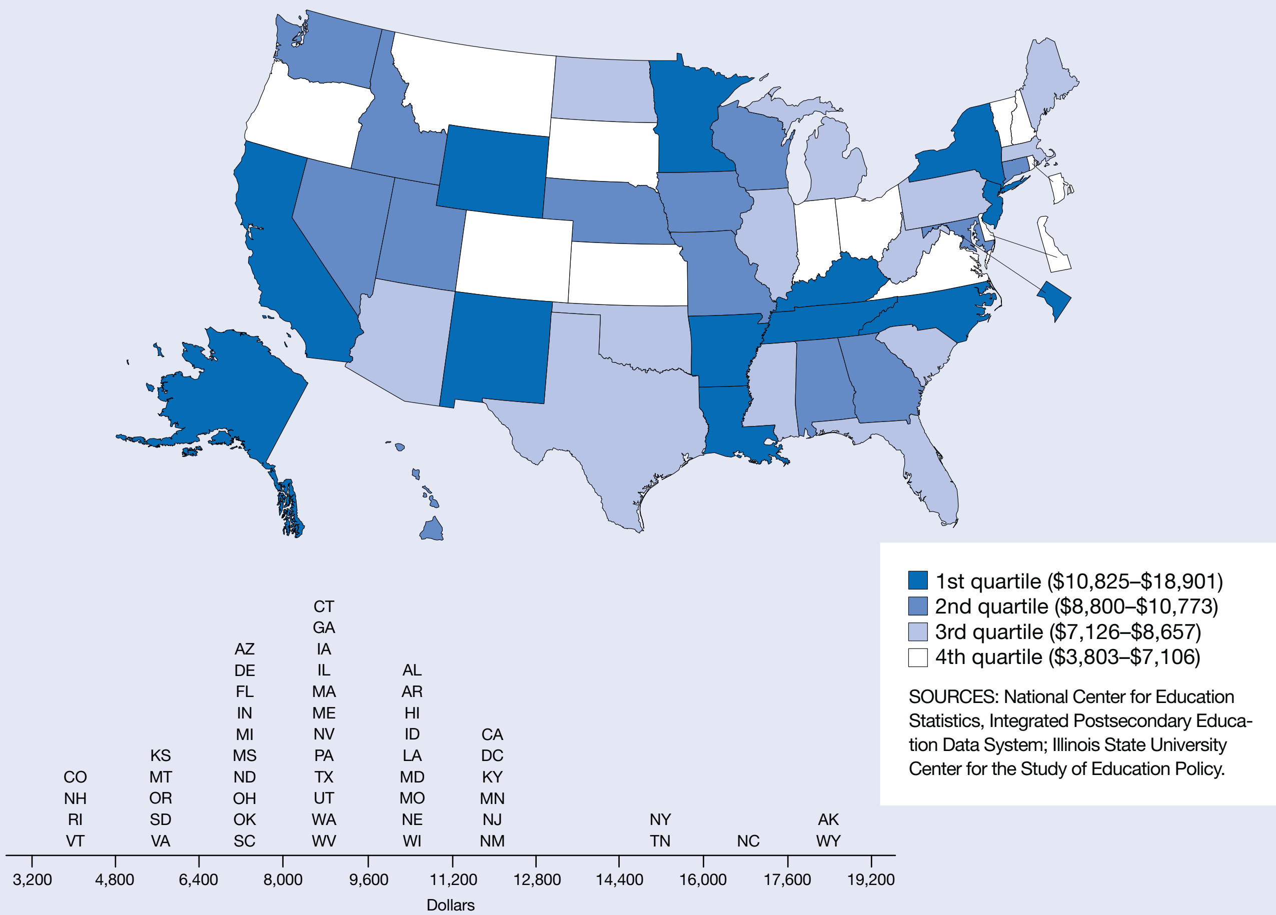
NOTE: State expenditures on student aid reported in current dollars.

SOURCES: National Association of State Student Grant and Aid Programs, Annual Survey Report (various years); National Center for Education Statistics, Integrated Postsecondary Education Data System (various years).

Science and Engineering Indicators 2012

State Funding for Major Public Research Universities per Enrolled Student

Figure 8-29
State funding for major public research universities per enrolled student: 2010



SOURCES: National Center for Education Statistics, Integrated Postsecondary Education Data System; Illinois State University Center for the Study of Education Policy.

Findings

- From 2002 to 2010, state funds for operating expenses of all public institutions of higher education increased by 21%. For major public research universities, state funds increased by only 8% dropping the states' share of their total operating funds from 28% to 19%.
- When adjusted for inflation, total state expenditures for public higher education were essentially flat over the decade, while the amount going to major public research universities decreased by 10%.
- Between 2002 and 2008, total enrollment at major public research universities increased by 8% and undergraduate enrollment at all public 4-year institutions increased by 22%.
- Over the decade, per-student state support to major research universities dropped by an average of 20% in inflation-adjusted dollars. In 10 states, the decline ranged from 30% to 48%. New York and Wyoming increased their funds per enrollment by over half. Their funds per student in 2010 put them among the top 5 states on this measure.

Public research universities rely on state support for a substantial share of their operating revenues, most of which support their education function. An indicator of states' investment in the education of their students is the amount of funding provided per enrolled student. Eventually, changes in these funds affect the institutions' financial health and the quality of education they provide.

Data for this indicator cover 102 public research universities with broad educational missions (excluding free-standing medical and engineering schools when possible). These institutions are either the leading recipient of academic R&D funding in their state or among the nation's top 100 recipients of academic R&D funding to public universities. State funds include state operating grants and contracts as well as state appropriations. Enrollment includes total enrollment measured in the fall of each academic year. Total state funds are shown in current dollars; the Findings also address constant dollar results.

Data were drawn from annual surveys of the National Center for Education Statistics (NCES), and supplemented with data from Illinois State University's Center for the Study of Education Policy when NCES data were unavailable or incomplete.

State funds are one of many sources of public university revenue. This indicator does not include changes in these other sources of revenue.

Table 8-29
State funding for major public research universities per enrolled student, by state: 2002, 2006, and 2010

State	State funding for major public research universities ($ thousands)			Enrolled students			State funding for major public research universities/ enrolled student ($)		
	2002	2006	2010	2002	2006	2010	2002	2006	2010
United States	23,826,069	24,969,781	25,835,178	2,527,368	2,663,015	2,844,570	9,427	9,377	9,082
Alabama	440,152	537,351	529,456	43,918	46,989	49,157	10,022	11,436	10,771
Alaska	97,177	125,062	164,911	7,142	8,228	9,137	13,606	15,200	18,049
Arizona	618,184	705,582	761,297	81,440	88,648	106,831	7,591	7,959	7,126
Arkansas	166,884	184,955	214,863	15,752	17,821	19,849	10,594	10,378	10,825
California	3,317,385	2,887,676	3,161,359	222,500	232,159	253,013	14,910	12,438	12,495
Colorado	355,986	262,707	235,480	58,166	59,369	61,912	6,120	4,425	3,803
Connecticut	188,379	205,800	239,156	19,876	23,185	25,029	9,478	8,876	9,555
Delaware	120,736	139,441	148,308	20,949	20,982	21,138	5,763	6,646	7,016
District of Columbia	46,068	61,266	62,070	5,456	5,363	4,960	8,444	11,424	12,514
Florida	1,457,282	1,808,109	1,704,160	186,295	213,259	223,509	7,822	8,478	7,625
Georgia	908,772	912,554	804,648	73,635	76,762	85,603	12,342	11,888	9,400
Hawaii	198,539	231,273	220,156	17,532	20,644	20,435	11,324	11,203	10,773
Idaho	130,026	138,166	118,466	12,067	12,476	11,957	10,775	11,075	9,908
Illinois	954,329	753,066	766,844	85,844	88,191	91,071	11,117	8,539	8,420
Indiana	532,994	532,791	563,341	77,845	78,109	83,399	6,847	6,821	6,755
Iowa	590,225	565,168	541,689	56,591	54,167	56,932	10,430	10,434	9,515
Kansas	313,888	320,226	317,732	48,178	50,116	52,823	6,515	6,390	6,015
Kentucky	514,549	602,485	559,642	43,583	46,398	47,311	11,806	12,985	11,829
Louisiana	288,601	330,639	320,314	32,059	34,128	28,643	9,002	9,688	11,183
Maine	96,188	101,515	102,969	10,698	11,435	11,894	8,991	8,878	8,657
Maryland	529,049	466,392	507,435	45,397	47,019	50,065	11,654	9,919	10,136
Massachusetts	227,241	263,877	218,861	24,678	25,093	27,016	9,208	10,516	8,101
Michigan	1,040,859	937,704	923,999	113,515	117,319	120,531	9,169	7,993	7,666
Minnesota	611,601	606,249	621,463	46,597	51,175	51,659	13,125	11,847	12,030
Mississippi	224,924	233,863	257,505	29,504	31,002	34,533	7,624	7,543	7,457
Missouri	223,274	252,801	306,294	23,667	27,930	31,237	9,434	9,051	9,805
Montana	62,345	62,875	63,841	11,670	12,143	12,348	5,342	5,178	5,170
Nebraska	217,607	222,523	250,498	22,764	21,675	24,100	9,559	10,266	10,394
Nevada	146,094	198,620	148,492	14,316	16,336	16,875	10,205	12,158	8,800
New Hampshire	65,447	66,162	73,144	14,766	14,511	15,253	4,432	4,559	4,795
New Jersey	646,252	682,817	572,428	44,512	42,507	46,206	14,519	16,064	12,389
New Mexico	383,411	459,827	534,212	38,977	42,244	45,767	9,837	10,885	11,672
New York	556,999	1,161,303	1,295,820	76,717	80,289	86,291	7,260	14,464	15,017
North Carolina	760,128	915,647	1,050,584	54,780	57,424	62,735	13,876	15,945	16,746
North Dakota	132,543	153,291	204,312	22,298	25,053	27,361	5,944	6,119	7,467
Ohio	702,689	731,819	776,038	96,079	97,637	109,212	7,314	7,495	7,106
Oklahoma	368,093	362,186	386,065	47,112	50,198	48,914	7,813	7,215	7,893
Oregon	217,853	218,217	213,453	36,969	39,571	44,285	5,893	5,515	4,820
Pennsylvania	774,683	827,682	946,362	97,410	100,963	110,020	7,953	8,198	8,602
Rhode Island	91,296	91,073	67,353	14,264	15,095	16,389	6,400	6,033	4,110
South Carolina	391,965	378,784	347,733	40,101	44,230	47,593	9,774	8,564	7,306
South Dakota	52,069	60,701	67,324	9,260	10,938	12,376	5,623	5,550	5,440
Tennessee	400,660	433,396	458,400	26,033	28,512	29,934	15,390	15,200	15,314
Texas	1,067,096	1,118,929	1,227,595	140,695	144,430	152,480	7,584	7,747	8,051
Utah	391,336	416,127	396,268	50,669	45,016	44,896	7,723	9,244	8,826
Vermont	43,369	50,131	51,893	10,078	11,597	13,391	4,303	4,323	3,875
Virginia	841,601	831,820	796,312	120,467	131,914	143,477	6,986	6,306	5,550
Washington	591,118	602,357	635,081	58,485	62,795	72,044	10,107	9,592	8,815
West Virginia	218,982	206,953	232,538	22,774	26,051	28,898	9,615	7,944	8,047
Wisconsin	388,883	382,379	432,132	40,922	40,793	41,654	9,503	9,374	10,374
Wyoming	120,257	167,445	234,883	12,366	13,126	12,427	9,725	12,757	18,901
Puerto Rico	NA	NA	NA	NA	NA	NA	NA	NA	NA

NA = not available

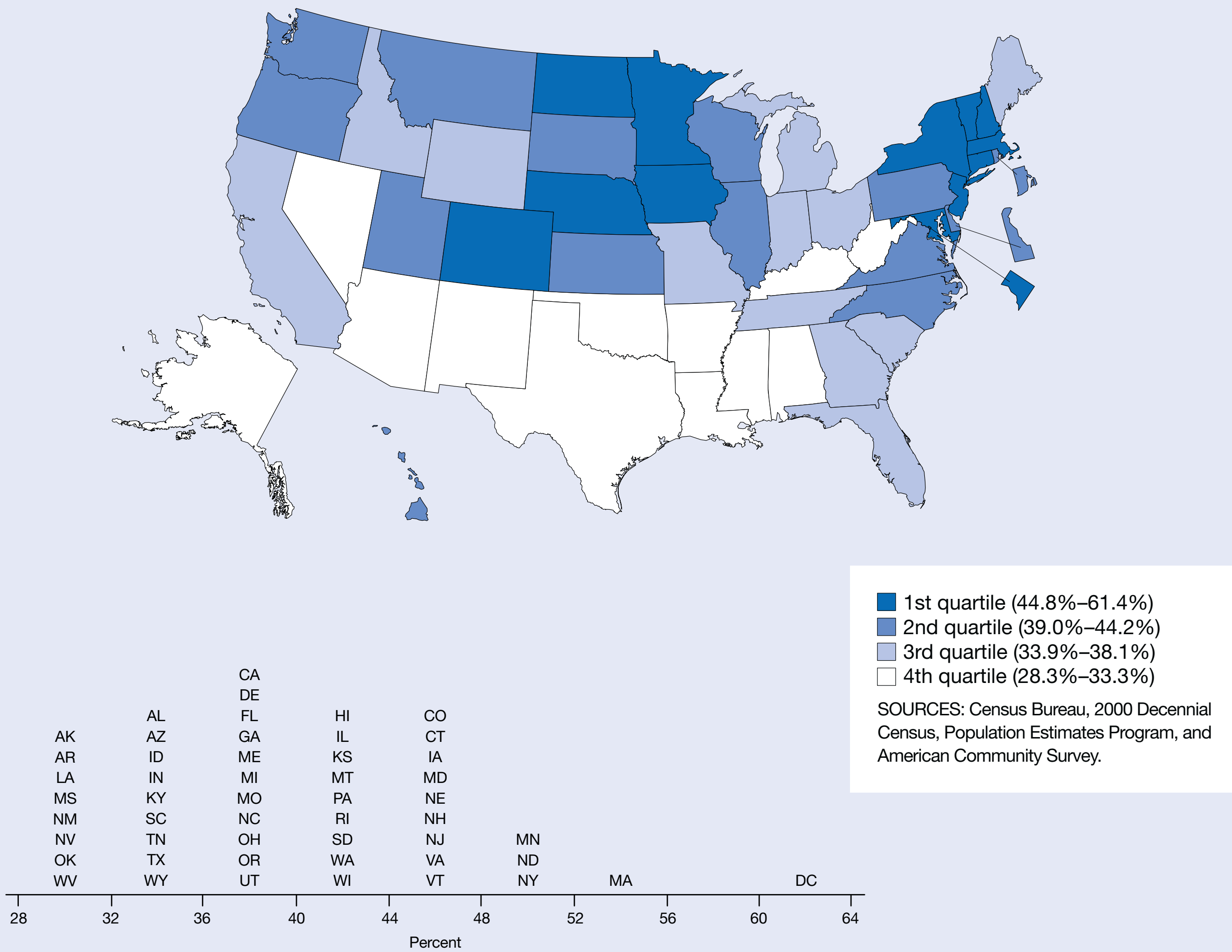
NOTES: National average state funds per enrolled student from Integrated Postsecondary Education Data System. For District of Columbia, funds are local education taxes. For Colorado, Connecticut, Kansas, New Jersey, and Tennessee, data for certain years include data from the Center for the Study of Education Policy's Grapevine tables. For Colorado, Connecticut, and Kansas, 2010 state funds are projected based on 2009. All other 2010 funds are preliminary.

SOURCES: National Center for Education Statistics, Integrated Postsecondary Education Data System; Illinois State University Center for the Study of Education Policy.

Science and Engineering Indicators 2012

Postsecondary Degree Holders Among Individuals 25–44 Years Old

Figure 8-30
Postsecondary degree holders among individuals 25–44 years old: 2009



SOURCES: Census Bureau, 2000 Decennial Census, Population Estimates Program, and American Community Survey.

Findings

- The early- to mid-career population with a post-secondary degree was 39.2% nationwide in 2009, an increase from 34.7% in 2000.
- In 2009, the percentage of this cohort with a postsecondary degree varied greatly among states, ranging from 28.3% to 52.6%.
- Between 2000 and 2009, all states showed an increase in the percentage of their early- to mid-career population with a postsecondary degree, ranging from nearly 1% to almost 10% over the time period.
- States with the lowest cost of living tended to rank lowest on this indicator.

This indicator represents the percentage of the early- to mid-career population that has earned a postsecondary degree. That degree may be an associate's, bachelor's, master's, or doctoral degree. The indicator represents where postsecondary degree holders live rather than where they were educated. The age cohort of 25–44 years represents the group most likely to have completed a post-secondary program.

Estimates of educational attainment and of the population of individuals 25-44 years old are provided by the U.S. Census Bureau. Small differences in the value of this indicator between states and across time generally are not meaningful.

Table 8-30
Postsecondary degree holders among individuals 25–44 years old, by state: 2000, 2005, and 2009

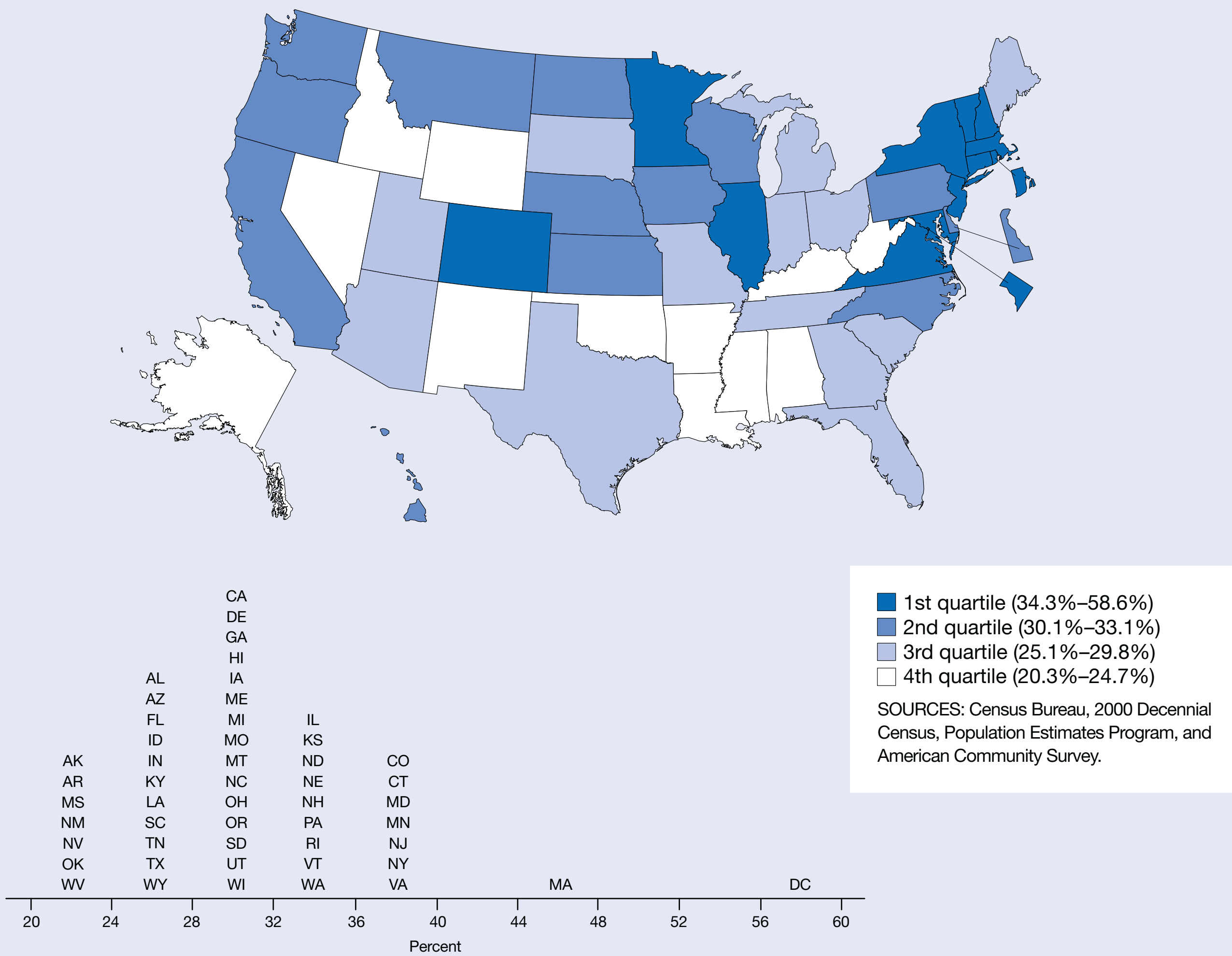
	Postsecondary degree holders 25–44 years old			Individuals 25–44 years old			Postsecondary degree holders/ individuals 25–44 years old (%)		
State	2000	2005	2009	2000	2005	2009	2000	2005	2009
United States	29,471,612	31,382,831	32,606,255	85,040,251	83,257,116	83,096,278	34.7	37.7	39.2
Alabama	370,196	389,490	405,826	1,288,527	1,231,043	1,235,509	28.7	31.6	32.8
Alaska	61,646	58,631	61,366	203,522	191,837	197,248	30.3	30.6	31.1
Arizona	472,901	552,805	608,775	1,511,469	1,695,189	1,826,751	31.3	32.6	33.3
Arkansas	177,657	202,622	216,126	750,972	747,630	755,915	23.7	27.1	28.6
California	3,670,622	3,892,099	4,024,498	10,714,403	10,668,824	10,604,180	34.3	36.5	38.0
Colorado	596,036	636,437	654,274	1,400,850	1,388,046	1,445,400	42.5	45.9	45.3
Connecticut	443,608	432,451	426,214	1,032,689	951,020	899,649	43.0	45.5	47.4
Delaware	84,170	87,994	92,531	236,441	234,823	232,837	35.6	37.5	39.7
District of Columbia	90,097	103,236	121,521	189,439	190,118	197,983	47.6	54.3	61.4
Florida	1,513,345	1,694,517	1,761,941	4,569,347	4,787,948	4,789,059	33.1	35.4	36.8
Georgia	884,108	1,013,471	1,039,426	2,652,764	2,746,294	2,830,740	33.3	36.9	36.7
Hawaii	136,758	129,858	157,298	362,336	354,560	360,037	37.7	36.6	43.7
Idaho	112,690	121,718	135,622	362,401	375,247	400,329	31.1	32.4	33.9
Illinois	1,444,942	1,530,725	1,553,736	3,795,544	3,611,958	3,544,995	38.1	42.4	43.8
Indiana	537,644	562,483	603,097	1,791,828	1,716,726	1,689,050	30.0	32.8	35.7
Iowa	289,740	317,772	331,841	808,259	746,659	734,622	35.8	42.6	45.2
Kansas	282,475	289,848	297,294	769,204	713,752	717,645	36.7	40.6	41.4
Kentucky	317,109	353,170	385,497	1,210,773	1,172,770	1,162,402	26.2	30.1	33.2
Louisiana	316,348	340,337	358,275	1,293,128	1,217,593	1,186,325	24.5	28.0	30.2
Maine	122,958	123,129	122,981	370,597	344,295	322,409	33.2	35.8	38.1
Maryland	672,460	693,317	713,321	1,664,677	1,611,882	1,557,085	40.4	43.0	45.8
Massachusetts	942,748	932,197	939,443	1,989,783	1,857,726	1,787,350	47.4	50.2	52.6
Michigan	982,169	1,013,031	946,696	2,960,544	2,743,365	2,536,880	33.2	36.9	37.3
Minnesota	631,677	684,727	688,731	1,497,320	1,420,387	1,394,305	42.2	48.2	49.4
Mississippi	208,866	231,759	226,353	807,170	771,676	761,785	25.9	30.0	29.7
Missouri	517,750	543,130	582,137	1,626,302	1,566,374	1,554,391	31.8	34.7	37.5
Montana	81,428	85,590	94,468	245,220	226,076	231,769	33.2	37.9	40.8
Nebraska	185,090	202,182	202,445	487,107	453,659	451,666	38.0	44.6	44.8
Nevada	152,536	193,902	226,510	628,572	719,501	769,608	24.3	26.9	29.4
New Hampshire	156,434	161,161	153,958	381,240	357,080	333,694	41.0	45.1	46.1
New Jersey	1,076,450	1,114,215	1,101,798	2,624,146	2,485,721	2,363,679	41.0	44.8	46.6
New Mexico	149,398	153,406	164,083	516,100	510,063	523,059	28.9	30.1	31.4
New York	2,359,507	2,499,314	2,566,265	5,831,622	5,548,409	5,351,598	40.5	45.0	48.0
North Carolina	844,019	933,034	1,004,796	2,500,535	2,485,963	2,553,673	33.8	37.5	39.3
North Dakota	71,509	73,974	77,223	174,891	151,681	153,582	40.9	48.8	50.3
Ohio	1,075,353	1,098,912	1,115,603	3,325,210	3,122,259	2,998,151	32.3	35.2	37.2
Oklahoma	276,525	296,769	298,455	975,169	929,451	957,235	28.4	31.9	31.2
Oregon	333,963	361,760	401,129	997,269	988,164	1,028,645	33.5	36.6	39.0
Pennsylvania	1,230,548	1,269,457	1,326,259	3,508,562	3,280,173	3,187,617	35.1	38.7	41.6
Rhode Island	117,758	127,598	120,458	310,636	296,463	274,622	37.9	43.0	43.9
South Carolina	357,570	389,378	425,929	1,185,955	1,172,501	1,200,366	30.2	33.2	35.5
South Dakota	73,128	82,619	80,521	206,399	194,122	196,143	35.4	42.6	41.1
Tennessee	489,940	521,417	579,010	1,718,428	1,698,113	1,710,134	28.5	30.7	33.9
Texas	1,973,279	2,112,582	2,312,816	6,484,321	6,665,252	7,064,651	30.4	31.7	32.7
Utah	222,534	276,707	302,339	626,600	686,668	775,481	35.5	40.3	39.0
Vermont	70,277	68,447	68,179	176,456	158,184	148,584	39.8	43.3	45.9
Virginia	874,239	925,208	970,871	2,237,655	2,194,670	2,194,699	39.1	42.2	44.2
Washington	693,591	739,976	782,873	1,816,217	1,783,093	1,855,094	38.2	41.5	42.2
West Virginia	115,337	125,231	130,226	501,343	468,846	459,606	23.0	26.7	28.3
Wisconsin	566,244	596,923	595,646	1,581,690	1,495,775	1,449,006	35.8	39.9	41.1
Wyoming	44,235	42,115	49,575	138,619	127,487	139,035	31.9	33.0	35.7
Puerto Rico	358,595	424,718	412,249	1,049,995	1,076,844	1,084,239	34.2	39.4	38.0

SOURCES: Census Bureau, 2000 Decennial Census, Population Estimates Program (various years), and American Community Survey (various years).

Science and Engineering Indicators 2012

Bachelor's Degree Holders Among Individuals 25–44 Years Old

Figure 8-31
Bachelor's degree holders among individuals 25–44 years old: 2009



Findings

- The early- to mid-career population with at least a bachelor's degree was 30.9% nationwide in 2009, an increase from 26.8% in 2000.
- All states showed an increase in the percentage of their early-career population with at least a bachelor's degree between 2000 and 2009.
- In 2009, the percentage of the early-career population with at least a bachelor's degree varied among states, ranging from 20.3 % to 45.1%. The highest percentages tended to be found in the New England and Middle Atlantic states.
- States with the lowest cost of living tended to rank lowest on this indicator.
- The difference between EPSCoR and non-EPSCoR states, as a group, remained relatively unchanged and may have increased slightly over the decade.

This indicator represents the percentage of the early- to mid-career population that has earned at least a 4-year undergraduate degree. The indicator represents where college degree holders live rather than where they were educated. The age cohort of 25–44 years represents a group of individuals who are potential long-term participants in a state's workforce.

Estimates of educational attainment are developed by the U.S. Census Bureau. Small differences in the value of this indicator between states and across time generally are not meaningful.

Table 8-31
Bachelor's degree holders among individuals 25–44 years old, by state: 2000, 2005, and 2009

State	Bachelor's degree holders 25–44 years old			Individuals 25–44 years old			Bachelor's degree holders/individuals 25–44 years old (%)		
	2000	2005	2009	2000	2005	2009	2000	2005	2009
EPSCoR states	3,004,954	3,199,506	3,399,367	13,582,778	13,120,340	13,171,410	22.1	24.4	25.8
Non-EPSCoR states	19,692,206	21,057,298	22,147,292	71,268,034	69,946,658	69,726,885	27.6	30.1	31.8
Average EPSCoR state value	na	na	na	na	na	na	23.4	26.0	27.4
Average non-EPSCoR state value	na	na	na	na	na	na	28.0	30.7	32.4
United States	22,781,996	24,353,620	25,662,617	85,040,251	83,257,116	83,096,278	26.8	29.3	30.9
Alabama	275,759	288,817	303,640	1,288,527	1,231,043	1,235,509	21.4	23.5	24.6
Alaska	45,560	45,315	45,858	203,522	191,837	197,248	22.4	23.6	23.2
Arizona	355,836	408,522	458,075	1,511,469	1,695,189	1,826,751	23.5	24.1	25.1
Arkansas	136,883	152,225	161,439	750,972	747,630	755,915	18.2	20.4	21.4
California	2,882,717	3,112,603	3,270,704	10,714,403	10,668,824	10,604,180	26.9	29.2	30.8
Colorado	480,984	512,178	537,204	1,400,850	1,388,046	1,445,400	34.3	36.9	37.2
Connecticut	362,272	362,929	354,994	1,032,689	951,020	899,649	35.1	38.2	39.5
Delaware	65,811	71,090	73,657	236,441	234,823	232,837	27.8	30.3	31.6
District of Columbia	84,836	96,816	115,958	189,439	190,118	197,983	44.8	50.9	58.6
Florida	1,081,551	1,212,200	1,270,000	4,569,347	4,787,948	4,789,059	23.7	25.3	26.5
Georgia	718,591	820,695	844,470	2,652,764	2,746,294	2,830,740	27.1	29.9	29.8
Hawaii	99,378	95,029	111,896	362,336	354,560	360,037	27.4	26.8	31.1
Idaho	80,235	89,959	98,196	362,401	375,247	400,329	22.1	24.0	24.5
Illinois	1,149,688	1,216,933	1,264,186	3,795,544	3,611,958	3,544,995	30.3	33.7	35.7
Indiana	397,050	408,107	440,159	1,791,828	1,716,726	1,689,050	22.2	23.8	26.1
Iowa	202,004	221,497	228,596	808,259	746,659	734,622	25.0	29.7	31.1
Kansas	223,467	224,946	234,605	769,204	713,752	717,645	29.1	31.5	32.7
Kentucky	234,921	256,209	287,622	1,210,773	1,172,770	1,162,402	19.4	21.8	24.7
Louisiana	256,363	267,429	285,090	1,293,128	1,217,593	1,186,325	19.8	22.0	24.0
Maine	86,989	85,987	91,692	370,597	344,295	322,409	23.5	25.0	28.4
Maryland	566,294	582,280	613,136	1,664,677	1,611,882	1,557,085	34.0	36.1	39.4
Massachusetts	773,569	780,522	805,478	1,989,783	1,857,726	1,787,350	38.9	42.0	45.1
Michigan	719,607	757,970	714,045	2,960,544	2,743,365	2,536,880	24.3	27.6	28.1
Minnesota	476,707	511,402	520,361	1,497,320	1,420,387	1,394,305	31.8	36.0	37.3
Mississippi	144,488	152,606	161,959	807,170	771,676	761,785	17.9	19.8	21.3
Missouri	407,449	429,501	456,593	1,626,302	1,566,374	1,554,391	25.1	27.4	29.4
Montana	62,682	63,693	71,370	245,220	226,076	231,769	25.6	28.2	30.8
Nebraska	134,516	149,233	148,518	487,107	453,659	451,666	27.6	32.9	32.9
Nevada	111,517	143,301	167,403	628,572	719,501	769,608	17.7	19.9	21.8
New Hampshire	114,745	122,682	118,843	381,240	357,080	333,694	30.1	34.4	35.6
New Jersey	899,016	943,939	935,352	2,624,146	2,485,721	2,363,679	34.3	38.0	39.6
New Mexico	110,360	110,562	117,143	516,100	510,063	523,059	21.4	21.7	22.4
New York	1,817,661	1,964,870	2,072,041	5,831,622	5,548,409	5,351,598	31.2	35.4	38.7
North Carolina	636,799	697,740	768,610	2,500,535	2,485,963	2,553,673	25.5	28.1	30.1
North Dakota	46,291	48,381	50,787	174,891	151,681	153,582	26.5	31.9	33.1
Ohio	806,803	833,138	852,179	3,325,210	3,122,259	2,998,151	24.3	26.7	28.4
Oklahoma	209,025	218,272	224,298	975,169	929,451	957,235	21.4	23.5	23.4
Oregon	257,875	284,778	315,664	997,269	988,164	1,028,645	25.9	28.8	30.7
Pennsylvania	938,930	979,367	1,035,976	3,508,562	3,280,173	3,187,617	26.8	29.9	32.5
Rhode Island	88,647	98,477	94,159	310,636	296,463	274,622	28.5	33.2	34.3
South Carolina	259,773	283,280	315,848	1,185,955	1,172,501	1,200,366	21.9	24.2	26.3
South Dakota	51,213	56,951	55,005	206,399	194,122	196,143	24.8	29.3	28.0
Tennessee	380,929	401,027	458,483	1,718,428	1,698,113	1,710,134	22.2	23.6	26.8
Texas	1,571,951	1,668,865	1,848,862	6,484,321	6,665,252	7,064,651	24.2	25.0	26.2
Utah	162,495	197,780	225,717	626,600	686,668	775,481	25.9	28.8	29.1
Vermont	52,787	53,693	52,956	176,456	158,184	148,584	29.9	33.9	35.6
Virginia	722,081	763,865	815,770	2,237,655	2,194,670	2,194,699	32.3	34.8	37.2
Washington	520,382	554,104	602,269	1,816,217	1,783,093	1,855,094	28.7	31.1	32.5
West Virginia	83,441	91,539	93,104	501,343	468,846	459,606	16.6	19.5	20.3
Wisconsin	402,965	430,486	438,368	1,581,690	1,495,775	1,449,006	25.5	28.8	30.3
Wyoming	30,103	29,830	34,279	138,619	127,487	139,035	21.7	23.4	24.7
Puerto Rico	245,975	276,934	286,174	1,049,995	1,076,844	1,084,239	23.4	25.7	26.4

na = not applicable

EPSCoR = Experimental Program to Stimulate Competitive Research

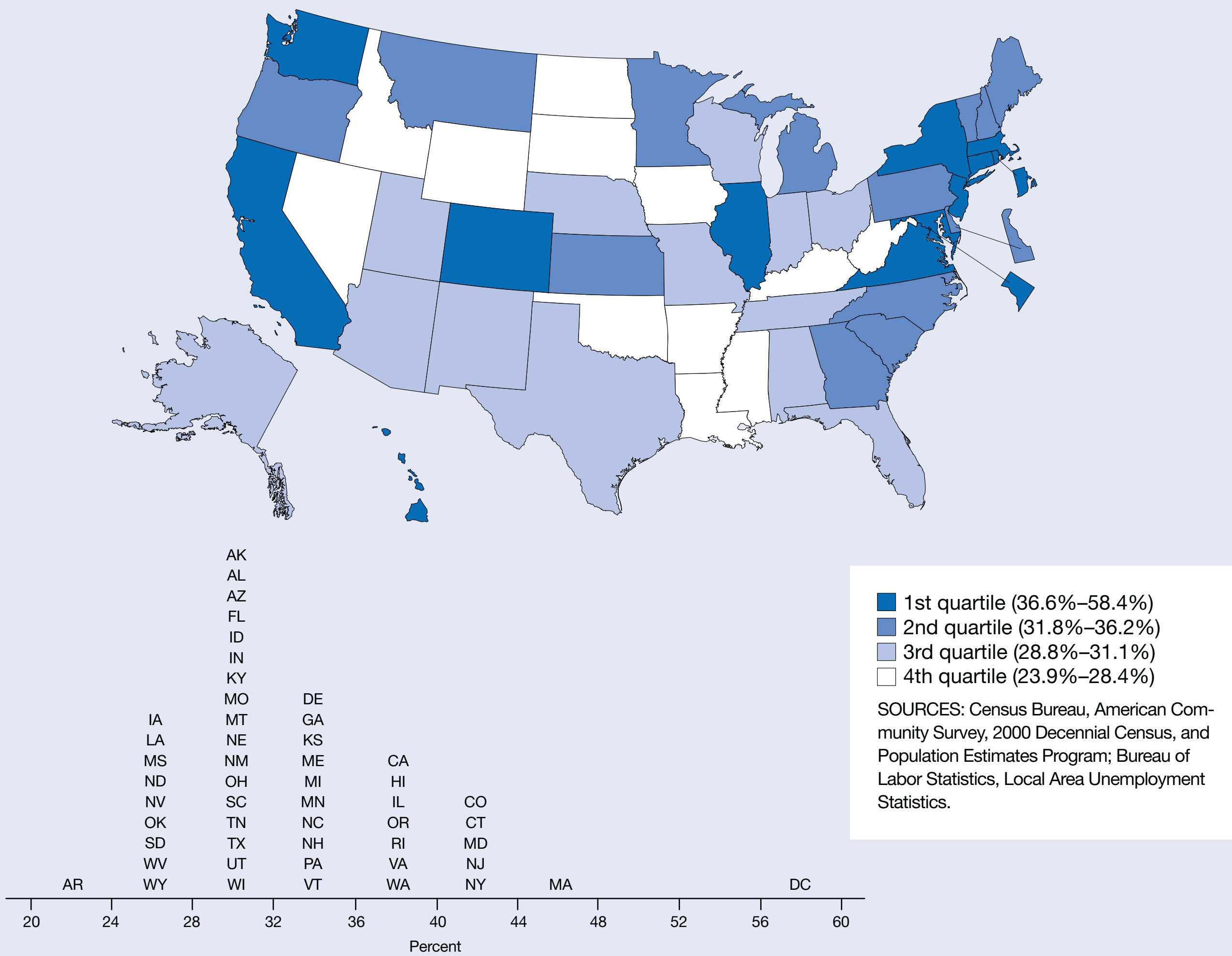
NOTE: For explanation of EPSCoR and non-EPSCoR averages, see chapter introduction.

SOURCES: Census Bureau, American Community Survey (various years), 2000 Decennial Census, and Population Estimates Program (various years).

Science and Engineering Indicators 2012

Bachelor's Degree Holders Potentially in the Workforce

Figure 8-32
Bachelor's degree holders potentially in the workforce: 2009



SOURCES: Census Bureau, American Community Survey, 2000 Decennial Census, and Population Estimates Program; Bureau of Labor Statistics, Local Area Unemployment Statistics.

Findings

- In 2009, 48 million individuals between ages 25 and 64 held bachelor's degrees in the United States, up from 39 million in 2000. Nationwide, the ratio of bachelor's degree holders to the size of the workforce rose from 28.5% in 2000 to 34.6% in 2009. This ratio varied considerably among the states, ranging from 23.9% to 47.1% in 2009.
- The value of this indicator increased in all jurisdictions between 2000 and 2009. This increase may reflect a replacement of older cohorts of workers with younger, more educated ones. It may also indicate the restructuring of state economies to emphasize work that requires a higher level of education or credentials.
- In 2009, the jurisdictions in which the highest concentrations of bachelor's degree holders lived included the District of Columbia, Massachusetts, New Jersey, and Maryland.

The ratio of degree holders (bachelor's, graduate, or professional) to the population potentially available for work is an indicator of the concentration of individuals with higher education qualifications in a jurisdiction. This indicator does not imply that all degree holders are currently employed; rather, it indicates the educational level of the workforce if all degree holders were employed. Knowledge-intensive businesses seeking to relocate may be attracted to states with high values on this indicator. Workers with at least a bachelor's degree have a clear advantage over less-educated workers in expected lifetime earnings.

Estimates of degree data are provided by the U.S. Census Bureau and are limited to individuals 25–64 years old, the age range most representative of a jurisdiction's workforce. Individuals younger than age 25 are considered to be in the process of completing their education. Individuals older than 64 are considered to be largely retired, so their educational attainment would have limited applicability to the quality of the workforce. Employed workforce data are Bureau of Labor Statistics estimates of employed civilians based on Local Area Unemployment Statistics. Estimates for states with smaller populations are generally less precise than estimates for states with larger populations.

Table 8-32
Bachelor's degree holders potentially in the workforce, by state: 2000, 2005, and 2009

State	Bachelor's degree holders 25–64 years old			Employed workforce			Bachelor's degree holders/workforce (%)		
	2000	2005	2009	2000	2005	2009	2000	2005	2009
United States	39,078,598	44,972,214	48,338,792	136,955,714	141,077,688	139,594,700	28.5	31.9	34.6
Alabama	479,734	549,086	583,697	2,067,147	2,051,893	1,959,849	23.2	26.8	29.8
Alaska	87,739	96,854	102,828	299,324	320,590	330,597	29.3	30.2	31.1
Arizona	638,515	781,932	886,445	2,404,916	2,724,859	2,851,063	26.6	28.7	31.1
Arkansas	247,079	287,058	300,180	1,207,352	1,270,930	1,256,136	20.5	22.6	23.9
California	4,960,210	5,732,017	6,060,404	16,024,341	16,592,204	16,141,519	31.0	34.5	37.5
Colorado	819,906	936,007	1,030,750	2,300,192	2,455,773	2,501,834	35.6	38.1	41.2
Connecticut	633,867	707,700	720,251	1,697,670	1,718,608	1,730,053	37.3	41.2	41.6
Delaware	111,260	131,287	142,848	402,777	417,196	400,004	27.6	31.5	35.7
District of Columbia	133,155	150,461	175,217	291,916	298,611	300,011	45.6	50.4	58.4
Florida	1,968,126	2,398,022	2,556,593	7,569,406	8,305,281	8,209,092	26.0	28.9	31.1
Georgia	1,148,814	1,394,550	1,522,467	4,095,362	4,375,178	4,302,039	28.1	31.9	35.4
Hawaii	184,130	200,132	219,868	584,858	609,835	588,662	31.5	32.8	37.4
Idaho	149,622	178,690	194,255	632,451	695,428	693,045	23.7	25.7	28.0
Illinois	1,876,455	2,113,824	2,274,031	6,176,837	6,033,421	5,927,804	30.4	35.0	38.4
Indiana	672,835	745,940	821,279	3,052,719	3,032,108	2,851,776	22.0	24.6	28.8
Iowa	351,922	404,729	430,363	1,557,081	1,557,545	1,571,691	22.6	26.0	27.4
Kansas	385,924	425,214	458,499	1,351,988	1,390,292	1,401,609	28.5	30.6	32.7
Kentucky	402,094	467,998	528,477	1,866,348	1,875,512	1,857,576	21.5	25.0	28.4
Louisiana	453,353	496,071	531,693	1,930,662	1,935,850	1,923,739	23.5	25.6	27.6
Maine	170,334	193,647	205,731	650,385	658,507	641,189	26.2	29.4	32.1
Maryland	979,588	1,095,665	1,172,521	2,711,382	2,825,040	2,786,271	36.1	38.8	42.1
Massachusetts	1,266,113	1,387,065	1,502,257	3,273,281	3,219,717	3,190,462	38.7	43.1	47.1
Michigan	1,242,388	1,407,669	1,403,052	4,953,421	4,717,188	4,210,871	25.1	29.8	33.3
Minnesota	783,613	906,335	959,272	2,720,492	2,756,709	2,712,250	28.8	32.9	35.4
Mississippi	256,581	293,533	310,187	1,239,859	1,219,135	1,170,719	20.7	24.1	26.5
Missouri	695,491	792,737	860,322	2,875,336	2,849,708	2,768,144	24.2	27.8	31.1
Montana	124,462	139,593	148,144	446,552	463,251	465,220	27.9	30.1	31.8
Nebraska	230,857	267,867	277,140	923,198	935,447	934,161	25.0	28.6	29.7
Nevada	206,361	272,492	315,597	1,015,221	1,173,425	1,184,431	20.3	23.2	26.6
New Hampshire	207,431	243,698	246,364	675,541	696,765	698,317	30.7	35.0	35.3
New Jersey	1,510,429	1,734,942	1,785,522	4,130,310	4,207,738	4,116,398	36.6	41.2	43.4
New Mexico	226,334	252,804	263,798	810,024	866,349	876,218	27.9	29.2	30.1
New York	3,031,927	3,460,430	3,718,473	8,751,441	8,947,069	8,864,298	34.6	38.7	41.9
North Carolina	1,044,025	1,229,917	1,409,863	3,969,235	4,123,857	4,064,521	26.3	29.8	34.7
North Dakota	80,545	95,520	93,818	335,780	343,625	353,008	24.0	27.8	26.6
Ohio	1,375,311	1,521,816	1,612,549	5,573,154	5,537,419	5,334,774	24.7	27.5	30.2
Oklahoma	383,381	431,778	455,513	1,609,522	1,628,655	1,636,917	23.8	26.5	27.8
Oregon	488,862	564,786	636,155	1,716,954	1,740,990	1,759,757	28.5	32.4	36.2
Pennsylvania	1,618,658	1,842,351	1,954,078	5,830,902	5,958,238	5,869,594	27.8	30.9	33.3
Rhode Island	156,862	181,553	187,708	520,758	532,961	504,828	30.1	34.1	37.2
South Carolina	454,656	534,821	613,174	1,917,365	1,922,367	1,928,110	23.7	27.8	31.8
South Dakota	89,855	104,555	110,431	397,678	413,819	421,961	22.6	25.3	26.2
Tennessee	649,844	750,100	843,026	2,756,498	2,778,489	2,734,302	23.6	27.0	30.8
Texas	2,646,909	3,062,665	3,405,108	9,896,002	10,551,547	11,006,179	26.7	29.0	30.9
Utah	276,360	339,337	387,625	1,097,915	1,230,451	1,285,134	25.2	27.6	30.2
Vermont	103,476	118,184	116,812	326,742	336,583	335,328	31.7	35.1	34.8
Virginia	1,232,454	1,438,181	1,537,471	3,502,524	3,783,813	3,895,448	35.2	38.0	39.5
Washington	932,352	1,069,031	1,172,377	2,898,677	3,075,972	3,205,644	32.2	34.8	36.6
West Virginia	157,883	181,476	188,924	764,649	763,696	735,130	20.6	23.8	25.7
Wisconsin	690,065	791,966	834,930	2,894,884	2,890,117	2,829,348	23.8	27.4	29.5
Wyoming	60,451	68,128	70,705	256,685	267,927	277,669	23.6	25.4	25.5
Puerto Rico	378,586	454,714	495,726	1,162,153	1,250,335	1,126,992	32.6	36.4	44.0

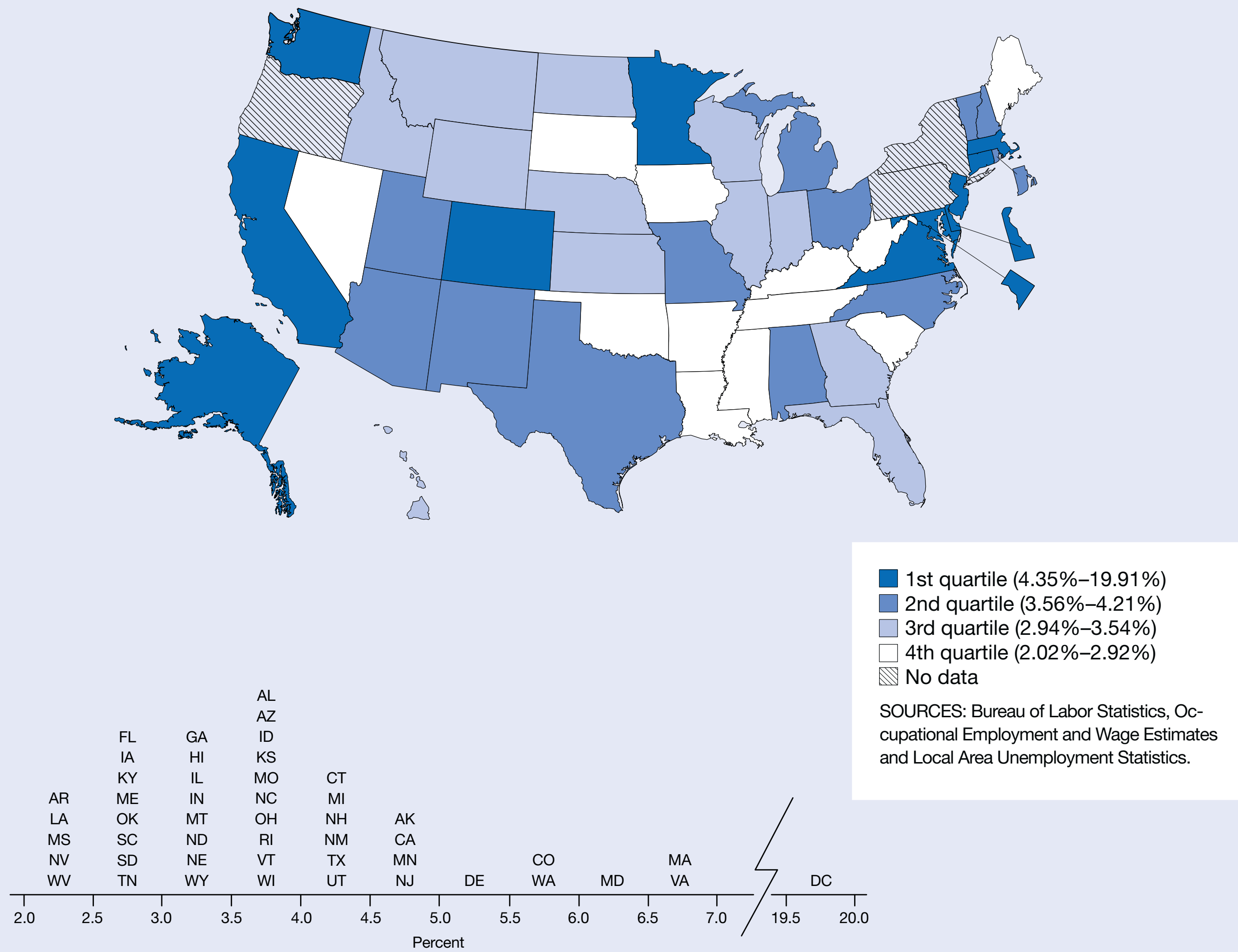
NOTES: Bachelor's degree holders include those who completed a bachelor's or higher degree. Workforce represents employed component of civilian labor force and reported as annual data not seasonally adjusted.

SOURCES: Census Bureau, 2000 Decennial Census and American Community Survey (various years); Bureau of Labor Statistics, Local Area Unemployment Statistics.

Science and Engineering Indicators 2012

Individuals in Science and Engineering Occupations as a Percentage of the Workforce

Figure 8-33
Individuals in science and engineering occupations as a percentage of the workforce: 2010



Findings

- In 2010, 4.0% of the U.S. workforce (about 5.5 million people), worked in occupations classified as S&E. This is an increase from the 5.0 million S&E workers in 2003.
- In 2010, the percentage of the workforce engaged in S&E occupations ranged from 2.0% to 6.6% in individual states.
- The highest percentages of S&E occupations were found in the District of Columbia and the adjacent states of Maryland and Virginia as well as in Massachusetts, Washington, and Colorado in 2010.

This indicator represents the extent to which a state's workforce is employed in S&E occupations. A high value indicates that a state's economy has a high percentage of technical jobs relative to other states.

S&E occupations are defined by standard occupational codes. They include engineers and computer, mathematical, life, physical, and social scientists. Managers, technicians, elementary and secondary schoolteachers, and medical personnel are not included.

Data on individuals in S&E occupations come from a survey of workplaces that assigns workers to a state based on where they work. Estimates do not include self-employed persons and are developed by the Bureau of Labor Statistics (BLS) from data provided by state workforce agencies. Data on the size of the workforce are BLS estimates and represent the employed component of the civilian labor force. In these estimates, workers are assigned to a state based on where they live.

Situations in which workers live in one state and work in another introduce some imprecision into the calculation of this indicator. The treatment of postsecondary teachers is another source of imprecision. Due to the way the data are collected, faculty teaching in S&E fields are not included as workers in S&E occupations. Estimates for states with smaller populations are generally less precise than estimates for states with larger populations.

Table 8-33
Individuals in science and engineering occupations as a percentage of the workforce, by state: 2003, 2006, and 2010

	S&E occupations			Employed workforce			Workforce in S&E occupations (%)		
State	2003	2006	2010	2003	2006	2010	2003	2006	2010
United States	4,961,550	5,407,710	5,549,980	137,186,622	143,729,350	138,893,366	3.62	3.76	4.00
Alabama	56,380	66,100	68,450	1,989,784	2,098,462	1,925,064	2.83	3.15	3.56
Alaska	10,600	10,720	15,430	310,762	326,109	332,403	3.41	3.29	4.64
Arizona	92,120	98,110	102,870	2,573,137	2,836,638	2,859,967	3.58	3.46	3.60
Arkansas	21,340	24,860	29,200	1,195,942	1,286,887	1,246,647	1.78	1.93	2.34
California	676,180	730,010	758,830	16,200,064	16,821,266	15,916,288	4.17	4.34	4.77
Colorado	124,140	133,730	143,210	2,339,532	2,541,828	2,447,712	5.31	5.26	5.85
Connecticut	81,380	79,380	74,990	1,696,857	1,745,993	1,724,024	4.80	4.55	4.35
Delaware	17,370	21,550	20,920	403,504	424,618	389,583	4.30	5.08	5.37
District of Columbia	54,890	64,120	59,870	285,361	303,791	300,663	19.24	21.11	19.91
Florida	221,070	246,190	239,600	7,785,547	8,584,095	8,159,147	2.84	2.87	2.94
Georgia	144,170	136,470	145,220	4,173,787	4,500,150	4,213,719	3.45	3.03	3.45
Hawaii	16,090	18,940	19,500	592,469	617,807	587,407	2.72	3.07	3.32
Idaho	22,150	NA	24,130	652,161	718,077	687,321	3.40	NA	3.51
Illinois	211,230	222,470	197,120	5,916,830	6,225,095	5,964,868	3.57	3.57	3.30
Indiana	78,410	80,110	90,710	2,997,847	3,080,047	2,822,693	2.62	2.60	3.21
Iowa	37,320	43,670	44,140	1,537,341	1,595,136	1,568,012	2.43	2.74	2.82
Kansas	51,970	48,620	48,970	1,364,787	1,403,938	1,396,558	3.81	3.46	3.51
Kentucky	45,230	44,680	48,790	1,848,059	1,904,467	1,865,961	2.45	2.35	2.61
Louisiana	41,900	40,180	44,200	1,898,829	1,900,240	1,926,492	2.21	2.11	2.29
Maine	15,020	15,950	17,470	650,458	665,856	641,978	2.31	2.40	2.72
Maryland	149,250	159,470	166,700	2,741,325	2,892,733	2,758,219	5.44	5.51	6.04
Massachusetts	184,690	198,670	208,160	3,209,062	3,255,504	3,197,210	5.76	6.10	6.51
Michigan	182,940	208,520	176,570	4,675,567	4,722,716	4,192,819	3.91	4.42	4.21
Minnesota	117,120	125,930	125,100	2,750,938	2,774,524	2,746,492	4.26	4.54	4.55
Mississippi	22,190	24,910	23,770	1,226,293	1,199,871	1,176,340	1.81	2.08	2.02
Missouri	84,150	96,420	102,300	2,813,571	2,889,461	2,725,527	2.99	3.34	3.75
Montana	11,450	13,010	14,620	450,190	476,412	461,337	2.54	2.73	3.17
Nebraska	30,710	32,500	30,930	931,622	943,176	931,414	3.30	3.45	3.32
Nevada	22,330	26,930	26,840	1,093,507	1,222,277	1,149,537	2.04	2.20	2.33
New Hampshire	23,430	27,680	29,200	679,420	708,748	698,859	3.45	3.91	4.18
New Jersey	161,420	176,460	185,360	4,108,397	4,257,899	4,076,713	3.93	4.14	4.55
New Mexico	33,600	30,800	36,130	835,835	886,708	873,112	4.02	3.47	4.14
New York	272,440	306,810	NA	8,703,889	9,062,464	8,806,778	3.13	3.39	NA
North Carolina	132,440	138,790	155,030	3,973,635	4,261,325	4,036,343	3.33	3.26	3.84
North Dakota	8,430	9,360	11,050	336,353	349,368	355,615	2.51	2.68	3.11
Ohio	177,100	185,190	195,840	5,498,936	5,602,764	5,303,019	3.22	3.31	3.69
Oklahoma	44,360	50,770	44,190	1,598,614	1,650,070	1,630,925	2.77	3.08	2.71
Oregon	61,230	64,520	NA	1,699,679	1,792,039	1,769,599	3.60	3.60	NA
Pennsylvania	185,560	214,910	NA	5,795,701	6,021,084	5,791,061	3.20	3.57	NA
Rhode Island	18,740	18,060	18,210	533,265	543,973	509,073	3.51	3.32	3.58
South Carolina	48,740	53,230	56,230	1,854,419	1,970,912	1,922,815	2.63	2.70	2.92
South Dakota	9,150	10,120	11,150	408,089	421,799	422,562	2.24	2.40	2.64
Tennessee	63,680	67,040	71,850	2,731,371	2,852,509	2,759,243	2.33	2.35	2.60
Texas	365,270	408,710	451,390	10,228,640	10,757,510	11,141,903	3.57	3.80	4.05
Utah	45,570	49,690	50,830	1,139,129	1,285,389	1,262,083	4.00	3.87	4.03
Vermont	11,420	12,780	12,670	331,292	343,149	338,295	3.45	3.72	3.75
Virginia	209,280	251,720	255,800	3,647,095	3,862,508	3,896,167	5.74	6.52	6.57
Washington	150,230	171,780	186,210	2,913,230	3,155,384	3,192,117	5.16	5.44	5.83
West Virginia	16,220	17,150	17,070	742,424	777,210	711,068	2.18	2.21	2.40
Wisconsin	93,320	96,860	99,240	2,862,587	2,932,482	2,807,301	3.26	3.30	3.54
Wyoming	6,130	7,640	8,260	259,489	276,882	273,313	2.36	2.76	3.02
Puerto Rico	19,940	23,850	20,850	1,200,322	1,260,703	1,088,762	1.66	1.89	1.92

NA = not available

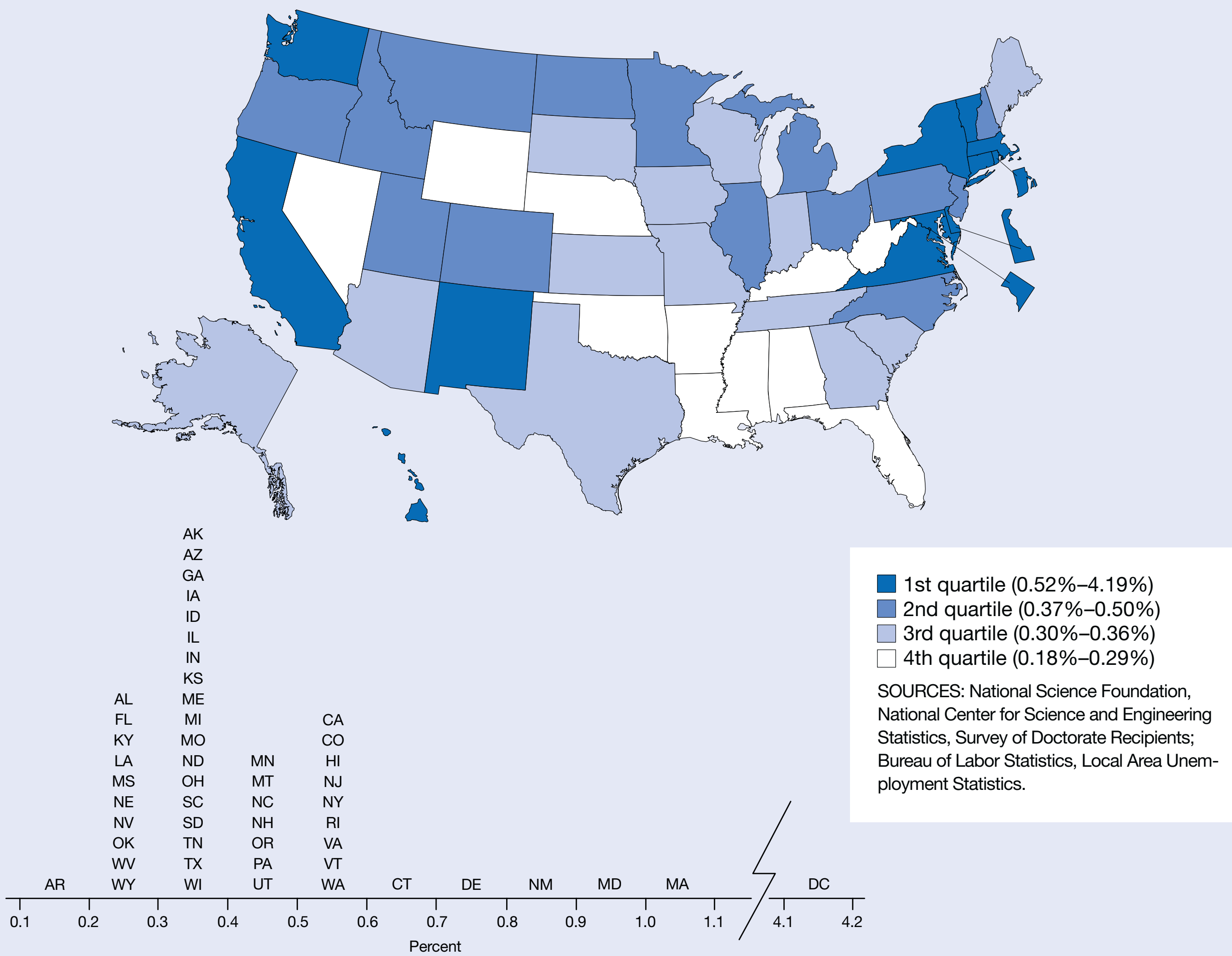
NOTES: Workforce represents employed component of civilian labor force and reported as annual data not seasonally adjusted. National total for S&E occupations in the United States provided by Occupational Employment Statistics (OES) and includes states with suppressed data. OES estimates for 2003, 2006, and 2010 S&E occupations based upon May data.

SOURCES: Bureau of Labor Statistics, Occupational Employment and Wage Estimates and Local Area Unemployment Statistics.

Science and Engineering Indicators 2012

Employed Science and Engineering Doctorate Holders as a Percentage of the Workforce

Figure 8-34
Employed science and engineering doctorate holders as a percentage of the workforce: 2008



SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Doctorate Recipients; Bureau of Labor Statistics, Local Area Unemployment Statistics.

Findings

- The number of employed S&E doctorate holders in the United States rose from 517,000 in 1997 to 648,000 in 2008, an increase of 25%.
- Overall, the value of this indicator rose from 0.39% in 1997 to 0.45% in 2008 because the number of employed S&E doctorate holders nationwide increased more rapidly than the size of the workforce.
- In 2008, the values for this indicator in individual states ranged from 0.18% to 1.07% of a state's workforce.
- States in the top quartile tended to be home to major research laboratories, research universities, or research-intensive industries.

This indicator represents a state's ability to attract and retain highly trained scientists and engineers. These individuals often conduct R&D, manage R&D activities, or are otherwise engaged in knowledge-intensive activities. A high value for this indicator in a state suggests employment opportunities for individuals with highly advanced training in S&E fields.

Data on employed S&E doctorate holders include those with doctoral degrees in computer and mathematical sciences; the biological, agricultural, or environmental life sciences; physical sciences; social sciences; psychology; engineering; and health fields. S&E doctorate data exclude individuals with doctorates from foreign institutions and those above the age of 75. S&E doctorate holders are assigned to a state based on where they work.

Employed workforce data are developed by the Bureau of Labor Statistics, which assigns workers to a state based on where they live. Workforce data represent annual estimates of the employed civilian labor force; estimates are not seasonally adjusted.

Small differences in the values of the indicator between states or across time are generally not meaningful.

Table 8-34
Employed science and engineering doctorate holders as a percentage of the workforce, by state: 1997, 2003, and 2008

State	Employed S&E doctorate holders[a]			Employed workforce			S&E doctorate holders in workforce (%)		
	1997	2003	2008	1997	2003	2008	1997	2003	2008
United States	516,560	590,910	647,800	130,988,267	137,186,622	144,860,347	0.39	0.43	0.45
Alabama	6,610	5,730	6,000	2,035,156	1,989,784	2,061,601	0.32	0.29	0.29
Alaska	1,110	1,140	1,200	289,963	310,762	332,389	0.38	0.37	0.36
Arizona	6,280	7,500	8,800	2,196,901	2,573,137	2,934,136	0.29	0.29	0.30
Arkansas	2,320	2,790	2,400	1,177,143	1,195,942	1,300,420	0.20	0.23	0.18
California	70,490	86,550	95,700	14,780,791	16,200,064	16,883,425	0.48	0.53	0.57
Colorado	10,740	12,220	13,100	2,154,294	2,339,532	2,605,535	0.50	0.52	0.50
Connecticut	8,770	9,780	10,600	1,674,937	1,696,857	1,763,911	0.52	0.58	0.60
Delaware	3,710	3,000	3,300	378,117	403,504	419,184	0.98	0.74	0.79
District of Columbia	11,800	13,800	13,100	262,789	285,361	312,877	4.49	4.84	4.19
Florida	13,330	16,000	18,600	7,040,660	7,785,547	8,621,454	0.19	0.21	0.22
Georgia	9,880	12,220	13,500	3,751,699	4,173,787	4,517,730	0.26	0.29	0.30
Hawaii	2,550	3,040	3,200	566,766	592,469	613,803	0.45	0.51	0.52
Idaho	2,030	2,450	2,800	598,004	652,161	722,714	0.34	0.38	0.39
Illinois	21,260	22,400	24,200	5,988,296	5,916,830	6,247,985	0.36	0.38	0.39
Indiana	7,570	9,590	10,300	3,014,499	2,997,847	3,049,268	0.25	0.32	0.34
Iowa	4,120	4,660	5,200	1,555,837	1,537,341	1,607,923	0.26	0.30	0.32
Kansas	3,770	4,060	4,300	1,329,797	1,364,787	1,421,107	0.28	0.30	0.30
Kentucky	4,110	4,720	4,800	1,809,785	1,848,059	1,898,083	0.23	0.26	0.25
Louisiana	5,360	5,420	5,200	1,890,102	1,898,829	1,974,881	0.28	0.29	0.26
Maine	2,150	2,110	2,300	624,410	650,458	665,057	0.34	0.32	0.35
Maryland	21,020	25,280	28,100	2,646,200	2,741,325	2,900,018	0.79	0.92	0.97
Massachusetts	23,330	30,220	35,000	3,158,851	3,209,062	3,283,147	0.74	0.94	1.07
Michigan	15,050	17,130	16,700	4,748,691	4,675,567	4,554,464	0.32	0.37	0.37
Minnesota	9,810	11,110	12,600	2,605,673	2,750,938	2,778,500	0.38	0.40	0.45
Mississippi	3,000	3,120	3,300	1,200,845	1,226,293	1,205,464	0.25	0.25	0.27
Missouri	9,490	9,080	10,000	2,780,185	2,813,571	2,869,569	0.34	0.32	0.35
Montana	1,690	1,740	2,100	427,504	450,190	485,375	0.40	0.39	0.43
Nebraska	3,010	2,820	2,800	904,492	931,622	960,438	0.33	0.30	0.29
Nevada	1,620	2,070	2,800	895,258	1,093,507	1,246,696	0.18	0.19	0.22
New Hampshire	2,230	2,640	2,900	635,469	679,420	716,611	0.35	0.39	0.40
New Jersey	20,440	20,980	21,300	4,031,022	4,108,397	4,256,251	0.51	0.51	0.50
New Mexico	7,480	8,120	7,800	768,596	835,835	909,809	0.97	0.97	0.86
New York	40,080	44,890	49,000	8,416,544	8,703,889	9,138,034	0.48	0.52	0.54
North Carolina	13,730	17,380	20,100	3,809,601	3,973,635	4,291,565	0.36	0.44	0.47
North Dakota	1,350	1,130	1,300	335,854	336,353	355,622	0.40	0.34	0.37
Ohio	18,700	20,870	20,800	5,448,161	5,498,936	5,570,514	0.34	0.38	0.37
Oklahoma	4,580	4,640	4,500	1,543,105	1,598,614	1,674,485	0.30	0.29	0.27
Oregon	6,210	7,830	8,700	1,652,997	1,699,679	1,828,477	0.38	0.46	0.48
Pennsylvania	23,940	27,820	30,000	5,775,178	5,795,701	6,095,678	0.41	0.48	0.49
Rhode Island	2,450	3,170	2,800	504,147	533,265	528,288	0.49	0.59	0.53
South Carolina	4,780	5,210	6,300	1,819,508	1,854,419	1,998,171	0.26	0.28	0.32
South Dakota	1,060	1,020	1,300	383,216	408,089	432,130	0.28	0.25	0.30
Tennessee	8,520	8,840	10,100	2,640,005	2,731,371	2,854,488	0.32	0.32	0.35
Texas	28,570	33,280	39,900	9,395,279	10,228,640	11,070,779	0.30	0.33	0.36
Utah	4,800	4,240	5,600	1,034,429	1,139,129	1,324,467	0.46	0.37	0.42
Vermont	1,750	1,770	1,800	315,806	331,292	342,130	0.55	0.53	0.53
Virginia	15,250	18,880	21,300	3,323,266	3,647,095	3,954,733	0.46	0.52	0.54
Washington	13,360	15,430	17,700	2,822,223	2,913,230	3,286,973	0.47	0.53	0.54
West Virginia	1,980	1,980	2,000	746,442	742,424	770,845	0.27	0.27	0.26
Wisconsin	8,460	8,390	9,900	2,855,830	2,862,587	2,936,749	0.30	0.29	0.34
Wyoming	860	650	700	243,944	259,489	286,394	0.35	0.25	0.24
Puerto Rico	660	1,710	2,000	1,132,658	1,200,322	1,208,595	0.06	0.14	0.17

[a]Coefficients of variation for estimates of employed S&E doctorate holders presented in appendix table 8-13.

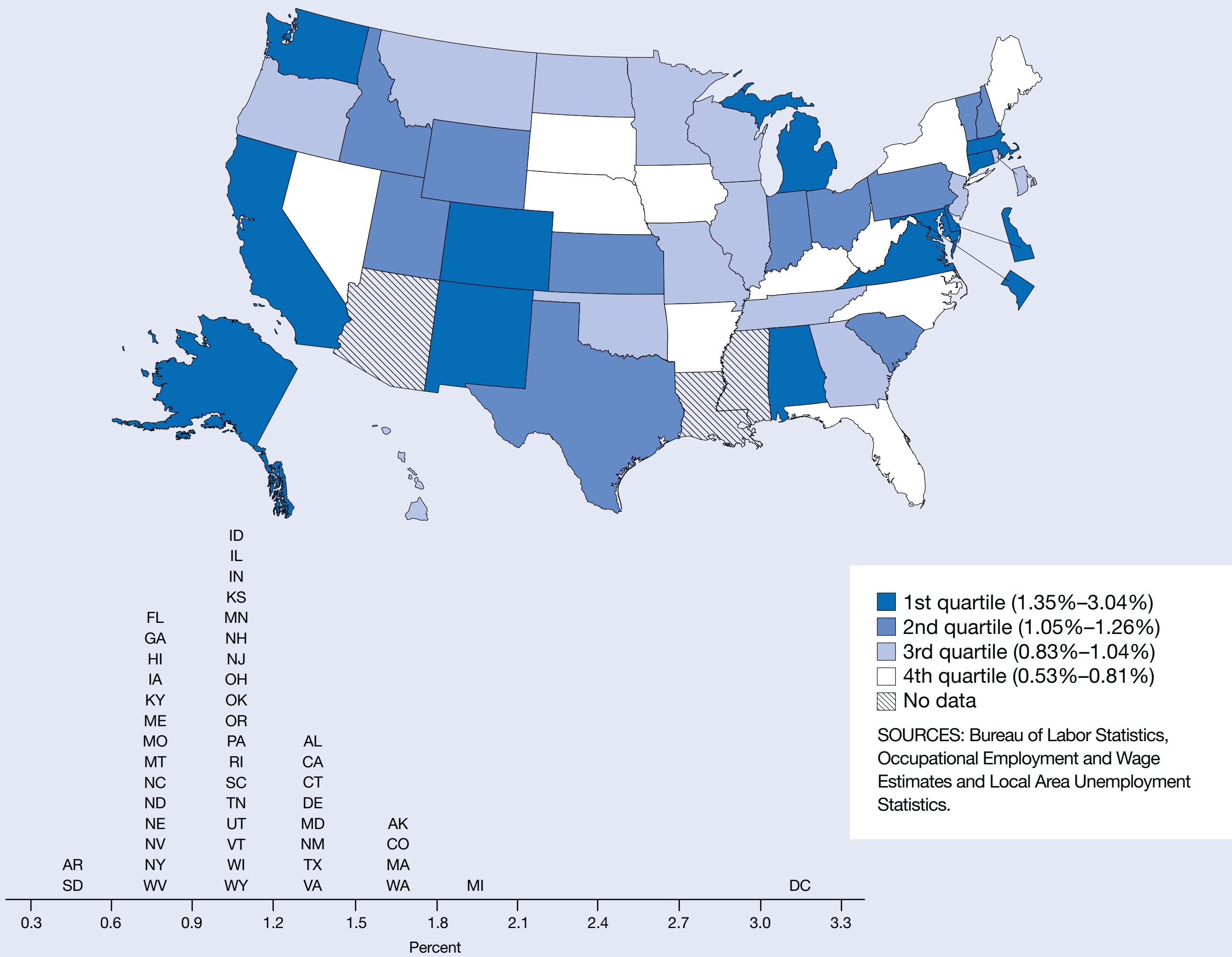
NOTE: Workforce represents employed component of civilian labor force and reported as annual data not seasonally adjusted.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Doctorate Recipients, (various years); Bureau of Labor Statistics, Local Area Unemployment Statistics.

Science and Engineering Indicators 2012

Engineers as a Percentage of the Workforce

Figure 8-35
Engineers as a percentage of the workforce: 2010



SOURCES: Bureau of Labor Statistics, Occupational Employment and Wage Estimates and Local Area Unemployment Statistics.

Findings

- In the United States, 1.55 million individuals were employed in engineering occupations in 2010, an increase from the 1.49 million engineers employed in 2004. Between 2004 and 2010, the percentage of the workforce employed in engineering occupations increased from 1.07% to 1.12%.
- The concentration of engineers in individual states ranged from 0.53% to 1.95% in 2010.
- The states with the highest percentage of engineers in their workforces were centers of automobile and aircraft manufacturing.
- States ranking highest on this indicator also ranked high on employment in high-technology establishments as share of total employment.

Engineers design and operate production processes and create new products and services. This indicator represents the percentage of trained engineers in a state's workforce. It includes the standard occupational codes for engineering fields: aerospace, agricultural, biomedical, chemical, civil, computer hardware, electrical and electronics, environmental, industrial, marine and naval architectural, materials, mechanical, mining and geological, nuclear, and petroleum.

Data on individuals in S&E occupations come from a survey of workplaces that assigns workers to a state based on where they work. Estimates do not include self-employed persons and are developed by the Bureau of Labor Statistics (BLS) from data provided by state workforce agencies. Data on the size of the workforce are BLS estimates and represent the employed component of the civilian labor force. In these estimates, workers are assigned to a state based on where they live.

Situations in which workers live in one state and work in another introduce some imprecision into the calculation of this indicator. The treatment of postsecondary teachers is another source of imprecision. Due to the way the data are collected, faculty teaching in S&E fields are not included as workers in S&E occupations. Estimates for states with smaller populations are generally less precise than estimates for states with larger populations.

Table 8-35
Engineers as a percentage of the workforce, by state: 2004, 2007, and 2010

State	Engineers 2004	Engineers 2007	Engineers 2010	Employed workforce 2004	Employed workforce 2007	Employed workforce 2010	Engineers in workforce (%) 2004	Engineers in workforce (%) 2007	Engineers in workforce (%) 2010
United States	1,487,810	1,588,350	1,554,780	138,762,591	145,156,139	138,893,366	1.07	1.09	1.12
Alabama	23,050	27,860	27,480	2,007,153	2,108,873	1,925,064	1.15	1.32	1.43
Alaska	3,410	3,820	5,600	314,753	329,431	332,403	1.08	1.16	1.68
Arizona	36,630	35,490	NA	2,650,277	2,903,992	2,859,967	1.38	1.22	NA
Arkansas	6,760	7,670	6,630	1,221,553	1,293,947	1,246,647	0.55	0.59	0.53
California	227,310	241,970	222,580	16,354,779	16,970,228	15,916,288	1.39	1.43	1.40
Colorado	34,390	38,580	37,590	2,392,952	2,598,433	2,447,712	1.44	1.48	1.54
Connecticut	25,960	24,310	23,210	1,703,865	1,761,588	1,724,024	1.52	1.38	1.35
Delaware	3,950	4,830	5,270	408,266	425,289	389,583	0.97	1.14	1.35
District of Columbia	9,760	7,840	9,140	288,397	310,652	300,663	3.38	2.52	3.04
Florida	61,830	70,400	63,170	7,998,202	8,704,110	8,159,147	0.77	0.81	0.77
Georgia	30,620	33,080	36,040	4,249,007	4,561,967	4,213,719	0.72	0.73	0.86
Hawaii	4,770	5,020	5,150	598,175	617,891	587,407	0.80	0.81	0.88
Idaho	8,830	8,360	7,490	666,080	731,362	687,321	1.33	1.14	1.09
Illinois	58,180	56,380	58,000	5,968,561	6,323,515	5,964,868	0.97	0.89	0.97
Indiana	31,160	28,110	30,150	2,997,800	3,081,177	2,822,693	1.04	0.91	1.07
Iowa	9,820	10,410	11,210	1,534,991	1,601,547	1,568,012	0.64	0.65	0.71
Kansas	19,080	16,910	14,680	1,381,343	1,415,942	1,396,558	1.38	1.19	1.05
Kentucky	13,230	13,520	13,530	1,854,703	1,915,131	1,865,961	0.71	0.71	0.73
Louisiana	15,130	15,170	NA	1,928,464	1,941,642	1,926,492	0.78	0.78	NA
Maine	4,510	4,000	4,620	653,847	666,305	641,978	0.69	0.60	0.72
Maryland	36,910	38,730	39,750	2,761,583	2,909,290	2,758,219	1.34	1.33	1.44
Massachusetts	51,450	52,820	49,510	3,203,810	3,280,932	3,197,210	1.61	1.61	1.55
Michigan	91,000	101,730	81,730	4,686,953	4,680,780	4,192,819	1.94	2.17	1.95
Minnesota	28,990	28,790	28,280	2,752,403	2,775,587	2,746,492	1.05	1.04	1.03
Mississippi	8,320	9,790	NA	1,232,139	1,210,732	1,176,340	0.68	0.81	NA
Missouri	22,700	25,880	22,910	2,815,878	2,899,695	2,725,527	0.81	0.89	0.84
Montana	2,600	3,200	3,810	456,385	485,132	461,337	0.57	0.66	0.83
Nebraska	5,690	5,840	5,940	938,105	953,057	931,414	0.61	0.61	0.64
Nevada	7,380	8,100	7,840	1,128,223	1,247,491	1,149,537	0.65	0.65	0.68
New Hampshire	8,120	8,140	8,000	687,855	715,310	698,859	1.18	1.14	1.14
New Jersey	38,540	39,960	37,870	4,144,223	4,265,294	4,076,713	0.93	0.94	0.93
New Mexico	10,550	11,290	12,830	849,970	901,704	873,112	1.24	1.25	1.47
New York	65,710	69,400	65,420	8,816,013	9,112,899	8,806,778	0.75	0.76	0.74
North Carolina	31,030	32,500	32,620	4,031,081	4,321,339	4,036,343	0.77	0.75	0.81
North Dakota	2,100	2,500	2,950	339,541	353,214	355,615	0.62	0.71	0.83
Ohio	60,790	57,720	56,790	5,502,533	5,626,086	5,303,019	1.10	1.03	1.07
Oklahoma	13,830	13,690	15,350	1,605,641	1,665,819	1,630,925	0.86	0.82	0.94
Oregon	19,260	18,870	18,320	1,714,447	1,822,010	1,769,599	1.12	1.04	1.04
Pennsylvania	56,950	61,720	63,940	5,859,561	6,054,254	5,791,061	0.97	1.02	1.10
Rhode Island	5,470	5,240	5,230	526,046	545,252	509,073	1.04	0.96	1.03
South Carolina	21,560	22,210	22,570	1,888,050	2,000,185	1,922,815	1.14	1.11	1.17
South Dakota	2,040	NA	2,380	411,708	428,850	422,562	0.50	NA	0.56
Tennessee	22,000	21,940	25,260	2,746,241	2,874,173	2,759,243	0.80	0.76	0.92
Texas	119,360	130,990	140,560	10,385,318	10,925,311	11,141,903	1.15	1.20	1.26
Utah	12,050	13,810	14,430	1,179,142	1,319,933	1,262,083	1.02	1.05	1.14
Vermont	3,730	3,670	3,700	334,188	341,588	338,295	1.12	1.07	1.09
Virginia	49,810	52,570	53,270	3,715,272	3,926,052	3,896,167	1.34	1.34	1.37
Washington	36,690	NA	54,830	2,999,526	3,235,735	3,192,117	1.22	NA	1.72
West Virginia	4,920	5,340	4,960	746,854	780,869	711,068	0.66	0.68	0.70
Wisconsin	29,170	31,010	28,820	2,868,376	2,951,001	2,807,301	1.02	1.05	1.03
Wyoming	2,300	2,840	3,140	262,358	283,543	273,313	0.88	1.00	1.15
Puerto Rico	7,370	NA	7,460	1,226,251	1,241,426	1,088,762	0.60	NA	0.69

NA = not available

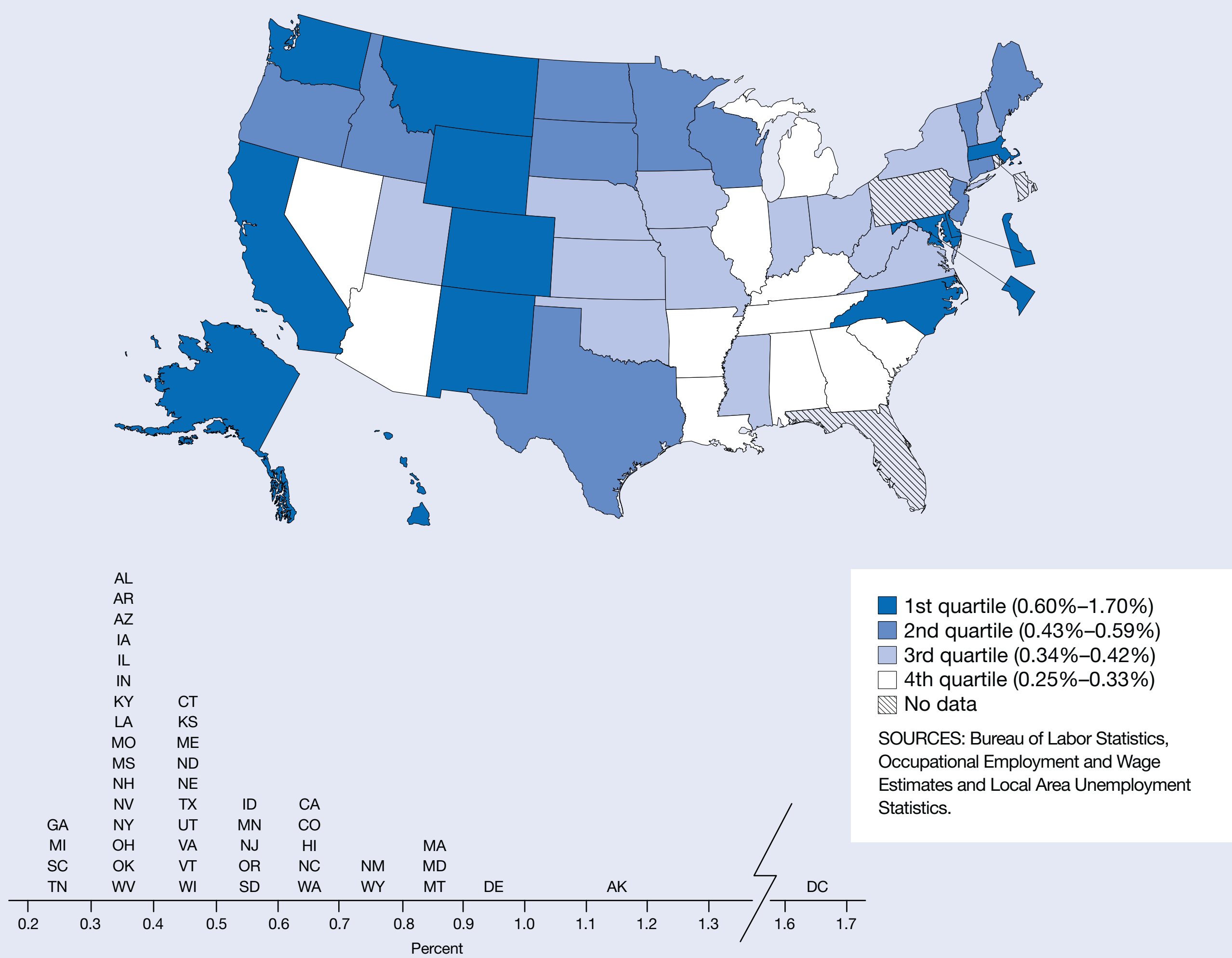
NOTES: Workforce represents employed component of civilian labor force and reported as annual data not seasonally adjusted. National totals for engineers in the United States provided by Occupational Employment Statistics and includes states with suppressed data.

SOURCES: Bureau of Labor Statistics, Occupational Employment and Wage Estimates and Local Area Unemployment Statistics.

Science and Engineering Indicators 2012

Life and Physical Scientists as a Percentage of the Workforce

Figure 8-36
Life and physical scientists as a percentage of the workforce: 2010



SOURCES: Bureau of Labor Statistics, Occupational Employment and Wage Estimates and Local Area Unemployment Statistics.

Findings

- About 629,000 individuals (0.45% of the workforce) were employed as life and physical scientists in the United States in 2010, an increase from the 549,000 life and physical scientists employed in 2004, which represented 0.40% of the workforce.
- In 2010, individual states had indicator values ranging from 0.25% to 1.18%, which showed major differences in the concentration of jobs in the life and physical sciences.
- States with the highest concentrations of life and physical scientists in their workforces were fairly evenly distributed throughout the United States.

This indicator represents the percentage of life and physical scientists in a state's workforce. Life scientists are identified from standard occupational codes that include agricultural and food scientists, biological scientists, conservation scientists and foresters, and medical scientists. Physical scientists are identified from standard occupational codes that include astronomers, physicists, atmospheric and space scientists, chemists, materials scientists, environmental scientists, and geoscientists. A high share of life and physical scientists in a state's workforce could indicate several scenarios, ranging from a robust cluster of life sciences companies to the presence of forests or national parks, which require foresters, wildlife specialists, and conservationists to manage the natural assets in these areas.

Data on individuals in S&E occupations come from a survey of workplaces that assigns workers to a state based on where they work. Estimates do not include self-employed persons and are developed by the Bureau of Labor Statistics (BLS) from data provided by state workforce agencies. Data on the size of the workforce are BLS estimates and represent the employed component of the civilian labor force. In these estimates, workers are assigned to a state based on where they live.

Situations in which workers live in one state and work in another introduce some imprecision into the calculation of this indicator. The treatment of postsecondary teachers is another source of imprecision. Due to the way data are collected, faculty teaching in S&E fields are not counted as working in S&E occupations. Estimates for states with smaller populations are generally less precise than estimates for states with larger populations.

Table 8-36
Life and physical scientists as a percentage of the workforce, by state: 2004, 2007, and 2010

State	Life and physical scientists			Employed workforce			Life and physical scientists in workforce (%)		
	2004	2007	2010	2004	2007	2010	2004	2007	2010
United States	548,860	602,360	629,280	138,762,591	145,156,139	138,893,366	0.40	0.41	0.45
Alabama	5,650	7,240	6,200	2,007,153	2,108,873	1,925,064	0.28	0.34	0.32
Alaska	3,100	3,550	3,930	314,753	329,431	332,403	0.98	1.08	1.18
Arizona	7,040	7,300	8,950	2,650,277	2,903,992	2,859,967	0.27	0.25	0.31
Arkansas	3,250	3,680	3,760	1,221,553	1,293,947	1,246,647	0.27	0.28	0.30
California	69,820	78,130	95,730	16,354,779	16,970,228	15,916,288	0.43	0.46	0.60
Colorado	11,030	14,800	15,290	2,392,952	2,598,433	2,447,712	0.46	0.57	0.62
Connecticut	8,610	7,330	8,060	1,703,865	1,761,588	1,724,024	0.51	0.42	0.47
Delaware	3,030	3,110	3,650	408,266	425,289	389,583	0.74	0.73	0.94
District of Columbia	5,980	6,290	5,100	288,397	310,652	300,663	2.07	2.02	1.70
Florida	21,620	21,920	NA	7,998,202	8,704,110	8,159,147	0.27	0.25	NA
Georgia	10,960	8,860	10,520	4,249,007	4,561,967	4,213,719	0.26	0.19	0.25
Hawaii	3,060	3,810	3,620	598,175	617,891	587,407	0.51	0.62	0.62
Idaho	3,980	3,500	3,740	666,080	731,362	687,321	0.60	0.48	0.54
Illinois	19,440	20,540	19,950	5,968,561	6,323,515	5,964,868	0.33	0.32	0.33
Indiana	9,820	10,990	10,880	2,997,800	3,081,177	2,822,693	0.33	0.36	0.39
Iowa	4,010	5,660	5,570	1,534,991	1,601,547	1,568,012	0.26	0.35	0.36
Kansas	4,280	4,900	5,780	1,381,343	1,415,942	1,396,558	0.31	0.35	0.41
Kentucky	4,740	5,350	5,550	1,854,703	1,915,131	1,865,961	0.26	0.28	0.30
Louisiana	6,410	NA	5,720	1,928,464	1,941,642	1,926,492	0.33	NA	0.30
Maine	2,400	2,750	2,830	653,847	666,305	641,978	0.37	0.41	0.44
Maryland	21,040	21,270	22,190	2,761,583	2,909,290	2,758,219	0.76	0.73	0.80
Massachusetts	20,300	24,030	27,470	3,203,810	3,280,932	3,197,210	0.63	0.73	0.86
Michigan	13,140	NA	12,030	4,686,953	4,680,780	4,192,819	0.28	NA	0.29
Minnesota	11,980	13,550	14,670	2,752,403	2,775,587	2,746,492	0.44	0.49	0.53
Mississippi	4,040	4,460	4,480	1,232,139	1,210,732	1,176,340	0.33	0.37	0.38
Missouri	10,210	10,960	9,560	2,815,878	2,899,695	2,725,527	0.36	0.38	0.35
Montana	3,050	NA	3,920	456,385	485,132	461,337	0.67	NA	0.85
Nebraska	4,170	3,550	3,740	938,105	953,057	931,414	0.44	0.37	0.40
Nevada	3,120	3,490	3,690	1,128,223	1,247,491	1,149,537	0.28	0.28	0.32
New Hampshire	1,880	3,170	2,650	687,855	715,310	698,859	0.27	0.44	0.38
New Jersey	22,420	21,820	24,040	4,144,223	4,265,294	4,076,713	0.54	0.51	0.59
New Mexico	2,040	NA	6,450	849,970	901,704	873,112	0.24	NA	0.74
New York	30,060	30,850	29,560	8,816,013	9,112,899	8,806,778	0.34	0.34	0.34
North Carolina	16,990	19,670	24,300	4,031,081	4,321,339	4,036,343	0.42	0.46	0.60
North Dakota	1,520	1,720	1,620	339,541	353,214	355,615	0.45	0.49	0.46
Ohio	15,310	18,430	17,940	5,502,533	5,626,086	5,303,019	0.28	0.33	0.34
Oklahoma	6,550	6,710	5,540	1,605,641	1,665,819	1,630,925	0.41	0.40	0.34
Oregon	8,090	8,530	9,380	1,714,447	1,822,010	1,769,599	0.47	0.47	0.53
Pennsylvania	25,030	26,980	NA	5,859,561	6,054,254	5,791,061	0.43	0.45	NA
Rhode Island	2,810	2,220	NA	526,046	545,252	509,073	0.53	0.41	NA
South Carolina	5,780	5,180	5,290	1,888,050	2,000,185	1,922,815	0.31	0.26	0.28
South Dakota	1,800	NA	2,300	411,708	428,850	422,562	0.44	NA	0.54
Tennessee	6,920	8,180	6,830	2,746,241	2,874,173	2,759,243	0.25	0.28	0.25
Texas	50,940	52,630	48,850	10,385,318	10,925,311	11,141,903	0.49	0.48	0.44
Utah	5,630	6,500	5,300	1,179,142	1,319,933	1,262,083	0.48	0.49	0.42
Vermont	1,370	1,720	1,470	334,188	341,588	338,295	0.41	0.50	0.43
Virginia	13,200	14,510	15,990	3,715,272	3,926,052	3,896,167	0.36	0.37	0.41
Washington	18,490	NA	22,020	2,999,526	3,235,735	3,192,117	0.62	NA	0.69
West Virginia	3,170	3,010	2,780	746,854	780,869	711,068	0.42	0.39	0.39
Wisconsin	11,970	14,590	12,990	2,868,376	2,951,001	2,807,301	0.42	0.49	0.46
Wyoming	1,960	2,260	2,100	262,358	283,543	273,313	0.75	0.80	0.77
Puerto Rico	4,790	NA	4,210	1,226,251	1,241,426	1,088,762	0.39	NA	0.39

NA = not available

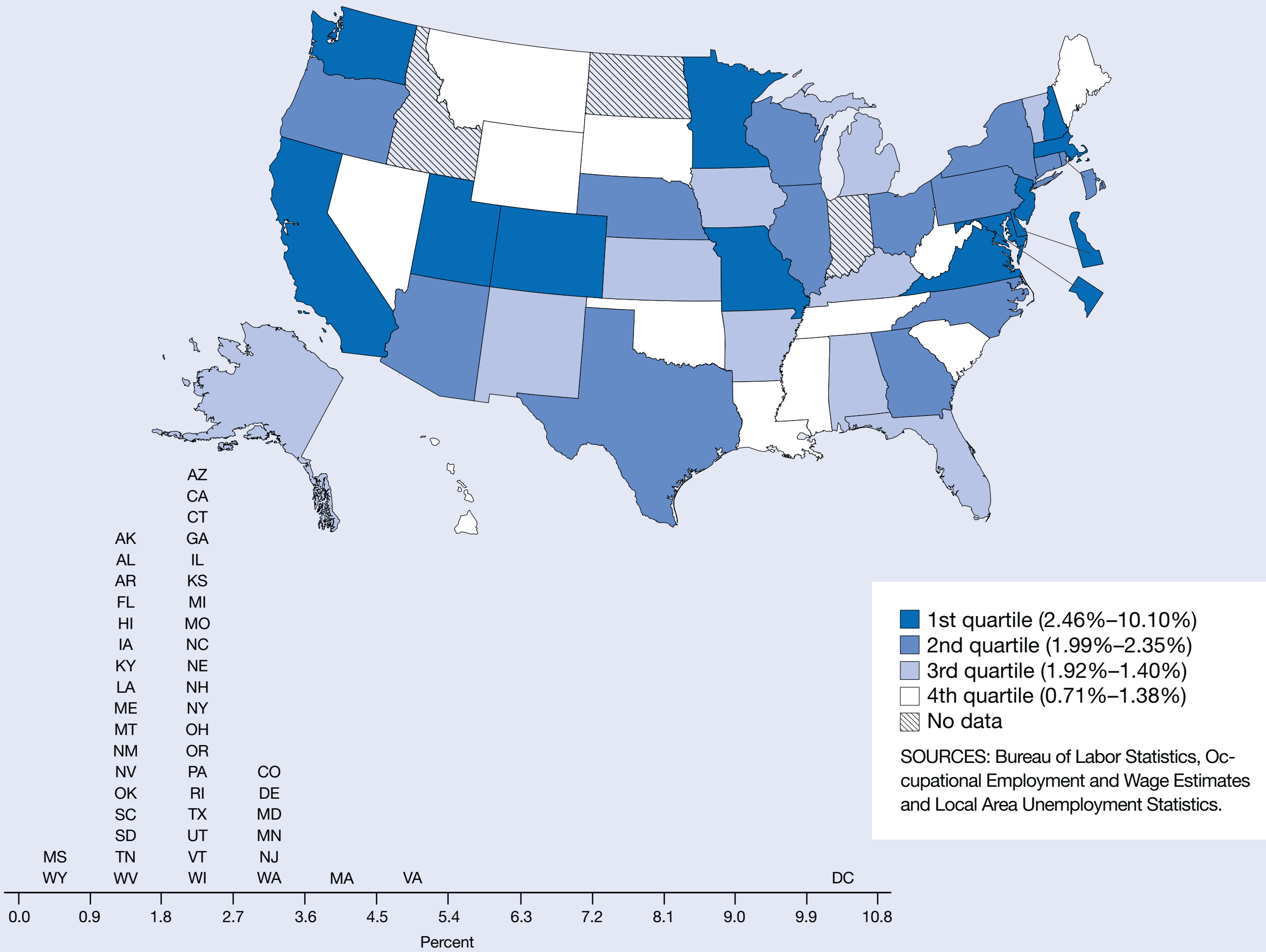
NOTES: Workforce represents employed component of civilian labor force and reported as annual data not seasonally adjusted. National totals for life and physical scientists in the United States provided by Occupational Employment Statistics and include states with suppressed data.

SOURCES: Bureau of Labor Statistics, Occupational Employment and Wage Estimates and Local Area Unemployment Statistics.

Science and Engineering Indicators 2012

Computer Specialists as a Percentage of the Workforce

Figure 8-37
Computer specialists as a percentage of the workforce: 2010



Findings

- In the United States, 3.11 million individuals (2.24% of the workforce) were employed as computer specialists in 2010, an increase from the 2.81 million computer specialists employed in 2004, which accounted for 2.03% of the workforce.
- Individual states showed large differences in the intensity of computer-related operations in their economies, with 0.71% to 4.51% of their workforce employed in computer-related occupations in 2010.
- There was a significant concentration of computer-intensive occupations in the District of Columbia and the adjacent states of Maryland and Virginia. This may be due to the presence of many government offices, colleges and universities, and government contractors in the area that employ scientists and engineers, especially computer scientists.
- EPSCoR states tended to have smaller percentages of computer specialists in their workforces and accounted in total for nearly 12% of computer specialists nationally.

This indicator represents the percent of specialists with advanced computer training in a state's workforce. Computer specialists are identified from 10 standard occupational codes that include computer and information scientists, programmers, software engineers, support specialists, systems analysts, database administrators, and network and computer system administrators. Higher values may indicate a state workforce that is better able to thrive in an information economy or to embrace and utilize computer technology.

Data on individuals in S&E occupations come from a survey of workplaces that assigns workers to a state based on where they work. Estimates do not include self-employed persons and are developed by the Bureau of Labor Statistics (BLS) from data provided by state workforce agencies. Data on the size of the workforce are BLS estimates and represent the employed component of the civilian labor force. In these estimates, workers are assigned to a state based on where they live.

Situations in which workers live in one state and work in another introduce some imprecision into the calculation of this indicator. The treatment of postsecondary teachers is another source of imprecision. Due to the way data are collected, faculty teaching in S&E fields are not included as workers in S&E occupations. Estimates for states with smaller populations are generally less precise than estimates for states with larger populations.

Table 8-37
Computer specialists as a percentage of the workforce, by state: 2004, 2007, and 2010

	Computer specialists			Employed workforce			Computer specialists in workforce (%)		
State	2004	2007	2010	2004	2007	2010	2004	2007	2010
EPSCoR states	285,770	317,290	315,910	22,441,400	23,358,559	22,453,679	1.27	1.36	1.41
Non-EPSCoR states	2,494,820	2,713,430	2,765,040	116,032,794	121,486,928	116,139,024	2.15	2.23	2.38
Average EPSCoR state value	na	na	na	na	na	na	1.32	1.38	1.54
Average non-EPSCoR state value	na	na	na	na	na	na	2.21	2.27	2.49
United States	2,811,480	3,062,930	3,111,330	138,762,591	145,156,139	138,893,366	2.03	2.11	2.24
Alabama	29,760	33,010	34,450	2,007,153	2,108,873	1,925,064	1.48	1.57	1.79
Alaska	3,430	3,720	4,770	314,753	329,431	332,403	1.09	1.13	1.44
Arizona	47,170	54,520	58,490	2,650,277	2,903,992	2,859,967	1.78	1.88	2.05
Arkansas	12,140[a]	15,500	18,420	1,221,553	1,293,947	1,246,647	0.99	1.20	1.48
California	368,000	383,900	408,810	16,354,779	16,970,228	15,916,288	2.25	2.26	2.57
Colorado	74,450	79,930	84,500	2,392,952	2,598,433	2,447,712	3.11	3.08	3.45
Connecticut	45,030	40,900	40,520	1,703,865	1,761,588	1,724,024	2.64	2.32	2.35
Delaware	10,240[a]	11,950	11,680	408,266	425,289	389,583	2.51	2.81	3.00
District of Columbia	30,890	32,210	30,380	288,397	310,652	300,663	10.71	10.37	10.10
Florida	139,510	141,320	145,710	7,998,202	8,704,110	8,159,147	1.74	1.62	1.79
Georgia	92,680	86,210	94,050	4,249,007	4,561,967	4,213,719	2.18	1.89	2.23
Hawaii	7,810	7,840	8,070	598,175	617,891	587,407	1.31	1.27	1.37
Idaho	8,510	9,410	NA	666,080	731,362	687,321	1.28	1.29	NA
Illinois	115,550[a]	137,420	124,300	5,968,561	6,323,515	5,964,868	1.94	2.17	2.08
Indiana	36,660	39,850	NA	2,997,800	3,081,177	2,822,693	1.22	1.29	NA
Iowa	22,620	26,400	25,460	1,534,991	1,601,547	1,568,012	1.47	1.65	1.62
Kansas	20,890	25,750	26,810	1,381,343	1,415,942	1,396,558	1.51	1.82	1.92
Kentucky	23,170	24,250	26,090	1,854,703	1,915,131	1,865,961	1.25	1.27	1.40
Louisiana	19,170	16,020	17,420	1,928,464	1,941,642	1,926,492	0.99	0.83	0.90
Maine	6,890	7,660	8,610	653,847	666,305	641,978	1.05	1.15	1.34
Maryland	88,260	89,900	94,120	2,761,583	2,909,290	2,758,219	3.20	3.09	3.41
Massachusetts	105,670	111,910	120,720	3,203,810	3,280,932	3,197,210	3.30	3.41	3.78
Michigan	79,490[a]	88,980	77,750	4,686,953	4,680,780	4,192,819	1.70	1.90	1.85
Minnesota	66,520	75,230	77,820	2,752,403	2,775,587	2,746,492	2.42	2.71	2.83
Mississippi	8,500	9,290	8,330	1,232,139	1,210,732	1,176,340	0.69	0.77	0.71
Missouri	57,890	61,000	68,500	2,815,878	2,899,695	2,725,527	2.06	2.10	2.51
Montana	4,700[a]	5,170	5,900	456,385	485,132	461,337	1.03	1.07	1.28
Nebraska	19,520[a]	20,410	21,360	938,105	953,057	931,414	2.08	2.14	2.29
Nevada	11,410	12,880	13,870	1,128,223	1,247,491	1,149,537	1.01	1.03	1.21
New Hampshire	14,170	16,780	17,680	687,855	715,310	698,859	2.06	2.35	2.53
New Jersey	111,890	121,690	127,160	4,144,223	4,265,294	4,076,713	2.70	2.85	3.12
New Mexico	8,740[a]	11,490	13,030	849,970	901,704	873,112	1.03	1.27	1.49
New York	177,010	200,900	195,990	8,816,013	9,112,899	8,806,778	2.01	2.20	2.23
North Carolina	78,040	81,630	90,640	4,031,081	4,321,339	4,036,343	1.94	1.89	2.25
North Dakota	4,470	3,140	NA	339,541	353,214	355,615	1.32	0.89	NA
Ohio	95,300	111,160	116,200	5,502,533	5,626,086	5,303,019	1.73	1.98	2.19
Oklahoma	22,290[a]	27,600	21,320	1,605,641	1,665,819	1,630,925	1.39	1.66	1.31
Oregon	33,630	34,980	35,700	1,714,447	1,822,010	1,769,599	1.96	1.92	2.02
Pennsylvania	101,230	115,300	116,600	5,859,561	6,054,254	5,791,061	1.73	1.90	2.01
Rhode Island	9,710[a]	9,940	10,280	526,046	545,252	509,073	1.85	1.82	2.02
South Carolina	20,670	25,130	25,610	1,888,050	2,000,185	1,922,815	1.09	1.26	1.33
South Dakota	5,000	5,860	5,570	411,708	428,850	422,562	1.21	1.37	1.32
Tennessee	36,670	38,490	38,200	2,746,241	2,874,173	2,759,243	1.34	1.34	1.38
Texas	204,490	245,730	255,470	10,385,318	10,925,311	11,141,903	1.97	2.25	2.29
Utah	26,830	30,750	31,090	1,179,142	1,319,933	1,262,083	2.28	2.33	2.46
Vermont	6,190	5,610	6,340	334,188	341,588	338,295	1.85	1.64	1.87
Virginia	159,070	171,440	175,640	3,715,272	3,926,052	3,896,167	4.28	4.37	4.51
Washington	85,430	101,030	105,860	2,999,526	3,235,735	3,192,117	2.85	3.12	3.32
West Virginia	6,650	6,900	8,140	746,854	780,869	711,068	0.89	0.88	1.14
Wisconsin	45,730	42,860	55,740	2,868,376	2,951,001	2,807,301	1.59	1.45	1.99
Wyoming	1,740	1,980	2,160	262,358	283,543	273,313	0.66	0.70	0.79
Puerto Rico	7,840	NA	8,960	1,226,251	1,241,426	1,088,762	0.64	NA	0.82

NA = not available

EPSCoR = Experimental Program to Stimulate Competitive Research

[a]Value may be underreported because one or more codes for computer occupations suppressed by state or Bureau of Labor Statistics and not reported at state level.

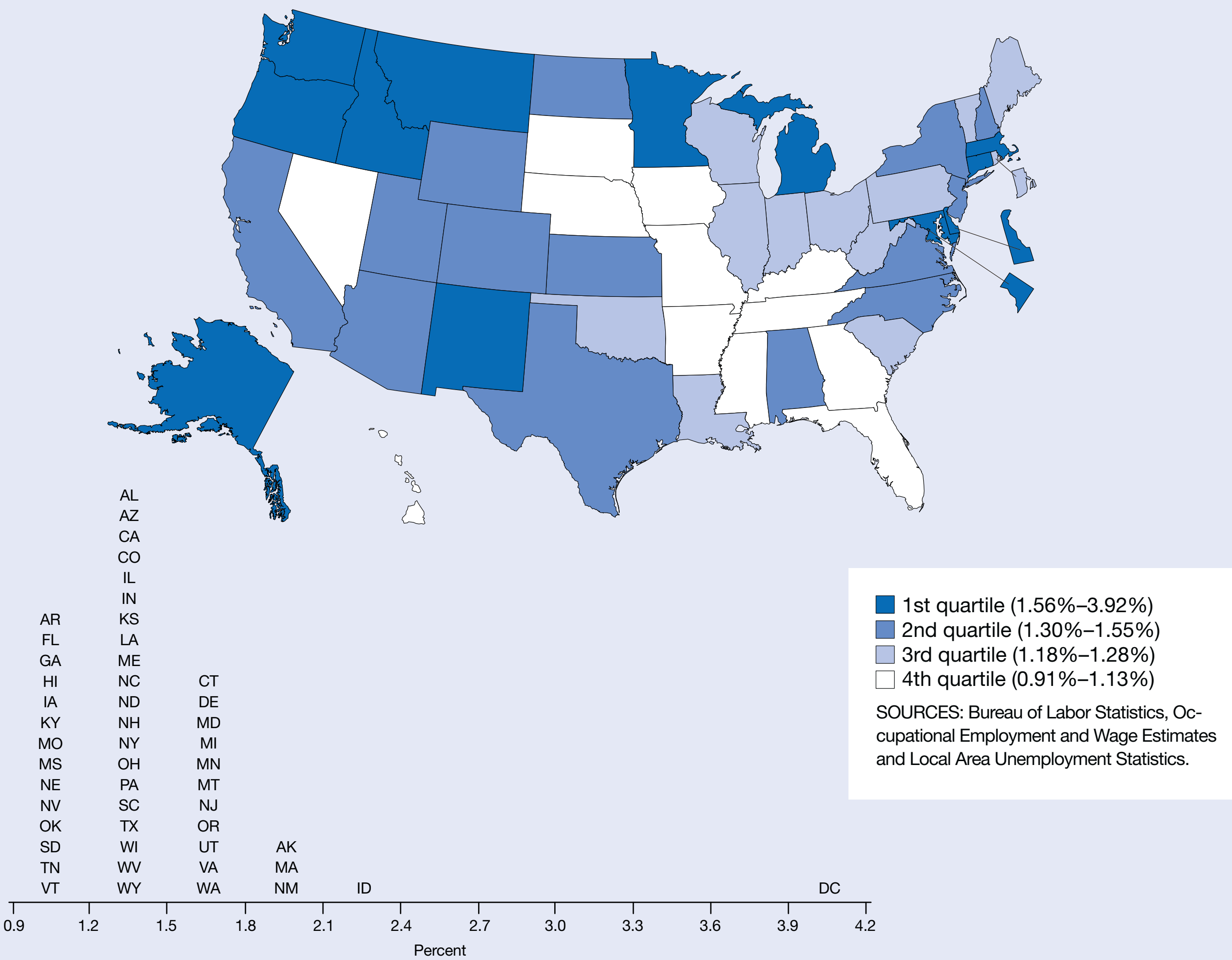
NOTES: Workforce represents employed component of civilian labor force and reported as annual data not seasonally adjusted. For explanation of EPSCoR and non-EPSCoR averages, see chapter introduction.

SOURCES: Bureau of Labor Statistics, Occupational Employment and Wage Estimates and Local Area Unemployment Statistics.

Science and Engineering Indicators 2012

Technical Workers as a Percentage of the Workforce

Figure 8-38
Technical workers as a percentage of the workforce: 2010



SOURCES: Bureau of Labor Statistics, Occupational Employment and Wage Estimates and Local Area Unemployment Statistics.

Findings

- Every state's workforce increased in the use of technical workers in the 6 years from 2004 to 2010. The number of technical workers exceeded the number of doctorate holders, engineers, or life and physical scientists in the workforce during this period.
- Nearly 1.9 million individuals (1.35% of the U.S. workforce) were employed as technical workers in 2010, an increase from the 1.5 million technical workers employed in 2004, which accounted for 1.11% of the workforce.
- Individual states showed large differences in the percentage of technical workers in their workforce, with 0.91% to 2.16% of their workforce employed as technical workers in 2010.
- EPSCoR states tended to have smaller percentages of technical workers in their workforces and accounted in total for nearly 15% of technical workers nationally.

Technical workers include managers in the areas of computer and information science, engineering, or the natural sciences; computer programmers; drafters working in architecture, civil engineering, electronics, or mechanical engineering; and technicians in a wide variety of technical fields. Individuals who work as scientists and engineers are not included in this indicator.

Data on workers' occupations come from a survey of workplaces that assigns workers to a state based on where they work. Estimates are developed by the Bureau of Labor Statistics (BLS) from data provided by state workforce agencies and do not include self-employed persons. Data on the size of the state workforce are BLS estimates and represent the employed component of the civilian labor force.

Situations in which workers live in one state and work in another introduce some imprecision into the calculation of this indicator. Estimates for states with smaller populations are generally less precise than estimates for states with larger populations.

Table 8-38
Technical workers as a percentage of the workforce, by state: 2004, 2007, and 2010

State	Technical workers			Employed workforce			Technical workers in workforce (%)		
	2004	2007	2010	2004	2007	2010	2004	2007	2010
EPSCoR states	229,470	295,910	281,200	22,441,400	23,358,559	22,453,679	1.02	1.27	1.25
Non-EPSCoR states	1,299,140	1,747,710	1,583,300	116,032,794	121,486,928	116,139,024	1.12	1.44	1.36
Average EPSCoR state value	na	na	na	na	na	na	1.05	1.33	1.33
Average non-EPSCoR state value	na	na	na	na	na	na	1.14	1.47	1.38
United States	1,535,310	2,054,980	1,876,290	138,762,591	145,156,139	138,893,366	1.11	1.42	1.35
Alabama	22,380	26,170	25,250	2,007,153	2,108,873	1,925,064	1.12	1.24	1.31
Alaska	5,120	6,830	6,900	314,753	329,431	332,403	1.63	2.07	2.08
Arizona	29,030	45,980	37,680	2,650,277	2,903,992	2,859,967	1.10	1.58	1.32
Arkansas	10,090	13,340	11,910	1,221,553	1,293,947	1,246,647	0.83	1.03	0.96
California	171,510	251,380	231,630	16,354,779	16,970,228	15,916,288	1.05	1.48	1.46
Colorado	28,880	39,050	33,070	2,392,952	2,598,433	2,447,712	1.21	1.50	1.35
Connecticut	20,710	30,060	29,140	1,703,865	1,761,588	1,724,024	1.22	1.71	1.69
Delaware	4,560	8,550	6,750	408,266	425,289	389,583	1.12	2.01	1.73
District of Columbia	6,700	11,360	11,790	288,397	310,652	300,663	2.32	3.66	3.92
Florida	84,970	97,980	80,170	7,998,202	8,704,110	8,159,147	1.06	1.13	0.98
Georgia	38,580	51,420	44,830	4,249,007	4,561,967	4,213,719	0.91	1.13	1.06
Hawaii	4,930	7,260	6,450	598,175	617,891	587,407	0.82	1.17	1.10
Idaho	7,920	12,880	14,880	666,080	731,362	687,321	1.19	1.76	2.16
Illinois	59,850	78,540	74,590	5,968,561	6,323,515	5,964,868	1.00	1.24	1.25
Indiana	30,990	36,080	33,810	2,997,800	3,081,177	2,822,693	1.03	1.17	1.20
Iowa	12,360	18,850	17,650	1,534,991	1,601,547	1,568,012	0.81	1.18	1.13
Kansas	13,610	18,420	18,090	1,381,343	1,415,942	1,396,558	0.99	1.30	1.30
Kentucky	16,410	18,510	17,990	1,854,703	1,915,131	1,865,961	0.88	0.97	0.96
Louisiana	19,700	24,710	23,730	1,928,464	1,941,642	1,926,492	1.02	1.27	1.23
Maine	6,770	8,200	7,910	653,847	666,305	641,978	1.04	1.23	1.23
Maryland	34,990	47,100	45,900	2,761,583	2,909,290	2,758,219	1.27	1.62	1.66
Massachusetts	42,360	63,400	61,110	3,203,810	3,280,932	3,197,210	1.32	1.93	1.91
Michigan	65,160	73,500	65,340	4,686,953	4,680,780	4,192,819	1.39	1.57	1.56
Minnesota	33,930	47,250	44,080	2,752,403	2,775,587	2,746,492	1.23	1.70	1.60
Mississippi	9,370	13,620	10,920	1,232,139	1,210,732	1,176,340	0.76	1.12	0.93
Missouri	27,980	34,560	30,930	2,815,878	2,899,695	2,725,527	0.99	1.19	1.13
Montana	5,740	8,100	8,120	456,385	485,132	461,337	1.26	1.67	1.76
Nebraska	9,560	11,260	10,500	938,105	953,057	931,414	1.02	1.18	1.13
Nevada	10,240	12,980	11,300	1,128,223	1,247,491	1,149,537	0.91	1.04	0.98
New Hampshire	7,290	9,760	10,010	687,855	715,310	698,859	1.06	1.36	1.43
New Jersey	52,180	67,710	63,350	4,144,223	4,265,294	4,076,713	1.26	1.59	1.55
New Mexico	12,930	16,540	15,750	849,970	901,704	873,112	1.52	1.83	1.80
New York	85,140	121,560	115,390	8,816,013	9,112,899	8,806,778	0.97	1.33	1.31
North Carolina	43,300	62,140	52,580	4,031,081	4,321,339	4,036,343	1.07	1.44	1.30
North Dakota	3,440	4,130	5,050	339,541	353,214	355,615	1.01	1.17	1.42
Ohio	56,900	68,930	63,510	5,502,533	5,626,086	5,303,019	1.03	1.23	1.20
Oklahoma	15,580	20,250	19,350	1,605,641	1,665,819	1,630,925	0.97	1.22	1.19
Oregon	21,840	31,980	27,770	1,714,447	1,822,010	1,769,599	1.27	1.76	1.57
Pennsylvania	62,880	81,430	70,910	5,859,561	6,054,254	5,791,061	1.07	1.35	1.22
Rhode Island	4,990	6,920	5,990	526,046	545,252	509,073	0.95	1.27	1.18
South Carolina	21,130	26,970	23,860	1,888,050	2,000,185	1,922,815	1.12	1.35	1.24
South Dakota	3,380	3,790	3,860	411,708	428,850	422,562	0.82	0.88	0.91
Tennessee	27,650	32,890	28,440	2,746,241	2,874,173	2,759,243	1.01	1.14	1.03
Texas	132,850	181,730	162,150	10,385,318	10,925,311	11,141,903	1.28	1.66	1.46
Utah	16,360	23,090	19,470	1,179,142	1,319,933	1,262,083	1.39	1.75	1.54
Vermont	3,800	4,350	4,030	334,188	341,588	338,295	1.14	1.27	1.19
Virginia	48,320	64,330	59,520	3,715,272	3,926,052	3,896,167	1.30	1.64	1.53
Washington	40,390	55,080	54,330	2,999,526	3,235,735	3,192,117	1.35	1.70	1.70
West Virginia	7,870	8,500	8,550	746,854	780,869	711,068	1.05	1.09	1.20
Wisconsin	30,030	41,690	35,950	2,868,376	2,951,001	2,807,301	1.05	1.41	1.28
Wyoming	2,660	3,870	4,050	262,358	283,543	273,313	1.01	1.36	1.48
Puerto Rico	9,680	NA	10,400	1,226,251	1,241,426	1,088,762	0.79	NA	0.96

na = not applicable; NA = not available

EPSCoR = Experimental Program to Stimulate Competitive Research

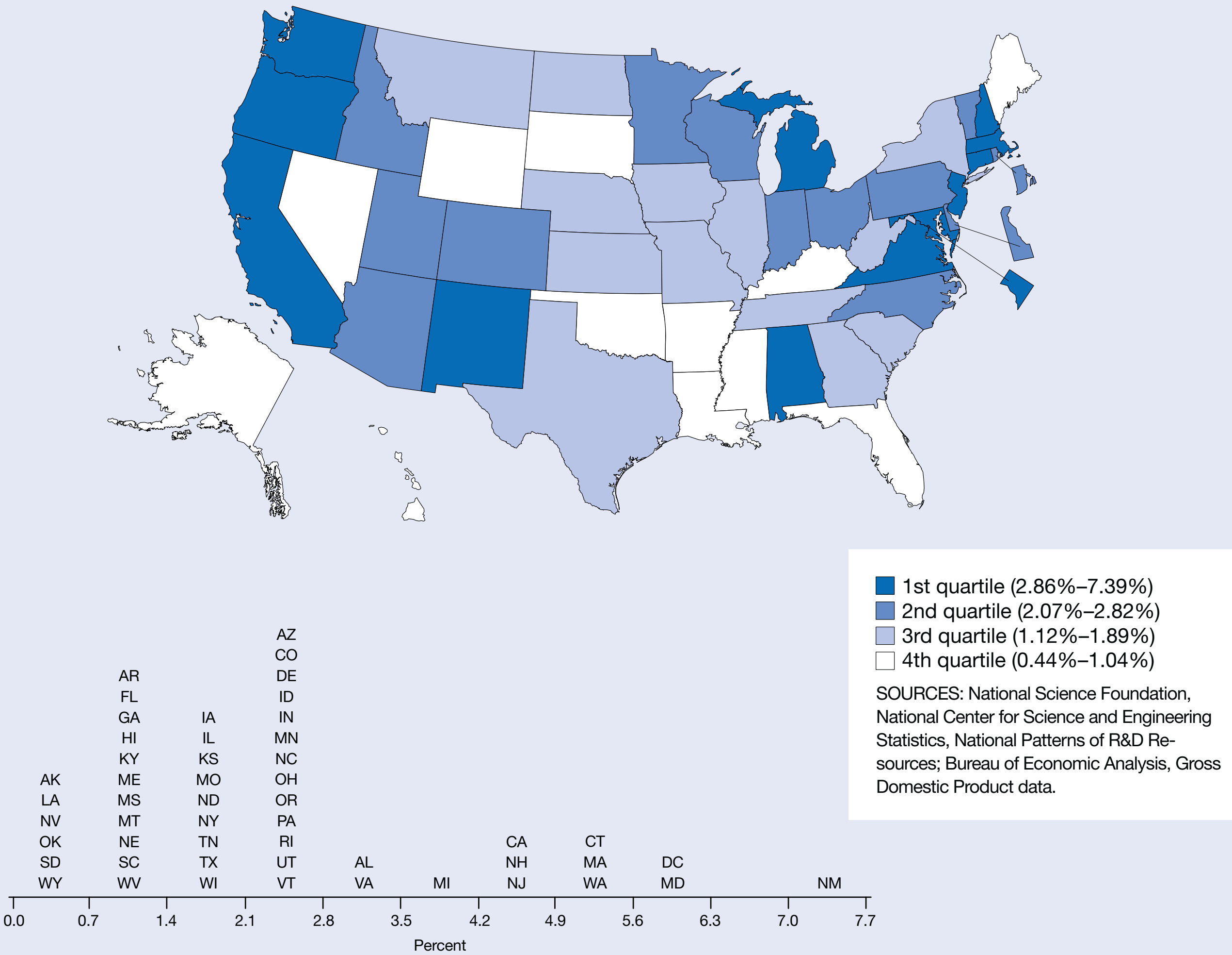
NOTES: Workforce represents employed component of civilian labor force and reported as annual data not seasonally adjusted. For explanation of EPSCoR and non-EPSCoR averages, see chapter introduction.

SOURCE: Bureau of Labor Statistics, Occupational Employment and Wage Estimates and Local Area Unemployment Statistics.

Science and Engineering Indicators 2012

R&D as a Percentage of Gross Domestic Product

Figure 8-39
R&D as a percentage of gross domestic product: 2008



SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources; Bureau of Economic Analysis, Gross Domestic Product data.

Findings

- The national value of R&D performed as a share of gross domestic product (GDP) rose slightly between 2000 and 2008, from 2.48% to 2.61%.
- In 2008, state values for this indicator ranged from 0.40% to 7.65%, indicating large differences in the geographic concentration of R&D activity.
- New Mexico has large federal R&D activities and a relatively small GDP giving it the highest value for this indicator.
- States with high rankings on this indicator also tended to rank high on S&E doctorate holders as a share of the workforce.
- The total R&D performed in states in the EPSCoR group was approximately one-tenth of that performed in states in the non-EPSCoR group.

This indicator represents the extent to which R&D plays a role in a state's economy. A high value indicates that a state has a high intensity of R&D activity, which may support future growth in knowledge-based industries. Industries that have a high percentage of R&D activity include pharmaceuticals, chemicals, computer equipment and services, electronic components, aerospace, and motor vehicles.

R&D performed refers to R&D activities conducted or funded by federal and state agencies, businesses, universities, and nonprofit organizations. In 2009, business performed nearly three-quarters of the total R&D at the national level followed by colleges and universities at 13%; followed by government facilities, including federally funded R&D centers, and nonprofit institutions.

Both gross domestic product (GDP) and R&D performance are shown in current dollars.

The methodology for assigning industry R&D activity at the state level was modified in 2001, and 1998–2000 data were recalculated using the new methodology.

Table 8-39
R&D as a percentage of gross domestic product, by state: 2000, 2004, and 2008

State	R&D performed ($millions)			State GDP ($millions)			R&D performed/GDP (%)		
	2000	2004	2008	2000	2004	2008	2000	2004	2008
EPSCoR states	18,730	25,969	32,822	1,368,845	1,684,709	2,079,663	1.37	1.54	1.58
Non-EPSCoR states	223,829	255,087	333,891	8,457,057	10,026,090	12,093,434	2.65	2.54	2.76
Average EPSCoR state value	na	na	na	na	na	na	1.55	1.71	1.71
Average non-EPSCoR state value	na	na	na	na	na	na	2.47	2.56	2.79
United States	244,855	283,439	372,660	9,884,171	11,788,910	14,270,458	2.48	2.40	2.61
Alabama	1,730	2,760	4,870	116,014	142,086	169,694	1.49	1.94	2.87
Alaska	196	271	269	25,913	34,408	49,186	0.76	0.79	0.55
Arizona	3,107	3,544	7,010	161,901	201,287	260,454	1.92	1.76	2.69
Arkansas	454	514	747	68,146	83,551	99,497	0.67	0.62	0.75
California	55,093	59,607	81,323	1,317,343	1,571,198	1,911,741	4.18	3.79	4.25
Colorado	4,230	5,497	5,810	171,930	201,656	254,218	2.46	2.73	2.29
Connecticut	4,888	7,881	11,322	163,943	188,576	225,958	2.98	4.18	5.01
Delaware	1,532	1,182	1,594	40,957	51,282	58,674	3.74	2.30	2.72
District of Columbia	2,296	2,383	5,946	58,269	78,111	97,361	3.94	3.05	6.11
Florida	4,663	5,409	6,515	481,115	621,251	747,770	0.97	0.87	0.87
Georgia	2,796	3,655	5,232	294,479	343,158	405,269	0.95	1.07	1.29
Hawaii	291	490	663	41,372	52,185	66,119	0.70	0.94	1.00
Idaho	1,434	1,006	1,375	36,091	44,050	55,212	3.97	2.28	2.49
Illinois	12,767	11,300	11,961	474,444	546,661	637,037	2.69	2.07	1.88
Indiana	3,252	5,130	6,111	198,020	231,961	263,616	1.64	2.21	2.32
Iowa	1,017	1,625	2,136	93,287	115,993	134,959	1.09	1.40	1.58
Kansas	1,420	2,169	2,029	85,742	99,974	125,333	1.66	2.17	1.62
Kentucky	866	1,006	1,463	113,108	131,655	155,592	0.77	0.76	0.94
Louisiana	627	972	1,193	131,430	171,848	213,441	0.48	0.57	0.56
Maine	319	384	516	36,395	44,342	49,972	0.88	0.87	1.03
Maryland	8,634	14,341	16,605	182,953	232,215	281,659	4.72	6.18	5.90
Massachusetts	13,004	15,987	20,090	272,680	310,476	365,623	4.77	5.15	5.49
Michigan	18,892	16,722	15,507	336,786	365,189	375,436	5.61	4.58	4.13
Minnesota	4,299	5,992	6,697	188,449	227,321	262,758	2.28	2.64	2.55
Mississippi	513	651	808	65,615	77,617	96,713	0.78	0.84	0.84
Missouri	2,583	3,038	3,884	180,982	208,763	241,344	1.43	1.46	1.61
Montana	170	295	401	21,629	27,863	35,838	0.79	1.06	1.12
Nebraska	439	740	988	57,233	69,615	84,884	0.77	1.06	1.16
Nevada	377	623	913	75,907	100,677	132,270	0.50	0.62	0.69
New Hampshire	775	1,665	2,496	44,067	51,293	58,780	1.76	3.25	4.25
New Jersey	13,133	12,460	20,713	349,334	410,176	483,560	3.76	3.04	4.28
New Mexico	3,085	5,114	5,906	50,262	64,208	77,168	6.14	7.97	7.65
New York	13,556	13,113	16,486	770,621	893,399	1,109,080	1.76	1.47	1.49
North Carolina	5,045	6,491	8,612	281,418	327,547	403,927	1.79	1.98	2.13
North Dakota	146	558	511	18,250	23,335	31,677	0.80	2.39	1.61
Ohio	7,662	7,816	10,164	381,175	428,974	470,640	2.01	1.82	2.16
Oklahoma	660	814	1,030	91,292	112,444	151,850	0.72	0.72	0.68
Oregon	2,116	3,664	4,802	112,974	137,341	174,454	1.87	2.67	2.75
Pennsylvania	9,842	10,813	13,068	395,811	462,280	545,198	2.49	2.34	2.40
Rhode Island	1,501	1,840	1,233	33,522	42,933	47,378	4.48	4.29	2.60
South Carolina	1,126	1,599	2,086	115,392	134,765	159,500	0.98	1.19	1.31
South Dakota	85	149	254	24,009	30,588	38,293	0.35	0.49	0.66
Tennessee	2,057	3,180	3,871	177,582	213,888	247,796	1.16	1.49	1.56
Texas	11,552	14,266	20,316	732,987	906,893	1,202,104	1.58	1.57	1.69
Utah	1,361	1,602	2,522	69,483	82,616	112,353	1.96	1.94	2.24
Vermont	465	546	546	18,033	21,909	24,636	2.58	2.49	2.22
Virginia	5,069	7,345	11,472	261,894	329,927	402,853	1.94	2.23	2.85
Washington	10,516	10,936	16,696	227,828	258,069	334,477	4.62	4.24	4.99
West Virginia	457	523	778	41,419	48,785	59,039	1.10	1.07	1.32
Wisconsin	2,693	3,675	4,967	177,638	209,275	239,150	1.52	1.76	2.08
Wyoming	61	98	154	17,047	23,296	38,917	0.36	0.42	0.40
Puerto Rico	NA	NA	NA	69,208	82,809	95,708	NA	NA	NA

na = not applicable; NA = not available

EPSCoR = Experimental Program to Stimulate Competitive Research; GDP = gross domestic product

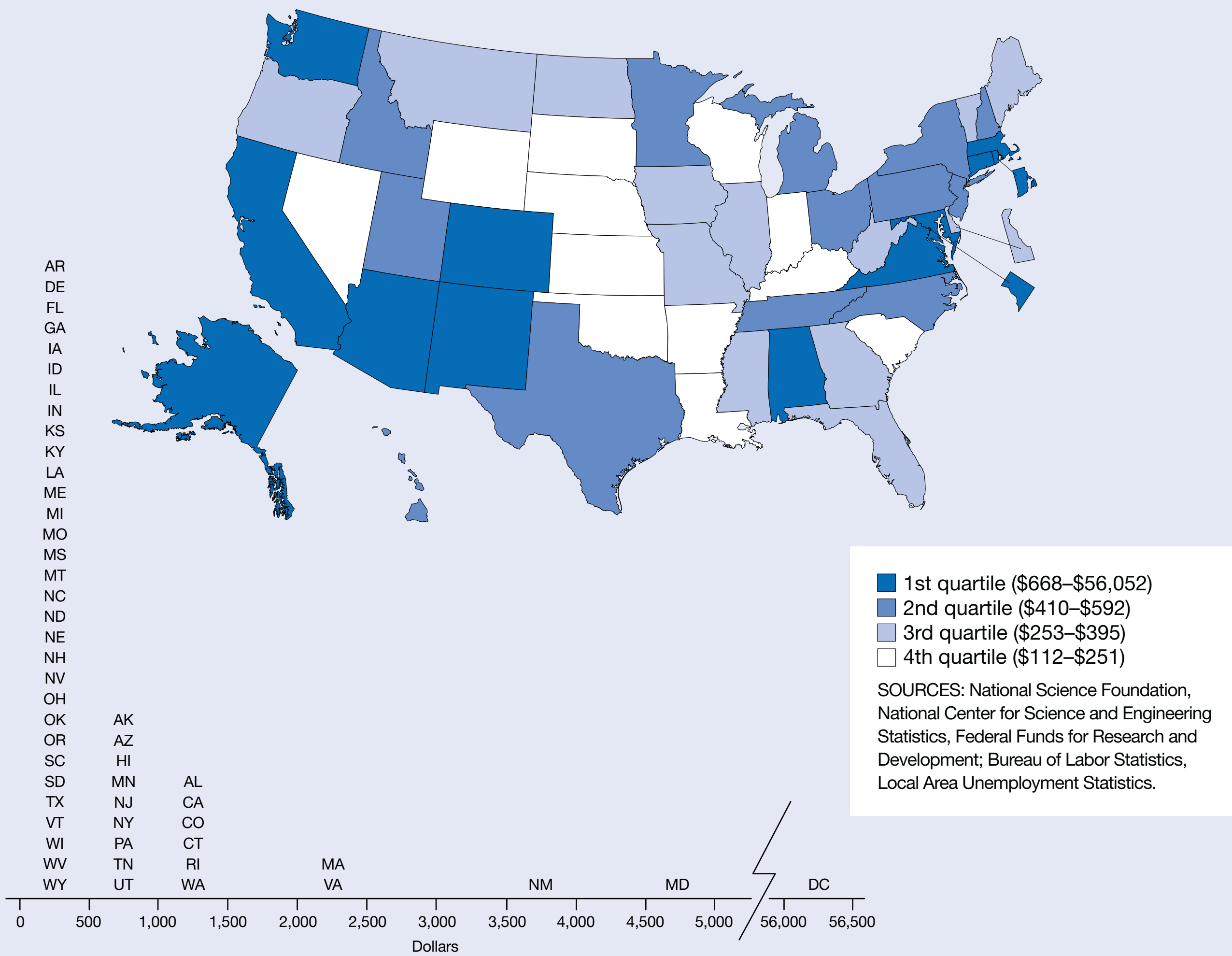
NOTES: R&D includes R&D performed by federal agencies, business, universities, other nonprofit organizations, and state agencies. R&D and GDP reported in current dollars. For explanation of EPSCoR and non-EPSCoR averages, see chapter introduction.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources (various years); Bureau of Economic Analysis, Gross Domestic Product data; United Nations Statistics Division.

Science and Engineering Indicators 2012

Federal R&D Obligations per Employed Worker

Figure 8-40
Federal R&D obligations per employed worker: 2008



SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Federal Funds for Research and Development; Bureau of Labor Statistics, Local Area Unemployment Statistics.

Findings

- Federal R&D obligations have increased appreciably from about $74 billion in 2000 to about $125 billion in 2008, an increase of 76% in current dollars.
- In 2008, federal R&D obligations per civilian worker were concentrated in a few states; only 10 states and the District of Columbia exceeded the national average of $862 per worker.
- Federal R&D obligations in 2008 varied greatly among the states, ranging from $112 to $4,591 per civilian worker. Higher values were found in the states surrounding the District of Columbia and in sparsely populated states with national laboratories or federal facilities.

This indicator represents how federal R&D obligations are disbursed geographically relative to the size of a state's employed civilian workforce. Federal R&D dollars are attributed to the states in which the recipients are located.

Federal obligations for R&D come from the National Center for Science and Engineering Statistics and cover data reported by 11 federal agencies. The Department of Defense (DoD) disburses the most federal R&D funding, approximately 50% of the total. The geographic distribution of DoD R&D funding for development to industry reflects the location of prime contractors only, not the subcontractors who perform much of the R&D. A high value may indicate the existence of a number of large prime contractors or major federally funded R&D facilities in a state.

The estimate of a state's workforce is provided by the Bureau of Labor Statistics (BLS). It represents the employed component of the civilian labor force and is not seasonally adjusted. BLS assigns workers to a location based on residence. Estimates for states with smaller populations are generally less precise than estimates for states with larger populations.

Table 8-40
Federal R&D obligations per employed worker, by state: 2000, 2004, and 2008

State	Federal R&D obligations ($thousands)			Employed workers			Federal R&D obligations/ employed worker ($)		
	2000	2004	2008	2000	2004	2008	2000	2004	2008
United States	74,074,333	109,498,570	124,844,682	136,955,714	138,762,591	144,860,347	541	789	862
Alabama	1,670,058	3,035,516	2,782,193	2,067,147	2,007,153	2,061,601	808	1,512	1,350
Alaska	155,155	461,308	222,163	299,324	314,753	332,389	518	1,466	668
Arizona	1,151,925	2,643,735	2,449,176	2,404,916	2,650,277	2,934,136	479	998	835
Arkansas	116,333	146,682	145,265	1,207,352	1,221,553	1,300,420	96	120	112
California	14,819,382	19,259,424	19,938,653	16,024,341	16,354,779	16,883,425	925	1,178	1,181
Colorado	1,398,887	2,068,038	2,668,121	2,300,192	2,392,952	2,605,535	608	864	1,024
Connecticut	806,228	2,122,540	1,815,401	1,697,670	1,703,865	1,763,911	475	1,246	1,029
Delaware	69,867	89,747	144,314	402,777	408,266	419,184	173	220	344
District of Columbia	2,443,108	3,329,397	17,537,244	291,916	288,397	312,877	8,369	11,544	56,052
Florida	2,286,464	3,265,014	2,290,401	7,569,406	7,998,202	8,621,454	302	408	266
Georgia	2,654,039	1,906,523	1,386,021	4,095,362	4,249,007	4,517,730	648	449	307
Hawaii	234,291	488,209	347,753	584,858	598,175	613,803	401	816	567
Idaho	217,349	288,538	355,408	632,451	666,080	722,714	344	433	492
Illinois	1,496,751	1,880,072	2,168,530	6,176,837	5,968,561	6,247,985	242	315	347
Indiana	512,847	556,743	672,029	3,052,719	2,997,800	3,049,268	168	186	220
Iowa	275,560	538,270	634,853	1,557,081	1,534,991	1,607,923	177	351	395
Kansas	224,013	287,446	300,406	1,351,988	1,381,343	1,421,107	166	208	211
Kentucky	253,526	251,763	252,464	1,866,348	1,854,703	1,898,083	136	136	133
Louisiana	249,045	446,722	406,131	1,930,662	1,928,464	1,974,881	129	232	206
Maine	249,812	210,258	168,009	650,385	653,847	665,057	384	322	253
Maryland	8,778,541	12,608,595	13,312,685	2,711,382	2,761,583	2,900,018	3,238	4,566	4,591
Massachusetts	4,552,289	5,963,595	6,883,096	3,273,281	3,203,810	3,283,147	1,391	1,861	2,096
Michigan	1,005,043	1,117,762	1,866,491	4,953,421	4,686,953	4,554,464	203	238	410
Minnesota	797,334	831,259	1,393,037	2,720,492	2,752,403	2,778,500	293	302	501
Mississippi	413,820	1,598,715	435,207	1,239,859	1,232,139	1,205,464	334	1,298	361
Missouri	905,875	3,058,821	1,111,285	2,875,336	2,815,878	2,869,569	315	1,086	387
Montana	105,359	188,774	159,461	446,552	456,385	485,375	236	414	329
Nebraska	104,079	210,458	204,579	923,198	938,105	960,438	113	224	213
Nevada	273,344	554,983	312,624	1,015,221	1,128,223	1,246,696	269	492	251
New Hampshire	357,828	422,144	294,312	675,541	687,855	716,611	530	614	411
New Jersey	1,979,346	2,273,723	2,192,726	4,130,310	4,144,223	4,256,251	479	549	515
New Mexico	2,210,494	3,363,175	3,502,888	810,024	849,970	909,809	2,729	3,957	3,850
New York	2,989,719	4,505,321	4,651,187	8,751,441	8,816,013	9,138,034	342	511	509
North Carolina	1,062,536	1,683,581	1,772,567	3,969,235	4,031,081	4,291,565	268	418	413
North Dakota	64,051	108,573	98,326	335,780	339,541	355,622	191	320	276
Ohio	2,164,645	2,794,181	2,580,353	5,573,154	5,502,533	5,570,514	388	508	463
Oklahoma	232,217	498,478	260,753	1,609,522	1,605,641	1,674,485	144	310	156
Oregon	468,167	504,810	581,074	1,716,954	1,714,447	1,828,477	273	294	318
Pennsylvania	2,396,146	3,731,084	3,279,378	5,830,902	5,859,561	6,095,678	411	637	538
Rhode Island	418,037	642,064	643,721	520,758	526,046	528,288	803	1,221	1,219
South Carolina	249,938	384,307	453,003	1,917,365	1,888,050	1,998,171	130	204	227
South Dakota	38,803	70,036	76,379	397,678	411,708	432,130	98	170	177
Tennessee	824,300	1,381,987	1,689,925	2,756,498	2,746,241	2,854,488	299	503	592
Texas	3,021,013	5,506,721	5,029,588	9,896,002	10,385,318	11,070,779	305	530	454
Utah	305,980	1,183,694	699,928	1,097,915	1,179,142	1,324,467	279	1,004	528
Vermont	72,030	417,091	120,985	326,742	334,188	342,130	220	1,248	354
Virginia	4,961,535	7,298,269	9,282,197	3,502,524	3,715,272	3,954,733	1,417	1,964	2,347
Washington	1,345,649	2,311,260	4,339,544	2,898,677	2,999,526	3,286,973	464	771	1,320
West Virginia	235,677	315,693	224,575	764,649	746,854	770,845	308	423	291
Wisconsin	420,839	645,875	660,915	2,894,884	2,868,376	2,936,749	145	225	225
Wyoming	35,059	47,596	47,358	256,685	262,358	286,394	137	181	165
Puerto Rico	81,016	100,904	84,929	1,162,153	1,226,251	1,208,595	70	82	70

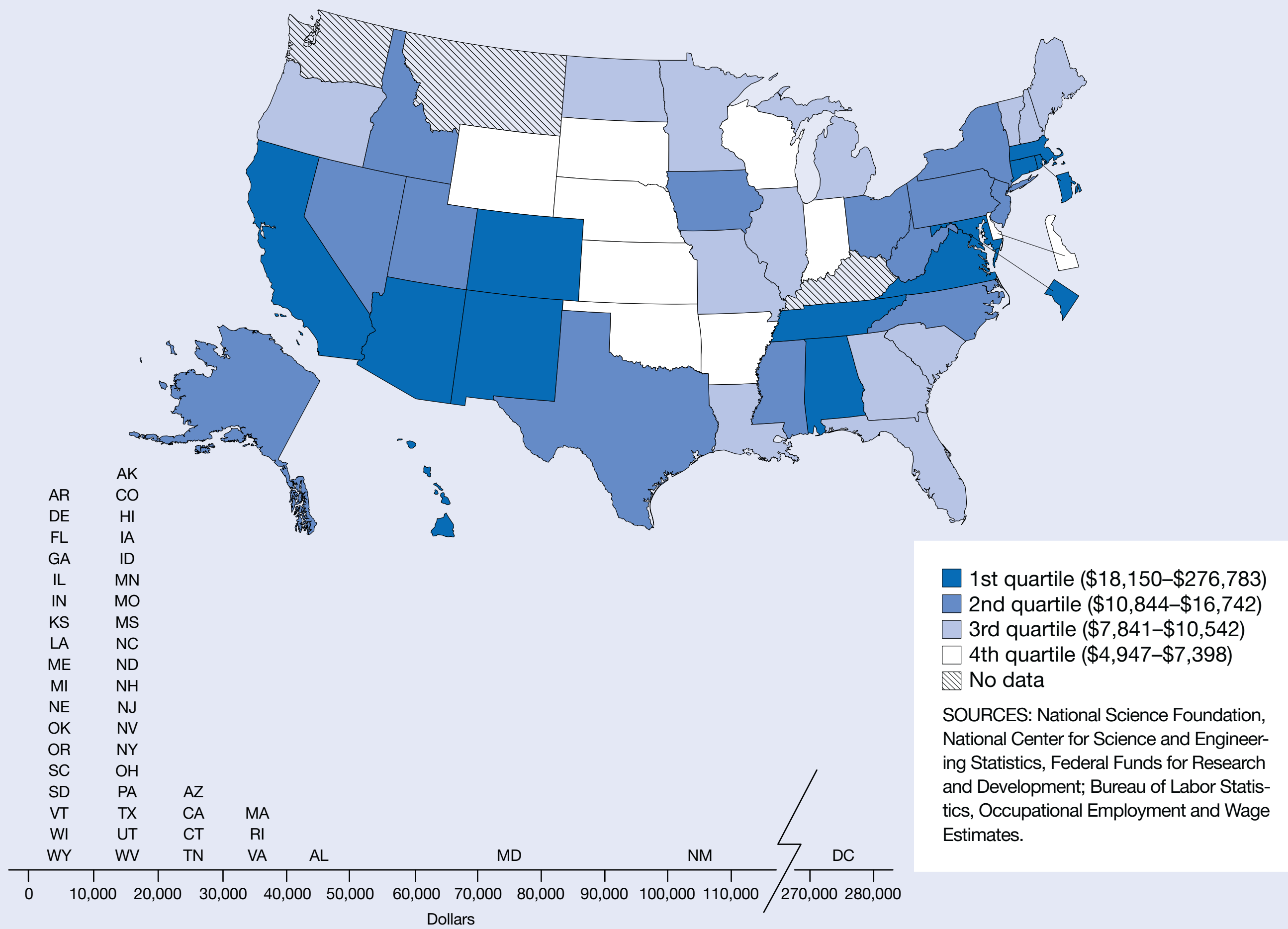
NOTES: Only 11 agencies required to report federal R&D obligations: Departments of Agriculture, Commerce, Defense, Energy, Health and Human Services, Homeland Security (established in 2002), Interior, and Transportation; Environmental Protection Agency; National Aeronautics and Space Administration; and National Science Foundation. These obligations represent approximately 98% of total federal R&D obligations. Civilian workers represent employed component of civilian labor force and reported as annual data not seasonally adjusted. Federal R&D obligations reported in current dollars.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Federal Funds for Research and Development (various years); Bureau of Labor Statistics, Local Area Unemployment Statistics.

Science and Engineering Indicators 2012

Federal R&D Obligations per Individual in Science and Engineering Occupation

Figure 8-41
Federal R&D obligations per individual in science and engineering occupation: 2008



SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Federal Funds for Research and Development; Bureau of Labor Statistics, Occupational Employment and Wage Estimates.

Findings

- The federal government obligated approximately $125 billion for R&D in 2008—more than $20,000 for each person employed in an S&E occupation.
- Federal R&D obligations per person employed in an S&E occupation ranged across the states from $4,347 to $101,360 in 2008.
- The distribution for this indicator was highly skewed in 2008, with only 10 states and the District of Columbia above the national average. High values were reported in the District of Columbia and adjoining states and also in states where federal facilities or major defense contractors are located.
- The 7 lowest ranking states are EPSCoR states.

This indicator represents the relationship between federal R&D spending in a state and the number of employees in the state who work in S&E occupations. Federal R&D dollars are attributed to the states in which the recipients of federal obligations are located.

Federal obligations for R&D come from the National Center for Science and Engineering Statistics and include data reported by 11 federal agencies. The Department of Defense (DoD) disburses the most funding, approximately 50% of the total. The geographic distribution of DoD R&D funding to industry, mostly for development, reflects the location of prime contractors only, not the numerous subcontractors who perform much of the R&D.

S&E occupations are defined by standard occupational codes. They include engineers and computer, mathematical, life, physical, and social scientists. Managers, technicians, elementary and secondary schoolteachers, and medical personnel are not included.

Data on individuals in S&E occupations come from a survey of workplaces that assigns workers to a state based on where they work. Estimates do not include self-employed persons and are developed by the Bureau of Labor Statistics (BLS) from data provided by state workforce agencies. Due to the way data are collected, faculty teaching in S&E fields are not included as workers in S&E occupations. Data on people in S&E occupations are sample based.

Estimates for states with smaller populations are generally less precise than estimates for states with larger populations.

Table 8-41
Federal R&D obligations per individual in science and engineering occupation, by state: 2003, 2005, and 2008

State	Federal R&D obligations ($millions)			Individuals in S&E occupations			Federal R&D obligations/individual in S&E occupation ($)		
	2003	2005	2008	2003	2005	2008	2003	2005	2008
United States	100,982	116,331	124,842	4,961,550	5,233,520	5,781,460	20,353	22,228	21,594
Alabama	3,212	3,108	2,782	56,380	62,790	68,580	56,971	49,498	40,566
Alaska	399	495	222	10,600	11,230	13,260	37,642	44,078	16,742
Arizona	2,385	2,959	2,449	92,120	96,410	102,100	25,890	30,692	23,986
Arkansas	145	165	145	21,340	24,660	29,310	6,795	6,691	4,947
California	20,170	19,964	19,939	676,180	716,530	791,750	29,829	27,862	25,183
Colorado	1,735	2,265	2,668	124,140	126,110	147,000	13,976	17,961	18,150
Connecticut	2,068	2,400	1,815	81,380	83,930	80,290	25,412	28,595	22,606
Delaware	95	94	144	17,370	18,010	22,330	5,469	5,219	6,449
District of Columbia	2,986	4,162	17,537	54,890	63,410	63,360	54,400	65,636	276,783
Florida	2,854	2,590	2,290	221,070	241,000	248,200	12,910	10,747	9,226
Georgia	2,133	2,182	1,386	144,170	137,580	147,380	14,795	15,860	9,404
Hawaii	414	600	348	16,090	17,460	18,830	25,730	34,364	18,481
Idaho	218	290	355	22,150	23,880	23,310	9,842	12,144	15,230
Illinois	1,935	2,128	2,169	211,230	221,630	224,370	9,161	9,602	9,667
Indiana	574	567	672	78,410	79,910	90,840	7,320	7,095	7,398
Iowa	500	488	635	37,320	40,300	46,180	13,398	12,109	13,751
Kansas	269	358	300	51,970	51,630	54,260	5,176	6,934	5,529
Kentucky	247	296	252	45,230	44,530	NA	5,461	6,647	NA
Louisiana	453	444	406	41,900	41,030	41,790	10,811	10,821	9,715
Maine	167	292	168	15,020	15,500	17,000	11,119	18,839	9,882
Maryland	8,027	12,501	13,313	149,250	160,120	167,070	53,782	78,073	79,685
Massachusetts	5,492	6,592	6,883	184,690	193,180	217,310	29,736	34,124	31,674
Michigan	1,693	1,177	1,866	182,940	192,150	204,290	9,254	6,125	9,134
Minnesota	866	768	1,393	117,120	120,930	134,440	7,394	6,351	10,361
Mississippi	1,181	438	435	22,190	23,480	27,270	53,222	18,654	15,952
Missouri	1,350	4,202	1,111	84,150	92,260	105,390	16,043	45,545	10,542
Montana	131	182	159	11,450	11,940	NA	11,441	15,243	NA
Nebraska	168	193	205	30,710	31,530	31,820	5,471	6,121	6,442
Nevada	419	593	313	22,330	24,400	27,300	18,764	24,303	11,465
New Hampshire	512	514	294	23,430	26,840	29,150	21,852	19,151	10,086
New Jersey	2,088	2,525	2,193	161,420	174,270	198,060	12,935	14,489	11,072
New Mexico	3,090	3,593	3,503	33,600	32,530	34,560	91,964	110,452	101,360
New York	4,383	5,320	4,651	272,440	289,010	326,510	16,088	18,408	14,245
North Carolina	1,617	1,806	1,773	132,440	134,290	153,680	12,209	13,449	11,537
North Dakota	107	118	98	8,430	9,070	9,450	12,693	13,010	10,370
Ohio	2,967	2,962	2,580	177,100	180,900	206,320	16,753	16,374	12,505
Oklahoma	570	401	261	44,360	46,370	48,900	12,849	8,648	5,337
Oregon	514	650	581	61,230	62,030	70,070	8,395	10,479	8,292
Pennsylvania	3,989	3,677	3,279	185,560	204,270	227,170	21,497	18,001	14,434
Rhode Island	566	889	644	18,740	18,080	18,090	30,203	49,170	35,600
South Carolina	454	493	453	48,740	50,460	57,770	9,315	9,770	7,841
South Dakota	55	70	76	9,150	9,460	11,870	6,011	7,400	6,403
Tennessee	1,131	1,426	1,690	63,680	66,390	72,760	17,761	21,479	23,227
Texas	5,414	5,187	5,030	365,270	389,550	463,850	14,822	13,315	10,844
Utah	803	1,058	700	45,570	45,110	52,570	17,621	23,454	13,316
Vermont	201	263	121	11,420	12,770	12,360	17,601	20,595	9,790
Virginia	6,709	8,747	9,282	209,280	236,650	259,280	32,058	36,962	35,799
Washington	2,442	2,641	4,340	150,230	160,960	NA	16,255	16,408	NA
West Virginia	383	808	225	16,220	16,040	17,000	23,613	50,374	13,235
Wisconsin	658	652	661	93,320	93,590	101,680	7,051	6,967	6,501
Wyoming	43	38	47	6,130	7,350	8,850	7,015	5,170	5,311
Puerto Rico	112	101	85	19,940	20,950	22,970	5,617	4,821	3,700

NA = not available

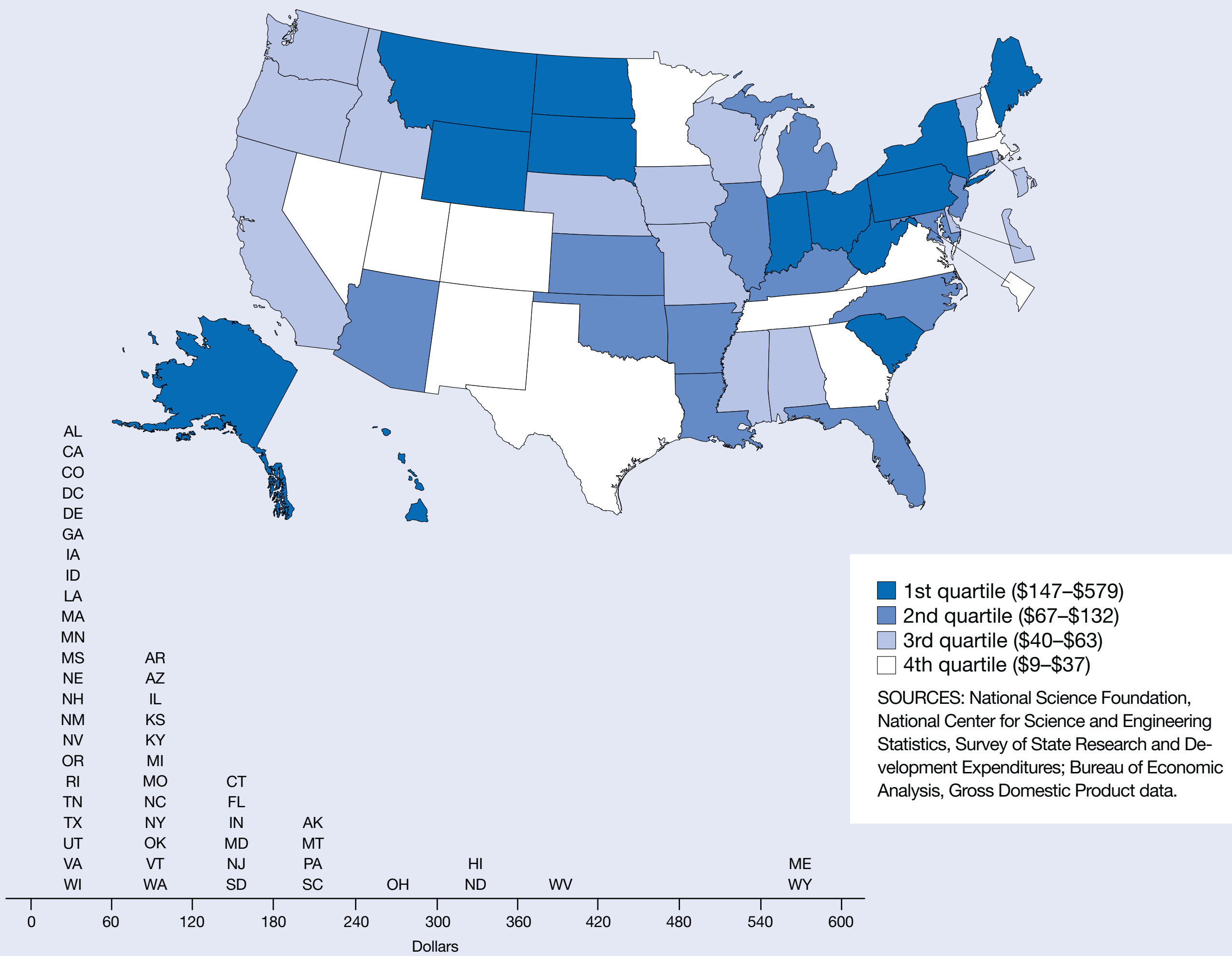
NOTES: Only 11 agencies required to report federal R&D obligations: Departments of Agriculture, Commerce, Defense, Energy, Health and Human Services, Homeland Security (established in 2002), Interior, and Transportation; Environmental Protection Agency; National Aeronautics and Space Administration; and National Science Foundation. These obligations represent approximately 98% of total federal R&D obligations. Federal R&D obligations reported in current dollars. National total for S&E occupations in the United States provided by Occupational Employment Statistics (OES). OES estimates for 2003 S&E occupations based upon November data; estimates for remaining years based upon May data.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Federal Funds for Research and Development (various years); Bureau of Labor Statistics, Occupational Employment and Wage Estimates.

Science and Engineering Indicators 2012

State Agency R&D Expenditures per $1 Million of Gross Domestic Product

Figure 8-42
State agency R&D expenditures per $1 million of gross domestic product: 2007



SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Survey of State Research and Development Expenditures; Bureau of Economic Analysis, Gross Domestic Product data.

Findings

- Nationally, state government agencies spent a total of $1.2 billion on R&D in 2007. This represented $88 for each $1 million of a state's gross domestic product (GDP).
- State agency R&D expenditures accounted for less than one-half of 1 percent of total R&D expenditures in 2007; most R&D was funded by nonstate sources.
- In 2007, the state values for this indicator ranged from $9 to $579 per $1 million of state GDP.
- Nine EPSCoR states are among those with the highest values for this indicator, suggesting that there is a state-level effort to improve R&D infrastructure in these states, not just a federal effort.
- State R&D totals display considerable volatility between FY 2006 and FY 2007. Four states (Florida, Indiana, New Jersey, and Rhode Island) included new agencies in their reporting from 2006 to 2007.

This indicator represents the ratio of state agency R&D funding to the size of a state's economy. State R&D expenditures include state-administered funds from all sources that support R&D performed by either a state agency or an external performer.

Data on state R&D funding cover funding administered by state government departments, agencies, independent commissions, and other state-run entities. They exclude state-run colleges and universities as well as laboratories or experiment stations controlled by state universities; funding administered by these institutions is classified as academic R&D. The data also exclude state legislatures' direct appropriations to nonstate agencies. Some data may include some expenditures for non-R&D activities such as commercialization, environmental testing, and routine survey work.

Because of differences in the survey populations, definition of covered R&D activities, and collection methods, the results of previous NSF surveys on state government R&D are not comparable. Data for the value of gross domestic product (GDP) and for R&D expenditures are shown in current dollars.

Table 8-42
State agency R&D expenditures per $1 million of gross domestic product, by state: 2006 and 2007

State	State agency R&D expenditures ($)		State GDP ($millions)		State agency R&D ($)/ $1 million GDP	
	2006	2007	2006	2007	2006	2007
EPSCoR states	195,833,394	232,177,940	1,917,410	2,014,616	102	115
Non-EPSCoR states	824,010,424	989,262,653	11,306,386	11,862,368	73	83
Average EPSCoR state value	na	na	na	na	140	157
Average non-EPSCoR state value	na	na	na	na	94	107
United States	1,021,016,894	1,223,449,593	13,310,942	13,969,326	77	88
Alabama	7,269,319	7,340,365	159,263	165,981	46	44
Alaska	10,019,060	9,526,100	41,820	44,587	240	214
Arizona	37,151,471	20,442,635	246,837	260,122	151	79
Arkansas	4,869,648	7,658,199	93,518	97,187	52	79
California	107,793,045	91,842,652	1,800,779	1,874,783	60	49
Colorado	8,997,236	11,924,981	230,206	242,900	39	49
Connecticut	19,209,064	29,285,710	210,278	222,498	91	132
Delaware	2,812,102	2,611,108	56,660	60,108	50	43
District of Columbia	1,173,076	2,009,000	87,146	92,342	13	22
Florida	42,329,624	96,968,573	730,191	759,572	58	128
Georgia	10,620,188	4,886,946	381,500	400,331	28	12
Hawaii	12,067,849	22,643,330	61,194	64,212	197	353
Idaho	2,280,873	2,739,006	50,526	54,344	45	50
Illinois	37,184,281	41,974,809	602,147	629,379	62	67
Indiana	6,220,575	40,534,381	249,209	262,596	25	154
Iowa	13,564,062	6,790,053	124,319	134,410	109	51
Kansas	14,348,384	11,752,696	112,207	121,268	128	97
Kentucky	17,558,997	11,960,634	147,177	151,506	119	79
Louisiana	11,216,568	6,587,314	204,861	205,758	55	32
Maine	17,509,051	27,525,552	47,688	49,195	367	560
Maryland	24,945,119	40,298,691	261,076	273,693	96	147
Massachusetts	10,729,419	5,600,189	337,723	353,329	32	16
Michigan	75,016,589	32,849,159	376,610	387,086	199	85
Minnesota	6,219,201	10,529,048	246,012	254,567	25	41
Mississippi	2,744,882	2,893,892	86,089	93,194	32	31
Missouri	18,465,303	15,567,277	223,716	233,008	83	67
Montana	8,606,319	8,200,230	32,256	35,100	267	234
Nebraska	5,602,163	4,043,480	76,547	82,185	73	49
Nevada	1,397,463	1,748,776	124,191	133,782	11	13
New Hampshire	2,040,544	1,685,178	56,071	57,856	36	29
New Jersey	25,900,482	59,747,701	454,978	472,000	57	127
New Mexico	3,105,000	672,921	71,478	74,393	43	9
New York	103,597,135	128,361,166	1,032,879	1,085,225	100	118
North Carolina	14,344,310	37,607,109	379,050	397,975	38	94
North Dakota	21,062,090	9,908,722	26,068	28,552	808	347
Ohio	55,068,629	114,086,509	454,145	468,707	121	243
Oklahoma	8,922,036	10,731,050	131,904	140,183	68	77
Oregon	7,382,722	7,389,914	160,019	167,016	46	44
Pennsylvania	117,320,158	103,973,448	507,275	532,117	231	195
Rhode Island	150,000	1,771,949	46,449	47,334	3	37
South Carolina	22,427,746	31,493,843	149,285	158,041	150	199
South Dakota	5,791,586	5,473,603	32,451	35,082	178	156
Tennessee	5,355,000	4,549,998	236,554	242,678	23	19
Texas	28,019,645	29,650,947	1,055,959	1,147,970	27	26
Utah	3,214,170	2,752,228	100,466	108,815	32	25
Vermont	1,680,533	1,529,805	23,651	24,093	71	63
Virginia	11,579,623	15,486,526	375,090	389,319	31	40
Washington	22,834,218	23,333,431	300,225	325,112	76	72
West Virginia	6,024,577	22,179,830	55,334	57,001	109	389
Wisconsin	10,949,155	12,828,572	229,143	237,160	48	54
Wyoming	6,326,604	19,500,357	30,722	33,674	206	579
Puerto Rico	1,458,790	2,326,241	88,902	93,263	16	25

na = not applicable

EPSCoR = Experimental Program to Stimulate Competitive Research; GDP = gross domestic product

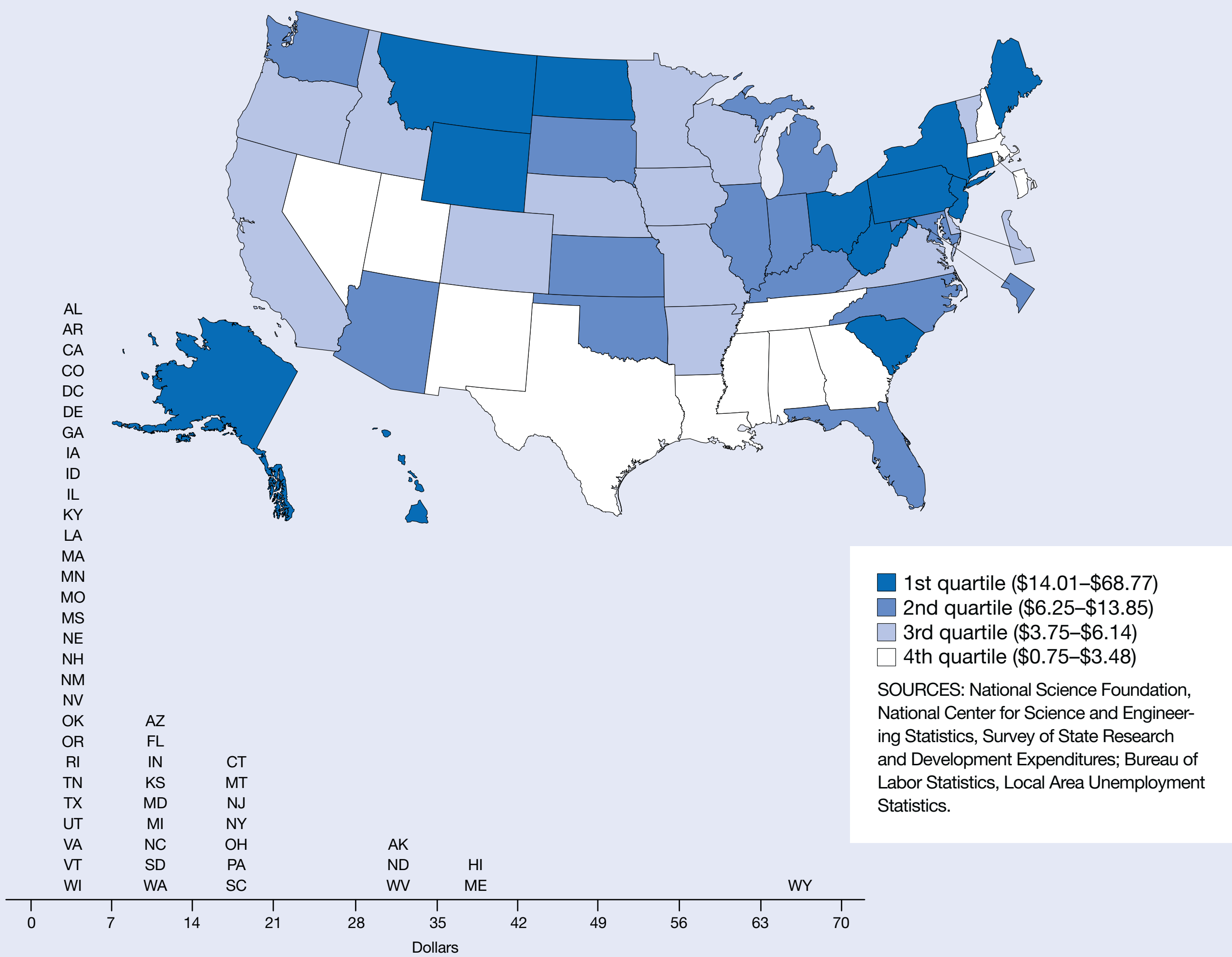
NOTES: For explanation of EPSCoR and non-EPSCoR averages, see chapter introduction. R&D and GDP reported in current dollars.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Survey of State Research and Development Expenditures (FY 2006 and FY 2007); Bureau of Economic Analysis, Gross Domestic Product data; United Nations Statistics Division.

Science and Engineering Indicators 2012

State Agency R&D Expenditures per Employed Worker

Figure 8-43
State agency R&D expenditures per employed worker: 2007



SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Survey of State Research and Development Expenditures; Bureau of Labor Statistics, Local Area Unemployment Statistics.

Findings

- In 2007, state government agency R&D expenditures averaged $8.43 per employed civilian worker nationwide.
- State agency R&D funding per civilian worker across the United States was approximately 1% of the $764 in federal R&D obligations per worker in 2007.
- State agency R&D spending per civilian worker varied greatly among the states in 2007, ranging from a low of $0.75 to a high of $68.77.
- Eight EPSCoR states are among those with the highest values for this indicator.

This indicator represents the extent of R&D activity funded by state government agencies relative to the size of the state's employed civilian workforce. State R&D expenditures include state-administered funds from all sources that support R&D performed by either a state agency or an external performer.

Data on state R&D cover funding administered by state government departments, agencies, independent commissions, and other state-run entities. They exclude state-run colleges and universities as well as laboratories or experiment stations controlled by state universities; funding administered by these institutions is classified as academic R&D. The data also exclude state legislatures' direct appropriations to nonstate agencies. Some data may include expenditures for non-R&D activities such as commercialization, environmental testing, and routine survey work.

Estimates of the size of a state's workforce are provided by the Bureau of Labor Statistics and represent the employed component of the civilian labor force. The data are not seasonally adjusted and workers are assigned to a location based on residence. Estimates for states with smaller populations are generally less precise than estimates for states with larger populations.

Table 8-43
State agency R&D expenditures per employed worker, by state: 2006 and 2007

State	State agency R&D expenditures ($)		Employed workers		State agency R&D expenditures/employed worker ($)	
	2006	2007	2006	2007	2006	2007
United States	1,021,016,894	1,223,449,593	143,729,350	145,156,139	7.10	8.43
Alabama	7,269,319	7,340,365	2,098,462	2,108,873	3.46	3.48
Alaska	10,019,060	9,526,100	326,109	329,431	30.72	28.92
Arizona	37,151,471	20,442,635	2,836,638	2,903,992	13.10	7.04
Arkansas	4,869,648	7,658,199	1,286,887	1,293,947	3.78	5.92
California	107,793,045	91,842,652	16,821,266	16,970,228	6.41	5.41
Colorado	8,997,236	11,924,981	2,541,828	2,598,433	3.54	4.59
Connecticut	19,209,064	29,285,710	1,745,993	1,761,588	11.00	16.62
Delaware	2,812,102	2,611,108	424,618	425,289	6.62	6.14
District of Columbia	1,173,076	2,009,000	303,791	310,652	3.86	6.47
Florida	42,329,624	96,968,573	8,584,095	8,704,110	4.93	11.14
Georgia	10,620,188	4,886,946	4,500,150	4,561,967	2.36	1.07
Hawaii	12,067,849	22,643,330	617,807	617,891	19.53	36.65
Idaho	2,280,873	2,739,006	718,077	731,362	3.18	3.75
Illinois	37,184,281	41,974,809	6,225,095	6,323,515	5.97	6.64
Indiana	6,220,575	40,534,381	3,080,047	3,081,177	2.02	13.16
Iowa	13,564,062	6,790,053	1,595,136	1,601,547	8.50	4.24
Kansas	14,348,384	11,752,696	1,403,938	1,415,942	10.22	8.30
Kentucky	17,558,997	11,960,634	1,904,467	1,915,131	9.22	6.25
Louisiana	11,216,568	6,587,314	1,900,240	1,941,642	5.90	3.39
Maine	17,509,051	27,525,552	665,856	666,305	26.30	41.31
Maryland	24,945,119	40,298,691	2,892,733	2,909,290	8.62	13.85
Massachusetts	10,729,419	5,600,189	3,255,504	3,280,932	3.30	1.71
Michigan	75,016,589	32,849,159	4,722,716	4,680,780	15.88	7.02
Minnesota	6,219,201	10,529,048	2,774,524	2,775,587	2.24	3.79
Mississippi	2,744,882	2,893,892	1,199,871	1,210,732	2.29	2.39
Missouri	18,465,303	15,567,277	2,889,461	2,899,695	6.39	5.37
Montana	8,606,319	8,200,230	476,412	485,132	18.06	16.90
Nebraska	5,602,163	4,043,480	943,176	953,057	5.94	4.24
Nevada	1,397,463	1,748,776	1,222,277	1,247,491	1.14	1.40
New Hampshire	2,040,544	1,685,178	708,748	715,310	2.88	2.36
New Jersey	25,900,482	59,747,701	4,257,899	4,265,294	6.08	14.01
New Mexico	3,105,000	672,921	886,708	901,704	3.50	0.75
New York	103,597,135	128,361,166	9,062,464	9,112,899	11.43	14.09
North Carolina	14,344,310	37,607,109	4,261,325	4,321,339	3.37	8.70
North Dakota	21,062,090	9,908,722	349,368	353,214	60.29	28.05
Ohio	55,068,629	114,086,509	5,602,764	5,626,086	9.83	20.28
Oklahoma	8,922,036	10,731,050	1,650,070	1,665,819	5.41	6.44
Oregon	7,382,722	7,389,914	1,792,039	1,822,010	4.12	4.06
Pennsylvania	117,320,158	103,973,448	6,021,084	6,054,254	19.48	17.17
Rhode Island	150,000	1,771,949	543,973	545,252	0.28	3.25
South Carolina	22,427,746	31,493,843	1,970,912	2,000,185	11.38	15.75
South Dakota	5,791,586	5,473,603	421,799	428,850	13.73	12.76
Tennessee	5,355,000	4,549,998	2,852,509	2,874,173	1.88	1.58
Texas	28,019,645	29,650,947	10,757,510	10,925,311	2.60	2.71
Utah	3,214,170	2,752,228	1,285,389	1,319,933	2.50	2.09
Vermont	1,680,533	1,529,805	343,149	341,588	4.90	4.48
Virginia	11,579,623	15,486,526	3,862,508	3,926,052	3.00	3.94
Washington	22,834,218	23,333,431	3,155,384	3,235,735	7.24	7.21
West Virginia	6,024,577	22,179,830	777,210	780,869	7.75	28.40
Wisconsin	10,949,155	12,828,572	2,932,482	2,951,001	3.73	4.35
Wyoming	6,326,604	19,500,357	276,882	283,543	22.85	68.77
Puerto Rico	1,458,790	2,326,241	1,260,703	1,241,426	1.16	1.87

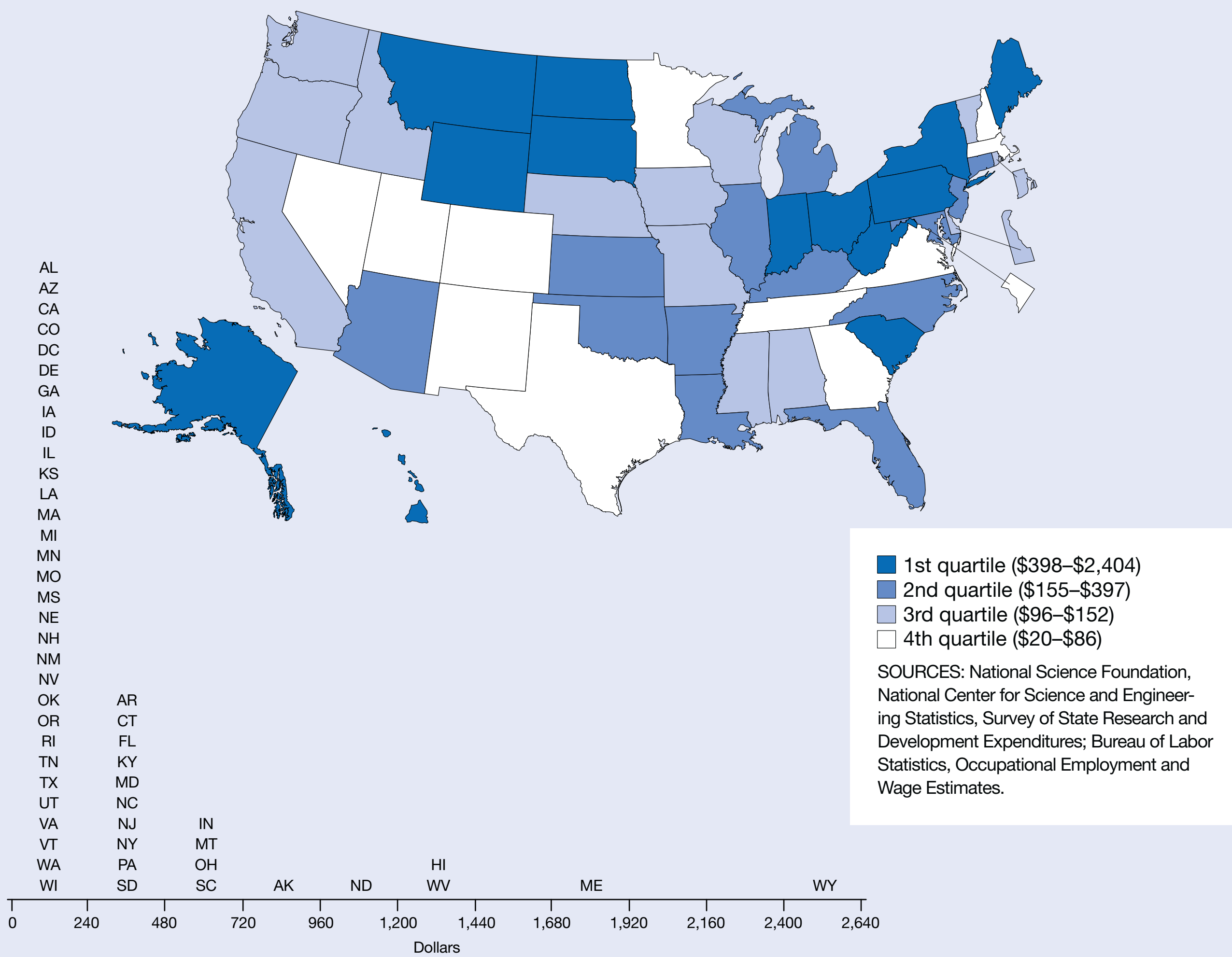
NOTE: R&D expenditures reported in current dollars.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Survey of State Research and Development Expenditures (FY 2006 and FY 2007); Bureau of Labor Statistics, Local Area Unemployment Statistics.

Science and Engineering Indicators 2012

State Agency R&D Expenditures per Individual in Science and Engineering Occupation

Figure 8-44
State agency R&D expenditures per individual in science and engineering occupation: 2007



SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Survey of State Research and Development Expenditures; Bureau of Labor Statistics, Occupational Employment and Wage Estimates.

Findings

- Nationally, state government agencies spent about $1.2 billion for R&D in 2007. By comparison, the federal government obligated more than $111 billion for R&D in 2007.
- In 2007, the average state agency R&D expenditure per person employed in an S&E occupation was $219, compared to about $20,000 the federal government averaged for each person employed in an S&E occupation.
- State agency R&D funding per person employed in an S&E occupation ranged from $20 to $2,404 to per state in 2007.
- Several EPSCoR states had the highest state agency R&D spending per S&E worker.

This indicator represents the ratio of state agency R&D funding to the number of individuals who work in S&E occupations in the state.

Data on state R&D cover funding administered by state government departments, agencies, independent commissions, and other state-run entities. They exclude state-run colleges and universities as well as laboratories or experiment stations controlled by state universities; funding administered by these institutions is classified as academic R&D. The data also exclude state legislatures' direct appropriations to nonstate agencies. Some data may include expenditures for non-R&D activities such as commercialization, environmental testing, and routine survey work.

S&E occupations are defined by standard occupational codes. They include engineers and computer, mathematical, life, physical, and social scientists. Managers, technicians, elementary and secondary schoolteachers, and medical personnel are not included.

Data on individuals in S&E occupations come from a survey of workplaces and assigns workers to a state based on where they work. Estimates do not include self-employed persons and are developed by the Bureau of Labor Statistics from data provided by state workforce agencies. Because of the way data are collected, faculty teaching in S&E fields are not included as workers in S&E occupations. Data on people in S&E occupations are sample based.

Table 8-44
State agency R&D expenditures per individual in science and engineering occupations, by state: 2006 and 2007

State	State agency R&D expenditures ($)		Individuals in S&E occupations		State agency R&D expenditures/individual in S&E occupation ($)	
	2006	2007	2006	2007	2006	2007
United States	1,021,016,894	1,223,449,593	5,382,290	5,591,990	190	219
Alabama	7,269,319	7,340,365	66,100	69,650	110	105
Alaska	10,019,060	9,526,100	10,720	11,990	935	795
Arizona	37,151,471	20,442,635	98,110	102,380	379	200
Arkansas	4,869,648	7,658,199	24,860	28,460	196	269
California	107,793,045	91,842,652	730,010	753,570	148	122
Colorado	8,997,236	11,924,981	133,730	138,990	67	86
Connecticut	19,209,064	29,285,710	79,380	80,280	242	365
Delaware	2,812,102	2,611,108	21,550	22,140	130	118
District of Columbia	1,173,076	2,009,000	64,120	63,150	18	32
Florida	42,329,624	96,968,573	246,190	244,140	172	397
Georgia	10,620,188	4,886,946	136,470	136,880	78	36
Hawaii	12,067,849	22,643,330	18,940	18,740	637	1,208
Idaho	2,280,873	2,739,006	NA	24,330	NA	113
Illinois	37,184,281	41,974,809	222,470	225,180	167	186
Indiana	6,220,575	40,534,381	80,110	83,080	78	488
Iowa	13,564,062	6,790,053	43,670	45,430	311	149
Kansas	14,348,384	11,752,696	48,620	50,040	295	235
Kentucky	17,558,997	11,960,634	44,680	49,030	393	244
Louisiana	11,216,568	6,587,314	40,180	38,450	279	171
Maine	17,509,051	27,525,552	15,950	15,960	1,098	1,725
Maryland	24,945,119	40,298,691	159,470	162,540	156	248
Massachusetts	10,729,419	5,600,189	198,670	205,610	54	27
Michigan	75,016,589	32,849,159	208,520	212,040	360	155
Minnesota	6,219,201	10,529,048	125,930	129,840	49	81
Mississippi	2,744,882	2,893,892	24,910	25,520	110	113
Missouri	18,465,303	15,567,277	96,420	102,170	192	152
Montana	8,606,319	8,200,230	13,010	13,240	662	619
Nebraska	5,602,163	4,043,480	32,500	31,420	172	129
Nevada	1,397,463	1,748,776	26,930	26,920	52	65
New Hampshire	2,040,544	1,685,178	27,680	28,450	74	59
New Jersey	25,900,482	59,747,701	176,460	186,120	147	321
New Mexico	3,105,000	672,921	30,800	33,440	101	20
New York	103,597,135	128,361,166	306,810	322,520	338	398
North Carolina	14,344,310	37,607,109	138,790	142,970	103	263
North Dakota	21,062,090	9,908,722	9,360	9,660	2,250	1,026
Ohio	55,068,629	114,086,509	185,190	196,390	297	581
Oklahoma	8,922,036	10,731,050	50,770	51,430	176	209
Oregon	7,382,722	7,389,914	64,520	67,890	114	109
Pennsylvania	117,320,158	103,973,448	214,910	218,890	546	475
Rhode Island	150,000	1,771,949	18,060	18,400	8	96
South Carolina	22,427,746	31,493,843	53,230	54,120	421	582
South Dakota	5,791,586	5,473,603	10,120	11,550	572	474
Tennessee	5,355,000	4,549,998	67,040	70,820	80	64
Texas	28,019,645	29,650,947	408,710	441,410	69	67
Utah	3,214,170	2,752,228	49,690	51,340	65	54
Vermont	1,680,533	1,529,805	12,780	12,760	131	120
Virginia	11,579,623	15,486,526	251,720	254,710	46	61
Washington	22,834,218	23,333,431	171,780	183,900	133	127
West Virginia	6,024,577	22,179,830	17,150	16,560	351	1,339
Wisconsin	10,949,155	12,828,572	96,860	99,380	113	129
Wyoming	6,326,604	19,500,357	7,640	8,110	828	2,404
Puerto Rico	1,458,790	2,326,241	23,850	NA	61	NA

NA = not available

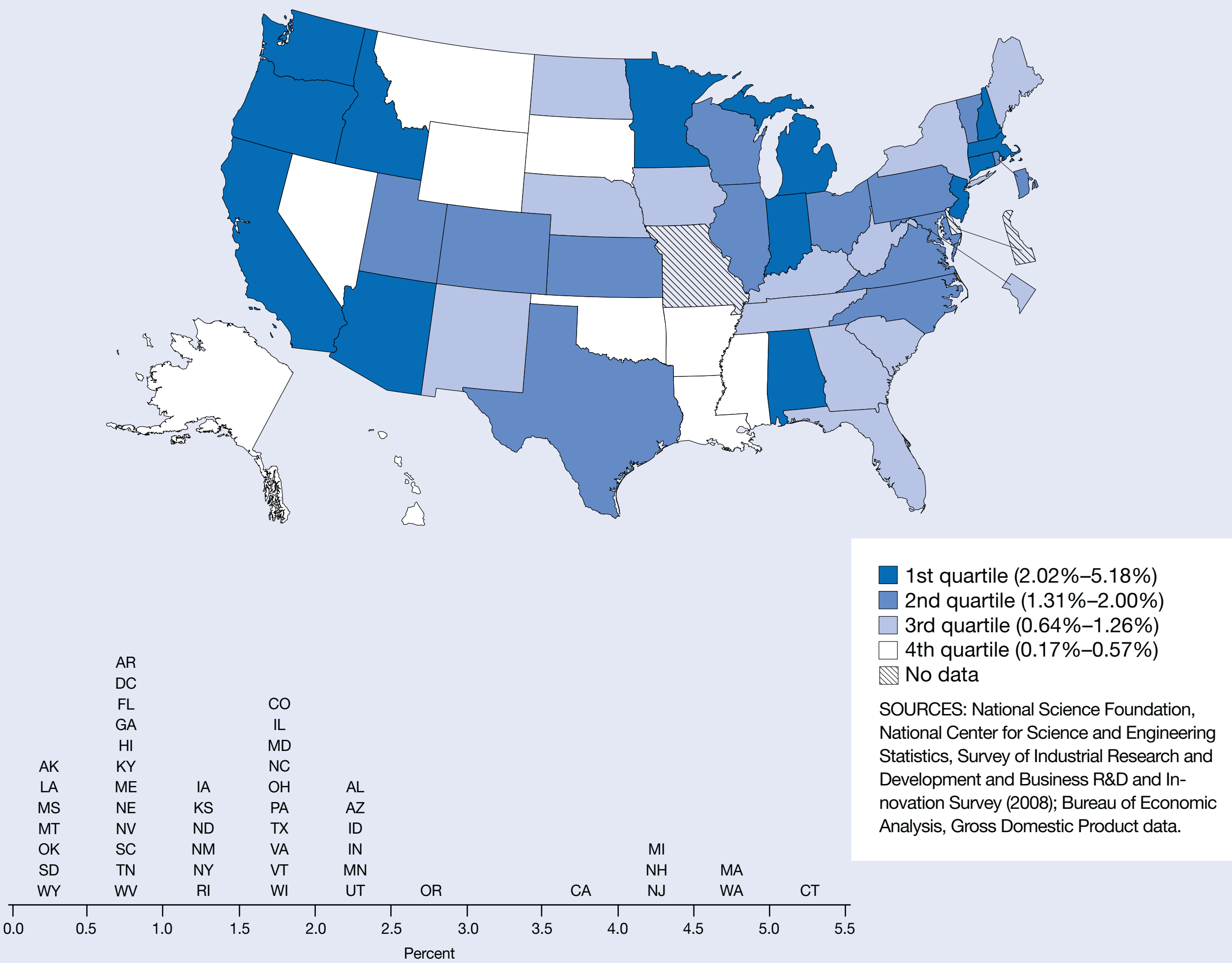
NOTES: R&D expenditures reported in current dollars. National total for S&E occupations in the United States provided by Occupational Employment Statistics (OES) and includes states with suppressed data. OES estimates for 2006 and 2007 S&E occupations based on May data.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Survey of State Research and Development Expenditures (FY 2006, FY 2007); Bureau of Labor Statistics, Occupational Employment and Wage Estimates.

Science and Engineering Indicators 2012

Business-Performed R&D as a Percentage of Private-Industry Output

Figure 8-45
Business-performed R&D as a percentage of private-industry output: 2008



SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Industrial Research and Development and Business R&D and Innovation Survey (2008); Bureau of Economic Analysis, Gross Domestic Product data.

Findings

- The amount of R&D performed by business rose from nearly $192 billion in 2000 to about $267 billion in 2008, an increase of 39% (in current dollars).
- The value of this indicator exhibited little overall change between 2000 and 2008.
- Business performed R&D as a share of private industry output varied greatly among states in 2008, ranging from 0.17 to 5.18.
- Business R&D was concentrated in a few states—only 11 states had indicator values that exceeded the national average in 2008.

This indicator represents the role of R&D in a state's business activity. The business sector is the largest performer of U.S. R&D. It accounts for more than half of all U.S. applied research funding and a significant portion, over 80%, of all development funding. A high value for this indicator indicates that the businesses within a state are making a large investment in their R&D activities.

R&D is geographically concentrated and states vary in the type of research performed. The indicator reflects state differences in industrial structure as well as the behavior or priorities of individual businesses.

Private-industry output is the portion of state gross domestic product contributed by state businesses. Data are presented in current dollars.

Estimates for states with smaller economies are generally less precise than those for states with larger economies.

Table 8-45
Business-performed R&D as a percentage of private-industry output, by state: 2000, 2004, and 2008

State	Business-performed R&D ($millions)			Private-industry output ($millions)			Business-performed R&D/private-industry output (%)		
	2000	2004	2008	2000	2004	2008	2000	2004	2008
United States	192,197	201,131	267,373	8,736,085	10,360,070	12,513,954	2.20	1.94	2.14
Alabama	821 i	1,227	3,099	98,017	120,036	141,959	0.84	1.02	2.18
Alaska	48e	35e	69	20,604	27,762	40,851	0.23	0.13	0.17
Arizona	2,182 i	2,570	5,232	142,165	175,425	226,566	1.53	1.47	2.31
Arkansas	400	287	443	59,543	72,483	85,589	0.67	0.40	0.52
California	45,455	46,614	67,532	1,178,200	1,394,822	1,690,730	3.86	3.34	3.99
Colorado	3,143	4,008	4,019	152,673	176,819	223,771	2.06	2.27	1.80
Connecticut	4,132 i	7,177	10,518	149,857	171,687	202,965	2.76	4.18	5.18
Delaware	1,468 i	1,059	NA	37,496	46,886	53,116	3.92	2.26	NA
District of Columbia	196e	182e	571	38,028	51,268	65,387	0.52	0.35	0.87
Florida	3,773 i	3,486	4,178	422,803	546,699	656,807	0.89	0.64	0.64
Georgia	2,159 i	2,160	3,344	259,656	299,108	350,732	0.83	0.72	0.95
Hawaii	93e	131	269	32,634	40,639	51,153	0.28	0.32	0.53
Idaho	1,363	681	961	31,101	37,741	47,506	4.38	1.80	2.02
Illinois	8,393 i	8,554	8,900	430,158	490,751	575,417	1.95	1.74	1.55
Indiana	2,888 i	4,208	4,991	178,905	209,833	236,860	1.61	2.01	2.11
Iowa	762	963	1,509	82,694	103,266	119,473	0.92	0.93	1.26
Kansas	1,327 i	1,804 i	1,600	74,127	85,461	107,298	1.79	2.11	1.49
Kentucky	762	565	933	97,524	112,663	131,054	0.78	0.50	0.71
Louisiana	364e	311	411	114,856	150,660	191,186	0.32	0.21	0.21
Maine	255	213	308	31,480	38,279	42,842	0.81	0.56	0.72
Maryland	2,213	3,826	4,333	151,696	192,127	231,981	1.46	1.99	1.87
Massachusetts	10,857	11,819	15,028	249,074	283,069	332,816	4.36	4.18	4.52
Michigan	17,489 i	15,170	13,742	302,201	325,281	330,225	5.79	4.66	4.16
Minnesota	3,971	5,199	5,728	169,289	204,355	235,450	2.35	2.54	2.43
Mississippi	242e	160	252	54,551	63,966	79,700	0.44	0.25	0.32
Missouri	1,978	2,151	NA	160,270	184,238	211,133	1.23	1.17	NA
Montana	78e	70	148	17,880	23,201	30,161	0.44	0.30	0.49
Nebraska	335e	383	561	49,625	60,247	73,777	0.68	0.64	0.76
Nevada	433	417	677	68,368	90,497	118,834	0.63	0.46	0.57
New Hampshire	722	1,330	2,169	40,297	46,535	52,702	1.79	2.86	4.12
New Jersey	10,580	10,993	19,054	315,519	367,791	431,293	3.35	2.99	4.42
New Mexico	1,203 i	450	735	40,561	51,351	62,598	2.97	0.88	1.17
New York	11,622	8,793	11,455	691,330	795,998	991,767	1.68	1.10	1.16
North Carolina	4,535	4,565	6,246	246,974	284,688	346,083	1.84	1.60	1.80
North Dakota	83e	379 i	303	15,279	19,494	27,627	0.54	1.94	1.10
Ohio	6,245	5,516	7,405	341,648	382,095	417,814	1.83	1.44	1.77
Oklahoma	463	410	595	75,743	93,288	126,536	0.61	0.44	0.47
Oregon	1,533	3,057	4,074	98,912	119,455	153,690	1.55	2.56	2.65
Pennsylvania	8,473	8,005	9,735	357,944	416,222	491,213	2.37	1.92	1.98
Rhode Island	1,167 i	1,320 i	538	29,270	37,672	41,163	3.99	3.50	1.31
South Carolina	1,059	961	1,221	97,797	113,129	131,991	1.08	0.85	0.93
South Dakota	89e	72	133	20,827	26,707	33,859	0.43	0.27	0.39
Tennessee	1,644	1,630	1,608	158,028	190,752	218,374	1.04	0.85	0.74
Texas	10,048	10,992	16,166	651,993	805,767	1,071,943	1.54	1.36	1.51
Utah	1,063	1,089	1,945	59,897	70,844	97,181	1.77	1.54	2.00
Vermont	389	423	422	15,846	19,025	21,161	2.45	2.22	1.99
Virginia	2,683	4,006	6,142	216,942	271,629	329,458	1.24	1.47	1.86
Washington	8,235 i	8,840 i	13,876	197,965	221,032	286,249	4.16	4.00	4.85
West Virginia	329	202	334	34,494	40,074	48,549	0.95	0.50	0.69
Wisconsin	2,415	2,645	3,798	158,975	187,471	213,141	1.52	1.41	1.78
Wyoming	37e	23	63	14,369	19,782	34,223	0.26	0.12	0.18
Puerto Rico	NA	NA	NA	NA	NA	NA	NA	NA	NA

e = estimated, more than 50% of value is imputed due to raking of state data; i = more than 50% of value is imputed; NA = not available

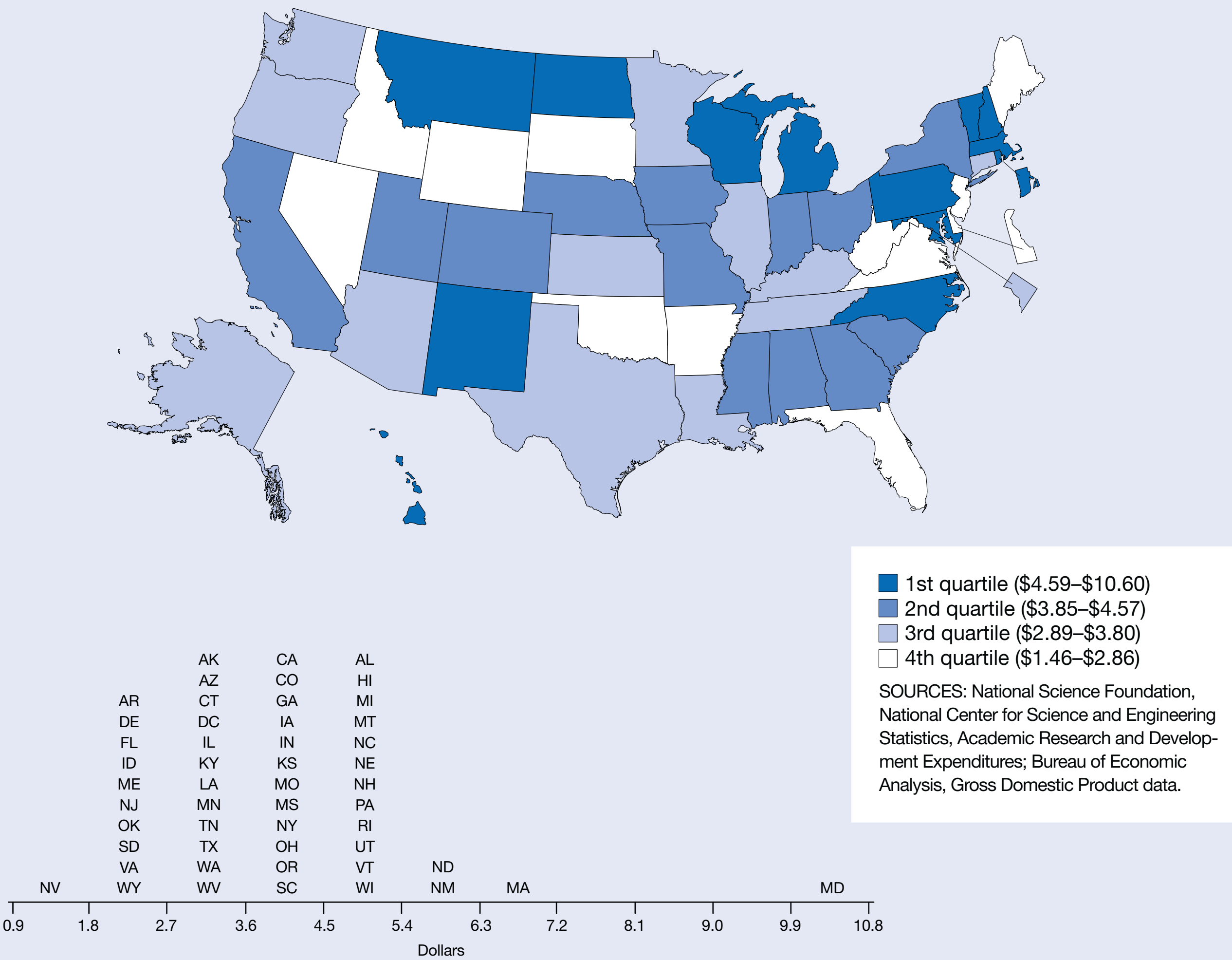
NOTE: R&D expenditures reported in current dollars.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Industrial Research and Development (various years) and Business R&D and Innovation Survey; Bureau of Economic Analysis, Gross Domestic Product data.

Science and Engineering Indicators 2012

Academic Science and Engineering R&D per $1,000 of Gross Domestic Product

Figure 8-46
Academic science and engineering R&D per $1,000 of gross domestic product: 2009



SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Academic Research and Development Expenditures; Bureau of Economic Analysis, Gross Domestic Product data.

Findings

- Expenditures for research performed in academic institutions have almost doubled in a decade, rising from $30.0 billion in 2000 to $54.8 billion in 2009 (in current dollars).
- In the United States, growth in academic research increased more rapidly than gross domestic product (GDP), causing the value of this indicator to increase by 29% between 2000 and 2009. Most of this change occurred between 2000 and 2005.
- In 2009, the value of this indicator ranged from $1.46 to $10.60 across states.
- The largest percentage increase in academic R&D as a share of GDP occurred in South Dakota, an EPSCoR state, where the value of this indicator more than doubled between 2000 and 2009.
- While the average indicator value for both EPSCoR and non-EPSCoR states increased over the period 2000 to 2009, non-EPSCoR states continued to have nearly 6.5 times the amount of spending academic S&E R&D as EPSCoR states.

This indicator represents the ratio of S&E R&D expenditures at a state's colleges and universities to the size of the state's economy. Academic R&D performers account for a little over half of the U.S. basic research, about a third of total research (basic plus applied), and roughly 10% of all R&D conducted in the U.S. Academic R&D can be a valuable basis for future economic development.

Data on academic R&D are provided by the National Center for Science and Engineering Statistics and represent S&E R&D at U.S. colleges and universities with over $150,000 in R&D expenditures.

Data for the value of gross domestic product (GDP) by state and for R&D expenditures are shown in current dollars.

Table 8-46
Academic science and engineering R&D per $1,000 of gross domestic product, by state: 2000, 2005, and 2009

State	Academic S&E R&D ($thousands)			State GDP ($millions)			Academic R&D ($)/ $1,000 GDP		
	2000	2005	2009	2000	2005	2009	2000	2005	2009
EPSCoR states	3,949,767	6,161,002	7,236,610	1,368,845	1,809,030	2,042,476	2.89	3.41	3.54
Non-EPSCoR states	25,784,807	39,205,177	47,239,938	8,457,057	10,662,668	11,873,474	3.05	3.68	3.98
Average EPSCoR state value	na	na	na	na	na	na	2.95	3.66	3.67
Average non-EPSCoR state value	na	na	na	na	na	na	3.25	3.87	4.16
United States	29,980,402	45,669,100	54,802,274	9,884,171	12,554,535	14,014,842	3.03	3.64	3.91
Alabama	428,122	589,860	761,982	116,014	151,096	166,819	3.69	3.90	4.57
Alaska	107,417	153,721	132,554	25,913	37,824	45,861	4.15	4.06	2.89
Arizona	465,777	720,184	873,063	161,901	222,968	249,711	2.88	3.23	3.50
Arkansas	130,894	209,518	239,593	68,146	88,227	98,795	1.92	2.37	2.43
California	4,053,042	6,264,908	7,406,053	1,317,343	1,691,991	1,847,048	3.08	3.70	4.01
Colorado	544,204	825,048	1,058,283	171,930	217,412	250,664	3.17	3.79	4.22
Connecticut	468,435	669,923	752,793	163,943	197,055	227,550	2.86	3.40	3.31
Delaware	78,126	115,751	133,810	40,957	54,749	60,660	1.91	2.11	2.21
District of Columbia	245,828	302,921	325,726	58,269	82,837	98,892	4.22	3.66	3.29
Florida	851,932	1,448,634	1,663,542	481,115	680,277	732,782	1.77	2.13	2.27
Georgia	926,749	1,274,410	1,565,574	294,479	363,154	394,117	3.15	3.51	3.97
Hawaii	161,300	240,247	300,302	41,372	56,869	65,428	3.90	4.22	4.59
Idaho	73,726	119,871	120,721	36,091	48,675	53,661	2.04	2.46	2.25
Illinois	1,170,625	1,771,107	2,113,124	474,444	569,544	631,970	2.47	3.11	3.34
Indiana	509,141	759,622	1,005,216	198,020	239,575	259,894	2.57	3.17	3.87
Iowa	418,263	548,301	562,569	93,287	120,258	136,062	4.48	4.56	4.13
Kansas	258,336	348,751	441,321	85,742	105,164	122,544	3.01	3.32	3.60
Kentucky	274,238	452,265	540,295	113,108	139,336	155,789	2.42	3.25	3.47
Louisiana	399,411	579,476	670,995	131,430	197,163	205,117	3.04	2.94	3.27
Maine	57,753	96,569	128,434	36,395	45,587	50,039	1.59	2.12	2.57
Maryland	1,507,549	2,356,905	3,021,052	182,953	248,139	285,116	8.24	9.50	10.60
Massachusetts	1,485,792	2,079,548	2,463,395	272,680	323,301	360,538	5.45	6.43	6.83
Michigan	995,756	1,456,218	1,742,051	336,786	375,260	369,671	2.96	3.88	4.71
Minnesota	416,411	558,259	757,745	188,449	238,367	258,499	2.21	2.34	2.93
Mississippi	217,064	353,078	416,804	65,615	81,500	94,406	3.31	4.33	4.42
Missouri	614,101	893,013	1,008,901	180,982	216,633	237,955	3.39	4.12	4.24
Montana	99,069	170,791	181,649	21,629	30,088	34,999	4.58	5.68	5.19
Nebraska	208,480	360,148	393,611	57,233	72,504	86,411	3.64	4.97	4.56
Nevada	106,340	178,492	182,016	75,907	114,771	125,037	1.40	1.56	1.46
New Hampshire	150,982	287,472	298,298	44,067	53,653	59,086	3.43	5.36	5.05
New Jersey	567,666	865,641	913,835	349,334	429,985	471,946	1.62	2.01	1.94
New Mexico	246,258	361,466	435,375	50,262	67,776	76,871	4.90	5.33	5.66
New York	2,290,812	3,610,287	4,224,536	770,621	961,941	1,094,104	2.97	3.75	3.86
North Carolina	1,040,017	1,655,844	2,160,505	281,418	354,973	407,032	3.70	4.66	5.31
North Dakota	67,406	149,994	185,708	18,250	24,672	31,626	3.69	6.08	5.87
Ohio	918,500	1,531,614	1,895,074	381,175	444,715	462,015	2.41	3.44	4.10
Oklahoma	252,419	291,697	335,840	91,292	120,662	142,388	2.76	2.42	2.36
Oregon	346,149	536,228	636,594	112,974	143,349	167,481	3.06	3.74	3.80
Pennsylvania	1,549,050	2,367,837	2,722,278	395,811	482,324	546,538	3.91	4.91	4.98
Rhode Island	129,697	199,709	246,322	33,522	44,169	47,470	3.87	4.52	5.19
South Carolina	294,184	487,776	611,539	115,392	141,929	158,786	2.55	3.44	3.85
South Dakota	27,269	67,012	102,299	24,009	31,641	38,255	1.14	2.12	2.67
Tennessee	405,013	726,078	832,991	177,582	224,522	243,849	2.28	3.23	3.42
Texas	2,039,642	3,073,724	3,984,258	732,987	970,997	1,146,647	2.78	3.17	3.47
Utah	308,059	400,276	500,421	69,483	90,748	111,301	4.43	4.41	4.50
Vermont	64,762	117,400	125,023	18,033	22,773	24,625	3.59	5.16	5.08
Virginia	587,718	910,163	1,088,367	261,894	356,852	409,732	2.24	2.55	2.66
Washington	642,934	901,558	1,083,799	227,828	279,405	331,639	2.82	3.23	3.27
West Virginia	73,420	146,489	174,486	41,419	51,964	61,043	1.77	2.82	2.86
Wisconsin	661,470	999,847	1,203,919	177,638	218,923	239,613	3.72	4.57	5.02
Wyoming	43,094	83,449	77,633	17,047	26,238	36,760	2.53	3.18	2.11
Puerto Rico	74,529	100,235	105,330	69,208	86,157	NA	1.08	1.16	NA

na = not applicable; NA = not available

EPSCoR = Experimental Program to Stimulate Competitive Research; GDP = gross domestic product

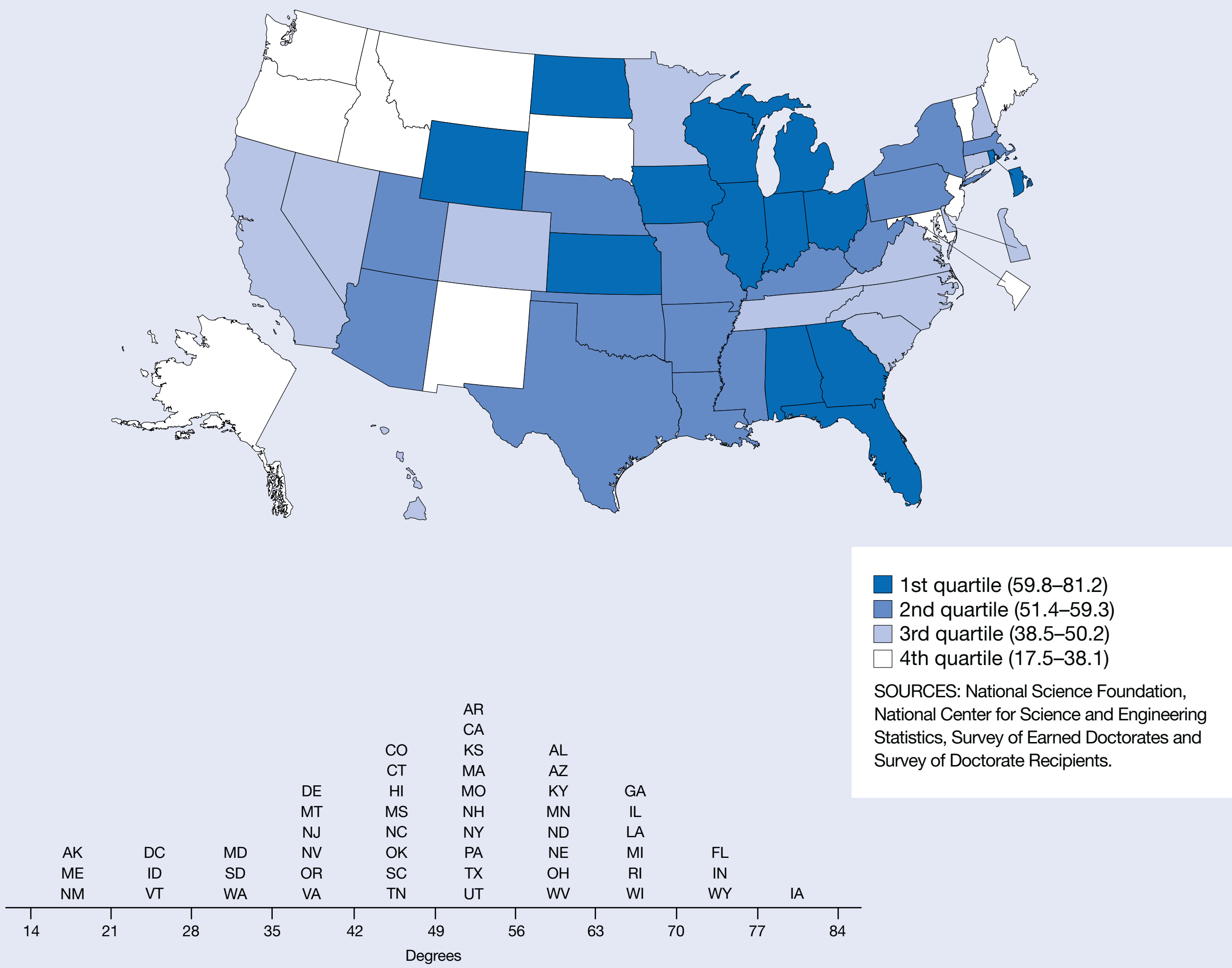
NOTES: Academic R&D reported for institutuons with R&D over $150,000. GDP reported in current dollars. For explanation of EPSCoR and non-EPSCoR averages, see chapter introduction.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Academic Research and Development Expenditures (various years); Bureau of Economic Analysis, Gross Domestic Product data.

Science and Engineering Indicators 2012

Science and Engineering Doctorates Conferred per 1,000 Employed S&E Doctorate Holders

Figure 8-47
Science and engineering doctorates conferred per 1,000 employed S&E doctorate holders: 2008



SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Earned Doctorates and Survey of Doctorate Recipients.

Findings

- In 2008, just over 33,000 S&E doctorates were awarded by U.S. academic institutions, approximately 26% more than in 1997.
- The value of this indicator in 2008 is back to the level it was in 1997 after a decline early in the decade and a slow increase to the current level.
- Low state values on this indicator may indicate either a small S&E graduate-level educational program or a concentration of S&E doctorate-level employment opportunities that attract significant numbers of S&E doctorate holders who were educated elsewhere. Low-ranking EPSCoR states tend to fall into the former category.

This indicator represents the rate at which the states are training new S&E doctorate recipients for entry into the workforce. High values indicate relatively large production of new doctorate holders compared with the existing stock of employed doctorate holders. States with relatively low values may need to attract S&E doctorate holders from elsewhere to meet the needs of local employers.

Data on doctorates conferred and on employed doctorate holders include those with doctoral degrees in computer and mathematical sciences; the biological, agricultural, or environmental life sciences; physical sciences; social sciences; psychology; engineering; and health fields. Both sets of data exclude individuals with doctorates from foreign institutions. The employed doctorate data also excludes those above the age of 75. Data for doctorates conferred are presented by the location where the doctorate was earned; employment data for S&E doctorate holders are presented by employment location regardless of residence. Estimates for states with smaller populations of employed doctorate holders are generally less precise than estimates for states with larger populations.

The indicator does not take into account any postgraduation mobility of recent S&E doctorate recipients to their place of employment. Doctorate recipients with temporary visas may decide to return home after graduation to begin their careers. The indicator also does not cover individuals with non-U.S. S&E doctorates who are working in the United States.

Table 8-47
Science and engineering doctorates conferred per 1,000 employed S&E doctorate holders, by state: 1997, 2003, and 2008

State	S&E doctorates conferred			Employed S&E doctorate holders[a]			S&E doctorates conferred/1,000 employed S&E doctorate holders		
	1997	2003	2008	1997	2003	2008	1997	2003	2008
United States	26,392	25,329	33,145	516,560	590,910	647,800	51.1	42.9	51.2
Alabama	283	293	356	6,610	5,730	6,000	42.8	51.1	59.3
Alaska	15	31	21	1,110	1,140	1,200	13.5	27.2	17.5
Arizona	457	417	526	6,280	7,500	8,800	72.8	55.6	59.8
Arkansas	68	74	120	2,320	2,790	2,400	29.3	26.5	50.0
California	3,352	3,768	4,800	70,490	86,550	95,700	47.6	43.5	50.2
Colorado	603	555	589	10,740	12,220	13,100	56.1	45.4	45.0
Connecticut	396	402	479	8,770	9,780	10,600	45.2	41.1	45.2
Delaware	117	84	128	3,710	3,000	3,300	31.5	28.0	38.8
District of Columbia	318	345	352	11,800	13,800	13,100	26.9	25.0	26.9
Florida	768	943	1,387	13,330	16,000	18,600	57.6	58.9	74.6
Georgia	519	632	929	9,880	12,220	13,500	52.5	51.7	68.8
Hawaii	139	105	152	2,550	3,040	3,200	54.5	34.5	47.5
Idaho	58	69	78	2,030	2,450	2,800	28.6	28.2	27.9
Illinois	1,499	1,373	1,690	21,260	22,400	24,200	70.5	61.3	69.8
Indiana	638	622	755	7,570	9,590	10,300	84.3	64.9	73.3
Iowa	357	274	422	4,120	4,660	5,200	86.7	58.8	81.2
Kansas	246	244	240	3,770	4,060	4,300	65.3	60.1	55.8
Kentucky	194	191	281	4,110	4,720	4,800	47.2	40.5	58.5
Louisiana	307	263	333	5,360	5,420	5,200	57.3	48.5	64.0
Maine	42	33	43	2,150	2,110	2,300	19.5	15.6	18.7
Maryland	620	578	840	21,020	25,280	28,100	29.5	22.9	29.9
Massachusetts	1,490	1,345	1,891	23,330	30,220	35,000	63.9	44.5	54.0
Michigan	951	943	1,099	15,050	17,130	16,700	63.2	55.0	65.8
Minnesota	504	474	739	9,810	11,110	12,600	51.4	42.7	58.7
Mississippi	139	130	156	3,000	3,120	3,300	46.3	41.7	47.3
Missouri	430	476	521	9,490	9,080	10,000	45.3	52.4	52.1
Montana	57	52	80	1,690	1,740	2,100	33.7	29.9	38.1
Nebraska	148	164	159	3,010	2,820	2,800	49.2	58.2	56.8
Nevada	58	75	98	1,620	2,070	2,800	35.8	36.2	35.0
New Hampshire	117	122	149	2,230	2,640	2,900	52.5	46.2	51.4
New Jersey	691	607	757	20,440	20,980	21,300	33.8	28.9	35.5
New Mexico	161	136	143	7,480	8,120	7,800	21.5	16.7	18.3
New York	2,445	2,099	2,713	40,080	44,890	49,000	61.0	46.8	55.4
North Carolina	678	681	925	13,730	17,380	20,100	49.4	39.2	46.0
North Dakota	53	64	74	1,350	1,130	1,300	39.3	56.6	56.9
Ohio	1,173	937	1,248	18,700	20,870	20,800	62.7	44.9	60.0
Oklahoma	210	172	208	4,580	4,640	4,500	45.9	37.1	46.2
Oregon	299	274	335	6,210	7,830	8,700	48.1	35.0	38.5
Pennsylvania	1,279	1,248	1,594	23,940	27,820	30,000	53.4	44.9	53.1
Rhode Island	166	147	190	2,450	3,170	2,800	67.8	46.4	67.9
South Carolina	206	191	288	4,780	5,210	6,300	43.1	36.7	45.7
South Dakota	36	32	38	1,060	1,020	1,300	34.0	31.4	29.2
Tennessee	372	320	449	8,520	8,840	10,100	43.7	36.2	44.5
Texas	1,575	1,426	2,166	28,570	33,280	39,900	55.1	42.8	54.3
Utah	253	211	288	4,800	4,240	5,600	52.7	49.8	51.4
Vermont	35	27	50	1,750	1,770	1,800	20.0	15.3	27.8
Virginia	697	636	868	15,250	18,880	21,300	45.7	33.7	40.8
Washington	426	409	553	13,360	15,430	17,700	31.9	26.5	31.2
West Virginia	55	95	121	1,980	1,980	2,000	27.8	48.0	60.5
Wisconsin	631	498	671	8,460	8,390	9,900	74.6	59.4	67.8
Wyoming	61	42	53	860	650	700	70.9	64.6	75.7
Puerto Rico	65	96	214	660	1,710	2,000	98.5	56.1	107.0

[a]Coefficients of variation for estimates of employed S&E doctorate holders provided in appendix table 8-13.

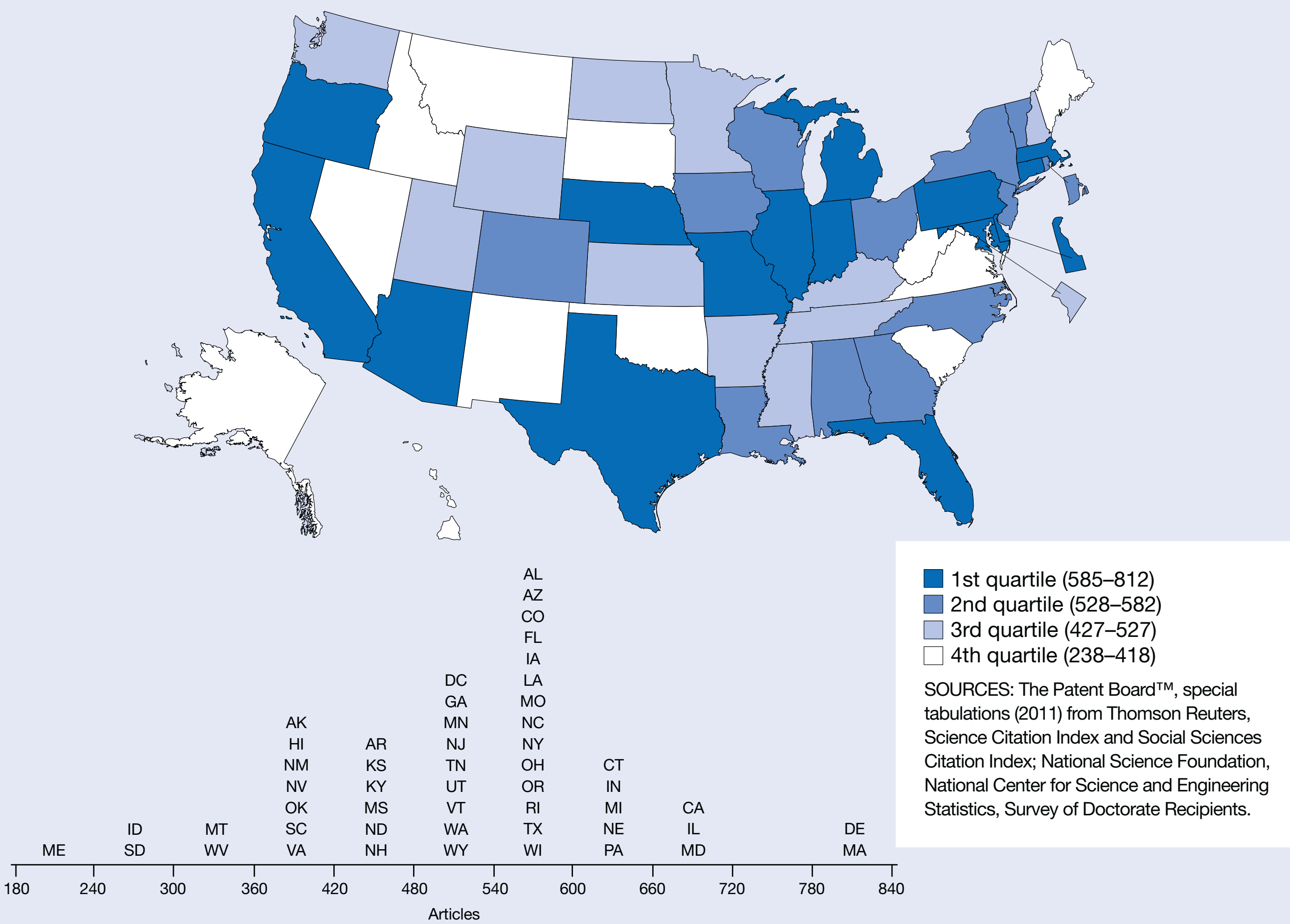
NOTE: Data on U.S. S&E doctorate holders classified by employment location.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Earned Doctorates and Survey of Doctorate Recipients (various years).

Science and Engineering Indicators 2012

Academic Science and Engineering Article Output per 1,000 S&E Doctorate Holders in Academia

Figure 8-48
Academic science and engineering article output per 1,000 S&E doctorate holders in academia: 2008



SOURCES: The Patent Board™, special tabulations (2011) from Thomson Reuters, Science Citation Index and Social Sciences Citation Index; National Science Foundation, National Center for Science and Engineering Statistics, Survey of Doctorate Recipients.

Findings

- Between 1997 and 2008, the number of scientific and engineering articles published by academia increased from 138,000 to 168,000 and the number of S&E doctorate holders in academia increased from 246,000 to 290,000.
- In 2008, the value of this indicator ranged from 238 S&E articles per 1,000 doctorate holders in academia to 812 across the states.
- The publication rate for academic S&E doctorate holders in states in the top quartile of this indicator was nearly twice as high as for states in the bottom quartile.
- The average indicator value for EPSCoR states was considerably lower than the average indicator value for non-EPSCoR states.

The volume of peer-reviewed articles per 1,000 academic S&E doctorate holders is an approximate measure of their contribution to scientific knowledge. Publications are only one measure of academic productivity, which includes trained personnel, patents, trademarks, copyrights, and other outputs. A high value on this indicator shows that the S&E faculty in a state's academic institutions are generating a high volume of publications relative to other states. Academic institutions include 2-year colleges, 4-year colleges and universities, medical schools, and university-affiliated research centers. Research is more central to the mission of some of these institutions than others.

Publication counts are based on the number of articles that appear in a set of journals tracked by Thomson Reuters in the Science Citation Index and Social Sciences Citation Index. Academic article output is based on the most recent journal set; data for earlier years may differ slightly from previous publications due to changes in the journal set. Articles with authors from different institutions were counted fractionally. For instance, for a publication with authors at N institutions, each institution would be credited with 1/N of the article.

S&E doctorates include those in computer sciences; mathematics; the biological, agricultural, or environmental life sciences; physical sciences; social sciences; psychology; engineering; and health fields. S&E doctorate data are estimates and exclude those with doctorates from foreign institutions and those above the age of 75. Estimates for states with smaller populations of S&E doctorate holders are generally less precise than estimates for states with larger populations. Data for S&E doctorate holders in academia are presented by employment location regardless of residence.

Table 8-48
Academic science and engineering article output per 1,000 S&E doctorate holders in academia, by state: 1997, 2003, and 2008

State	Academic S&E article output 1997	Academic S&E article output 2003	Academic S&E article output 2008	S&E doctorate holders in academia[a] 1997	S&E doctorate holders in academia[a] 2003	S&E doctorate holders in academia[a] 2008	Academic articles/ 1,000 academic doctorate holders 1997	Academic articles/ 1,000 academic doctorate holders 2003	Academic articles/ 1,000 academic doctorate holders 2008
EPSCoR states	16,096	17,479	19,506	41,750	42,890	43,300	386	408	450
Non-EPSCoR states	120,251	129,972	146,975	201,710	232,390	244,100	596	559	602
Average EPSCoR state value	na	na	na	na	na	na	372	394	445
Average non-EPSCoR state value	na	na	na	na	na	na	585	546	583
United States	137,597	148,722	167,852	245,670	277,970	289,500	560	535	580
Alabama	1,838	1,851	1,974	4,640	3,240	3,500	396	571	564
Alaska	160	195	285	450	600	700	356	325	407
Arizona	2,133	2,152	2,455	3,050	3,660	4,200	699	588	585
Arkansas	575	664	716	1,520	1,850	1,500	379	359	477
California	16,862	18,744	21,001	26,050	29,830	30,500	647	628	689
Colorado	2,408	2,615	2,855	4,550	5,320	5,200	529	492	549
Connecticut	2,692	2,748	3,070	4,000	4,490	5,100	673	612	602
Delaware	476	580	650	750	800	800	635	725	812
District of Columbia	1,083	1,061	1,106	2,210	2,690	2,100	490	394	527
Florida	3,976	4,551	5,678	6,850	8,710	9,700	580	523	585
Georgia	3,076	3,640	4,299	5,780	7,240	8,100	532	503	531
Hawaii	531	572	697	1,380	1,910	1,900	385	299	367
Idaho	287	305	360	780	1,190	1,400	368	257	257
Illinois	6,469	6,959	7,662	10,620	10,930	11,500	609	637	666
Indiana	2,862	3,022	3,645	4,680	5,810	5,900	612	520	618
Iowa	2,130	2,220	2,232	3,100	3,390	3,900	687	655	572
Kansas	1,134	1,235	1,292	2,260	2,380	2,700	502	519	478
Kentucky	1,320	1,434	1,604	3,040	3,320	3,400	434	432	472
Louisiana	1,810	1,759	1,753	3,580	3,570	3,100	506	493	565
Maine	238	267	285	1,340	1,150	1,200	178	233	238
Maryland	4,259	4,946	5,453	6,400	7,060	8,200	666	700	665
Massachusetts	8,762	9,445	10,834	11,810	14,630	13,800	742	646	785
Michigan	4,620	5,071	5,804	7,850	9,050	9,000	589	560	645
Minnesota	2,300	2,287	2,634	4,490	5,600	5,400	512	408	488
Mississippi	583	710	840	1,940	2,060	1,900	301	345	442
Missouri	3,032	3,122	3,443	5,770	5,770	5,800	526	541	594
Montana	256	363	396	1,020	1,090	1,200	251	333	330
Nebraska	983	991	1,115	2,360	1,880	1,800	417	527	619
Nevada	352	458	571	980	1,260	1,500	359	364	381
New Hampshire	579	627	683	1,130	1,360	1,600	512	461	427
New Jersey	2,952	3,150	3,326	5,290	6,160	6,300	558	511	528
New Mexico	782	792	835	2,450	2,960	2,300	319	268	363
New York	11,781	12,179	13,378	20,900	22,360	23,100	564	545	579
North Carolina	4,762	5,321	6,170	7,740	9,650	10,600	615	551	582
North Dakota	262	315	411	900	740	900	292	426	457
Ohio	4,900	5,088	5,635	9,750	10,620	9,900	503	479	569
Oklahoma	853	933	1,081	2,680	2,900	3,000	318	322	360
Oregon	1,550	1,648	1,972	2,690	3,690	3,300	576	447	598
Pennsylvania	7,756	8,260	9,419	12,150	15,650	15,200	638	528	620
Rhode Island	828	871	1,020	1,730	2,180	1,800	479	399	567
South Carolina	1,155	1,428	1,587	3,230	3,000	3,800	358	476	418
South Dakota	136	165	202	700	670	700	194	246	289
Tennessee	2,123	2,310	2,826	4,720	5,210	5,500	450	443	514
Texas	8,415	9,423	10,755	13,760	15,240	18,400	612	618	585
Utah	1,492	1,538	1,786	3,080	2,770	3,400	485	555	525
Vermont	369	383	475	1,140	1,100	900	324	349	528
Virginia	2,822	2,991	3,593	5,830	7,630	8,800	484	392	408
Washington	3,091	3,412	3,605	5,410	6,740	7,300	571	506	494
West Virginia	400	375	417	1,190	1,190	1,200	336	315	348
Wisconsin	3,025	3,129	3,445	5,390	5,180	6,000	561	604	574
Wyoming	189	204	255	560	490	500	337	417	510
Puerto Rico	167	212	265	640	1,360	1,300	261	156	204

na = not applicable

EPSCoR = Experimental Program to Stimulate Competitive Research

[a]Coefficients of variation for estimates of S&E doctorate holders in academia presented in appendix table 8-14.

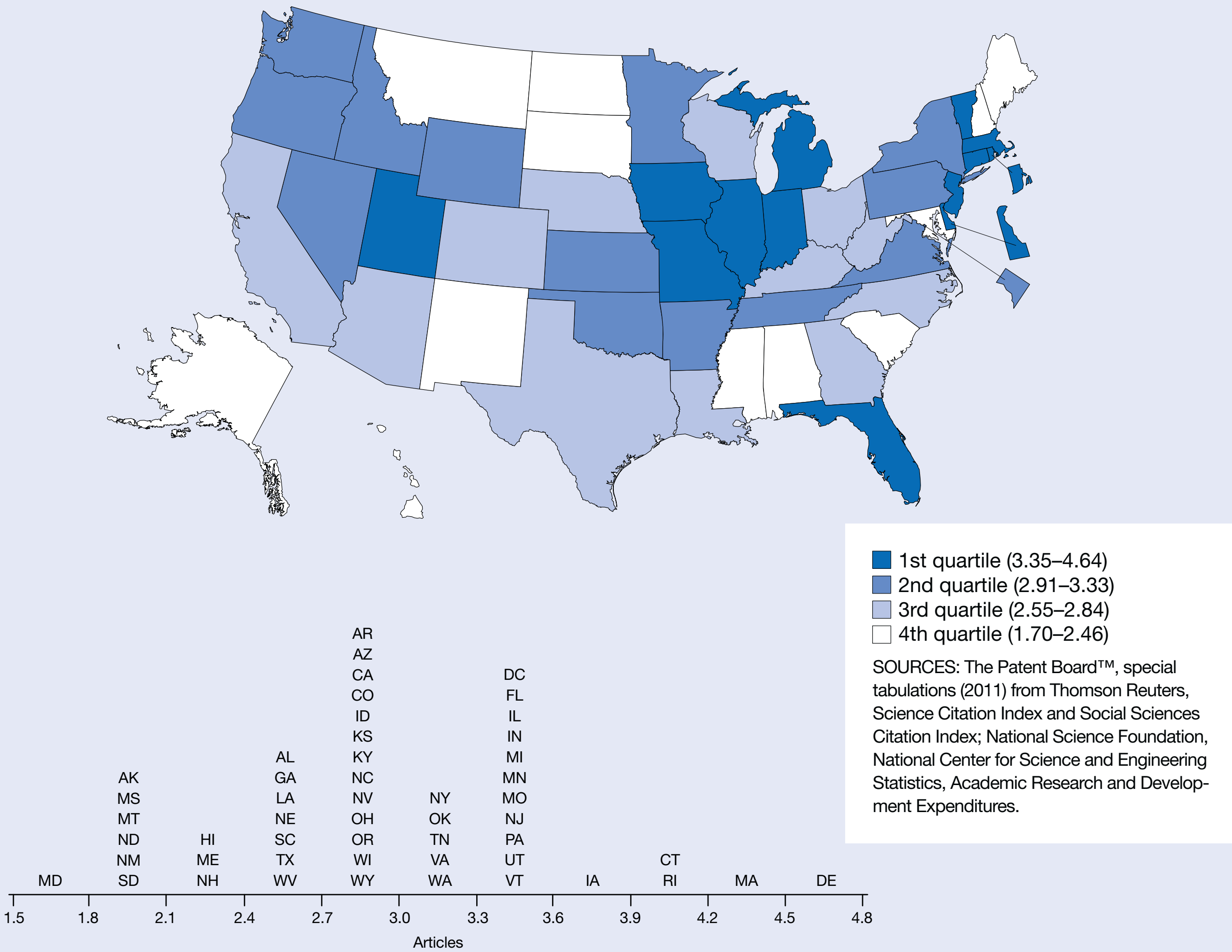
NOTE: For explanation of EPSCoR and non-EPSCoR averages, see chapter introduction.

SOURCES: The Patent Board™, special tabulations (2011) from Thomson Reuters, Science Citation Index and Social Sciences Citation Index, http://thomsonreuters.com/products_services/science/; National Science Foundation, National Center for Science and Engineering Statistics, Survey of Doctorate Recipients.

Science and Engineering Indicators 2012

Academic Science and Engineering Article Output per $1 Million of Academic S&E R&D

Figure 8-49
Academic science and engineering article output per $1 million of academic S&E R&D: 2009



SOURCES: The Patent Board™, special tabulations (2011) from Thomson Reuters, Science Citation Index and Social Sciences Citation Index; National Science Foundation, National Center for Science and Engineering Statistics, Academic Research and Development Expenditures.

Findings

- From 2000 to 2009, the number of academic S&E publications rose from about 137,000 to about 163,000—an increase of 19% that may reflect both an increase in publications and an increase in the size of the journal set.
- In 2009, academic researchers produced an average of 3.0 publications per $1 million of academic R&D, compared with 4.6 in 2000. This partly reflects the effect of general price inflation but may also indicate rising academic research costs.
- The value of this indicator ranged from 1.70 to 4.64 across the states in 2009.
- Between 2000 and 2009, the value for this indicator decreased in all states except Alaska and by 35% nationwide.

This indicator represents the relationship between the number of academic S&E publications and the amount of money expended for academic R&D. Academic institutions include 2-year colleges, 4-year colleges or universities, medical schools, and university-affiliated research centers. This indicator is not an efficiency measure; it is affected by the highly variable costs of R&D and by publishing conventions in different fields and institutions. It may also reflect variations in field emphasis among states and institutions.

Publication counts are based on the number of articles that appear in a set of journals tracked by Thomson Reuters in the Science Citation Index and Social Sciences Citation Index. Academic article output is based on the most recent journal set; data for earlier years may differ slightly from previous publications due to changes in the journal set. Articles with authors from different institutions were counted fractionally. For instance, for a publication with authors at *N* institutions, each institution would be credited with 1/*N* of the article.

Table 8-49
Academic science and engineering article output per $1 million of academic S&E R&D, by state: 2000, 2004, and 2009

State	Academic S&E article output			Academic S&E R&D ($millions)			Academic articles/ $1 million academic R&D		
	2000	2004	2009	2000	2004	2009	2000	2004	2009
United States	137,088	142,535	162,969	29,980	43,143	54,802	4.57	3.30	2.97
Alabama	1,714	1,760	1,833	428	572	762	4.00	3.08	2.41
Alaska	167	180	256	107	146	133	1.55	1.23	1.93
Arizona	2,059	2,092	2,478	466	651	873	4.42	3.21	2.84
Arkansas	543	626	710	131	183	240	4.15	3.42	2.96
California	16,962	17,873	20,722	4,053	6,013	7,406	4.19	2.97	2.80
Colorado	2,381	2,360	2,900	544	771	1,058	4.38	3.06	2.74
Connecticut	2,659	2,718	3,006	468	649	753	5.68	4.19	3.99
Delaware	492	560	621	78	115	134	6.29	4.87	4.64
District of Columbia	1,074	999	1,083	246	303	326	4.37	3.30	3.32
Florida	4,029	4,503	5,604	852	1,307	1,664	4.73	3.45	3.37
Georgia	3,072	3,570	4,210	927	1,222	1,566	3.31	2.92	2.69
Hawaii	528	538	680	161	241	300	3.27	2.23	2.27
Idaho	265	304	351	74	117	121	3.59	2.60	2.91
Illinois	6,466	6,682	7,513	1,171	1,713	2,113	5.52	3.90	3.56
Indiana	2,871	2,854	3,507	509	841	1,005	5.64	3.39	3.49
Iowa	2,094	2,033	2,109	418	532	563	5.01	3.82	3.75
Kansas	1,219	1,118	1,283	258	333	441	4.72	3.36	2.91
Kentucky	1,282	1,356	1,500	274	424	540	4.67	3.20	2.78
Louisiana	1,716	1,689	1,718	399	559	671	4.30	3.02	2.56
Maine	255	251	287	58	99	128	4.41	2.53	2.24
Maryland	4,457	4,728	5,127	1,508	2,268	3,021	2.96	2.08	1.70
Massachusetts	8,957	9,249	10,490	1,486	2,000	2,463	6.03	4.62	4.26
Michigan	4,609	4,870	5,888	996	1,397	1,742	4.63	3.49	3.38
Minnesota	2,147	2,238	2,519	416	535	758	5.16	4.18	3.32
Mississippi	614	689	859	217	348	417	2.83	1.98	2.06
Missouri	2,933	2,940	3,376	614	842	1,009	4.78	3.49	3.35
Montana	295	323	380	99	155	182	2.98	2.08	2.09
Nebraska	934	1,035	1,002	208	325	394	4.48	3.19	2.55
Nevada	400	393	536	106	164	182	3.76	2.40	2.95
New Hampshire	558	656	661	151	277	298	3.70	2.37	2.22
New Jersey	2,856	2,860	3,195	568	805	914	5.03	3.55	3.50
New Mexico	765	757	791	246	304	435	3.11	2.49	1.82
New York	11,535	11,820	13,019	2,291	3,352	4,225	5.04	3.53	3.08
North Carolina	4,851	5,133	5,989	1,040	1,447	2,161	4.66	3.55	2.77
North Dakota	236	323	345	67	152	186	3.50	2.13	1.86
Ohio	4,801	4,976	5,364	919	1,320	1,895	5.23	3.77	2.83
Oklahoma	849	897	1,101	252	283	336	3.36	3.17	3.28
Oregon	1,600	1,637	1,860	346	505	637	4.62	3.24	2.92
Pennsylvania	7,649	7,870	9,071	1,549	2,208	2,722	4.94	3.56	3.33
Rhode Island	826	838	982	130	192	246	6.37	4.36	3.99
South Carolina	1,219	1,364	1,507	294	456	612	4.14	2.99	2.46
South Dakota	131	149	207	27	59	102	4.80	2.52	2.02
Tennessee	2,141	2,249	2,717	405	658	833	5.29	3.42	3.26
Texas	8,433	8,924	10,335	2,040	2,879	3,984	4.13	3.10	2.59
Utah	1,491	1,427	1,723	308	407	500	4.84	3.51	3.44
Vermont	390	383	426	65	116	125	6.02	3.30	3.41
Virginia	2,845	2,835	3,439	588	849	1,088	4.84	3.34	3.16
Washington	3,153	3,168	3,386	643	897	1,084	4.90	3.53	3.12
West Virginia	359	352	470	73	135	174	4.89	2.60	2.69
Wisconsin	2,845	2,967	3,318	661	957	1,204	4.30	3.10	2.76
Wyoming	173	202	232	43	60	78	4.01	3.36	2.98
Puerto Rico	191	215	282	75	NA	105	2.56	NA	2.67

NA = not available

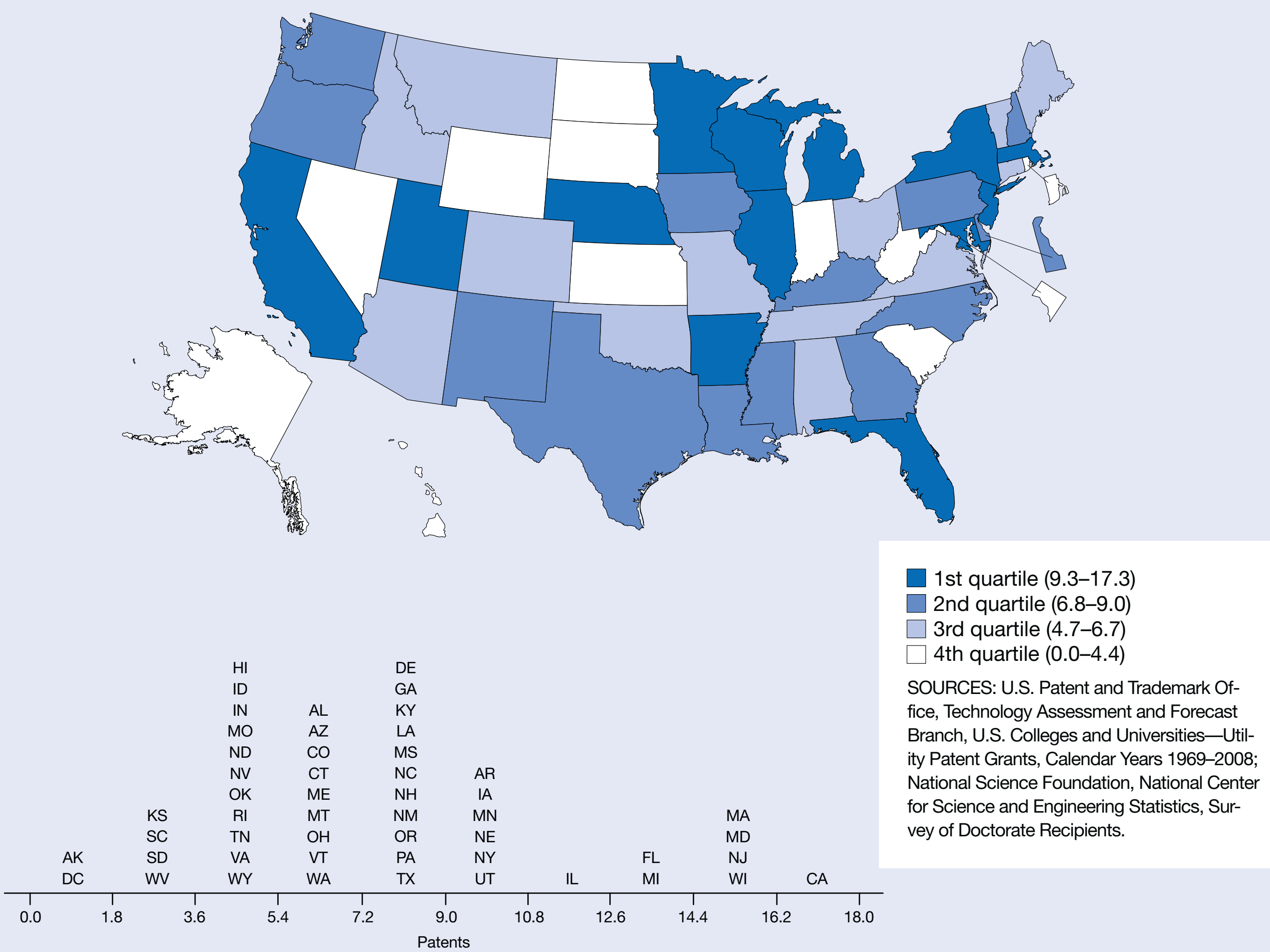
NOTE: Academic R&D expenditures reported in current dollars.

SOURCES: The Patent Board™, special tabulations (2011) from Thomson Reuters, Science Citation Index and Social Sciences Citation Index, http://thomsonreuters.com/products_services/science/; National Science Foundation, National Center for Science and Engineering Statistics, Academic R&D Expenditures.

Science and Engineering Indicators 2012

Academic Patents Awarded per 1,000 Science and Engineering Doctorate Holders in Academia

Figure 8-50
Academic patents awarded per 1,000 science and engineering doctorate holders in academia: 2008



SOURCES: U.S. Patent and Trademark Office, Technology Assessment and Forecast Branch, U.S. Colleges and Universities—Utility Patent Grants, Calendar Years 1969–2008; National Science Foundation, National Center for Science and Engineering Statistics, Survey of Doctorate Recipients.

Findings

- Throughout the United States, the number of patents assigned to academic institutions increased from about 2,400 in 1997 to about 2,800 in 2008, an increase of 15%; the number of academic S&E doctorate holders rose by 18% during the same period.
- In 2008, states varied widely on this indicator, with values ranging from 0 to 17.3 patents per 1,000 S&E doctorate holders employed in academia, possibly indicating a difference in patenting philosophy or the mix of industries with which these academic institutions deal.
- California showed the highest level of both academic patenting and venture capital investment.
- The value of this indicator fluctuates over time and across states.

Since the early 1980s, academic institutions have increasingly been viewed as engines of economic growth. Growing attention has been paid to the role of academic R&D in creating new products, processes, and services. One indicator of such R&D results is the volume of patents assigned to academic institutions. Academic patenting is highly concentrated and partly reflects the resources devoted to institutional patenting offices.

This indicator relates the number of academic-owned utility patents to the size of the doctoral S&E workforce in academia and is one approximate measure of the degree to which results with perceived economic value are generated by the doctoral academic workforce. Academia includes 2-year colleges, 4-year colleges and universities, medical schools, and university-affiliated research centers. Utility patents, commonly known as patents for inventions, include any new, useful, or improved method, process, machine, device, manufactured item, or chemical compound, and represent a key measure of intellectual property. Changes in the number of patents assigned to academic institutions may occur for a given year when the assignee is changed or when the list of approved academic institutions is modified, as occurred in 2005.

S&E doctorates include those in computer sciences; mathematics; biological, agricultural, or environmental life sciences; physical sciences; social sciences; psychology; engineering; and health fields. S&E doctorate data exclude those with doctorates from foreign institutions and those above the age of 75. For states with smaller populations, estimates of doctorate holders in academia are generally less precise than estimates for states with larger populations. Data for S&E doctorate holders are presented by employment location regardless of residence.

Table 8-50
Academic patents awarded per 1,000 science and engineering doctorate holders in academia, by state: 1997, 2003, and 2008

State	Patents awarded to academic institutions			S&E doctorate holders in academia[a]			Academic patents/1,000 academic S&E doctorate holders		
	1997	2003	2008	1997	2003	2008	1997	2003	2008
United States	2,443	3,256	2,818	245,670	277,970	289,500	9.9	11.7	9.7
Alabama	23	41	19	4,640	3,240	3,500	5.0	12.7	5.4
Alaska	2	3	0	450	600	700	4.4	5.0	0.0
Arizona	22	22	25	3,050	3,660	4,200	7.2	6.0	6.0
Arkansas	8	24	14	1,520	1,850	1,500	5.3	13.0	9.3
California	428	664	527	26,050	29,830	30,500	16.4	22.3	17.3
Colorado	37	32	32	4,550	5,320	5,200	8.1	6.0	6.2
Connecticut	37	44	28	4,000	4,490	5,100	9.3	9.8	5.5
Delaware	5	7	7	750	800	800	6.7	8.8	8.8
District of Columbia	4	3	2	2,210	2,690	2,100	1.8	1.1	1.0
Florida	91	130	129	6,850	8,710	9,700	13.3	14.9	13.3
Georgia	49	76	68	5,780	7,240	8,100	8.5	10.5	8.4
Hawaii	6	7	7	1,380	1,910	1,900	4.3	3.7	3.7
Idaho	8	7	7	780	1,190	1,400	10.3	5.9	5.0
Illinois	79	105	131	10,620	10,930	11,500	7.4	9.6	11.4
Indiana	39	23	22	4,680	5,810	5,900	8.3	4.0	3.7
Iowa	44	56	35	3,100	3,390	3,900	14.2	16.5	9.0
Kansas	7	20	8	2,260	2,380	2,700	3.1	8.4	3.0
Kentucky	15	21	25	3,040	3,320	3,400	4.9	6.3	7.4
Louisiana	25	29	24	3,580	3,570	3,100	7.0	8.1	7.7
Maine	1	4	7	1,340	1,150	1,200	0.7	3.5	5.8
Maryland	71	128	119	6,400	7,060	8,200	11.1	18.1	14.5
Massachusetts	177	208	222	11,810	14,630	13,800	15.0	14.2	16.1
Michigan	97	115	122	7,850	9,050	9,000	12.4	12.7	13.6
Minnesota	50	68	55	4,490	5,600	5,400	11.1	12.1	10.2
Mississippi	6	11	17	1,940	2,060	1,900	3.1	5.3	8.9
Missouri	37	41	27	5,770	5,770	5,800	6.4	7.1	4.7
Montana	4	4	7	1,020	1,090	1,200	3.9	3.7	5.8
Nebraska	28	17	17	2,360	1,880	1,800	11.9	9.0	9.4
Nevada	2	9	6	980	1,260	1,500	2.0	7.1	4.0
New Hampshire	7	11	14	1,130	1,360	1,600	6.2	8.1	8.8
New Jersey	71	118	99	5,290	6,160	6,300	13.4	19.2	15.7
New Mexico	46	90	18	2,450	2,960	2,300	18.8	30.4	7.8
New York	204	236	217	20,900	22,360	23,100	9.8	10.6	9.4
North Carolina	97	121	94	7,740	9,650	10,600	12.5	12.5	8.9
North Dakota	3	4	4	900	740	900	3.3	5.4	4.4
Ohio	70	85	58	9,750	10,620	9,900	7.2	8.0	5.9
Oklahoma	17	14	14	2,680	2,900	3,000	6.3	4.8	4.7
Oregon	18	19	25	2,690	3,690	3,300	6.7	5.1	7.6
Pennsylvania	131	161	131	12,150	15,650	15,200	10.8	10.3	8.6
Rhode Island	10	7	7	1,730	2,180	1,800	5.8	3.2	3.9
South Carolina	14	23	13	3,230	3,000	3,800	4.3	7.7	3.4
South Dakota	1	0	2	700	670	700	1.4	0.0	2.9
Tennessee	28	42	26	4,720	5,210	5,500	5.9	8.1	4.7
Texas	123	166	155	13,760	15,240	18,400	8.9	10.9	8.4
Utah	39	25	32	3,080	2,770	3,400	12.7	9.0	9.4
Vermont	2	7	6	1,140	1,100	900	1.8	6.4	6.7
Virginia	55	62	46	5,830	7,630	8,800	9.4	8.1	5.2
Washington	39	52	50	5,410	6,740	7,300	7.2	7.7	6.8
West Virginia	2	11	3	1,190	1,190	1,200	1.7	9.2	2.5
Wisconsin	59	80	93	5,390	5,180	6,000	10.9	15.4	15.5
Wyoming	5	3	2	560	490	500	8.9	6.1	4.0
Puerto Rico	0	5	2	640	1,360	1,300	0.0	3.7	1.5

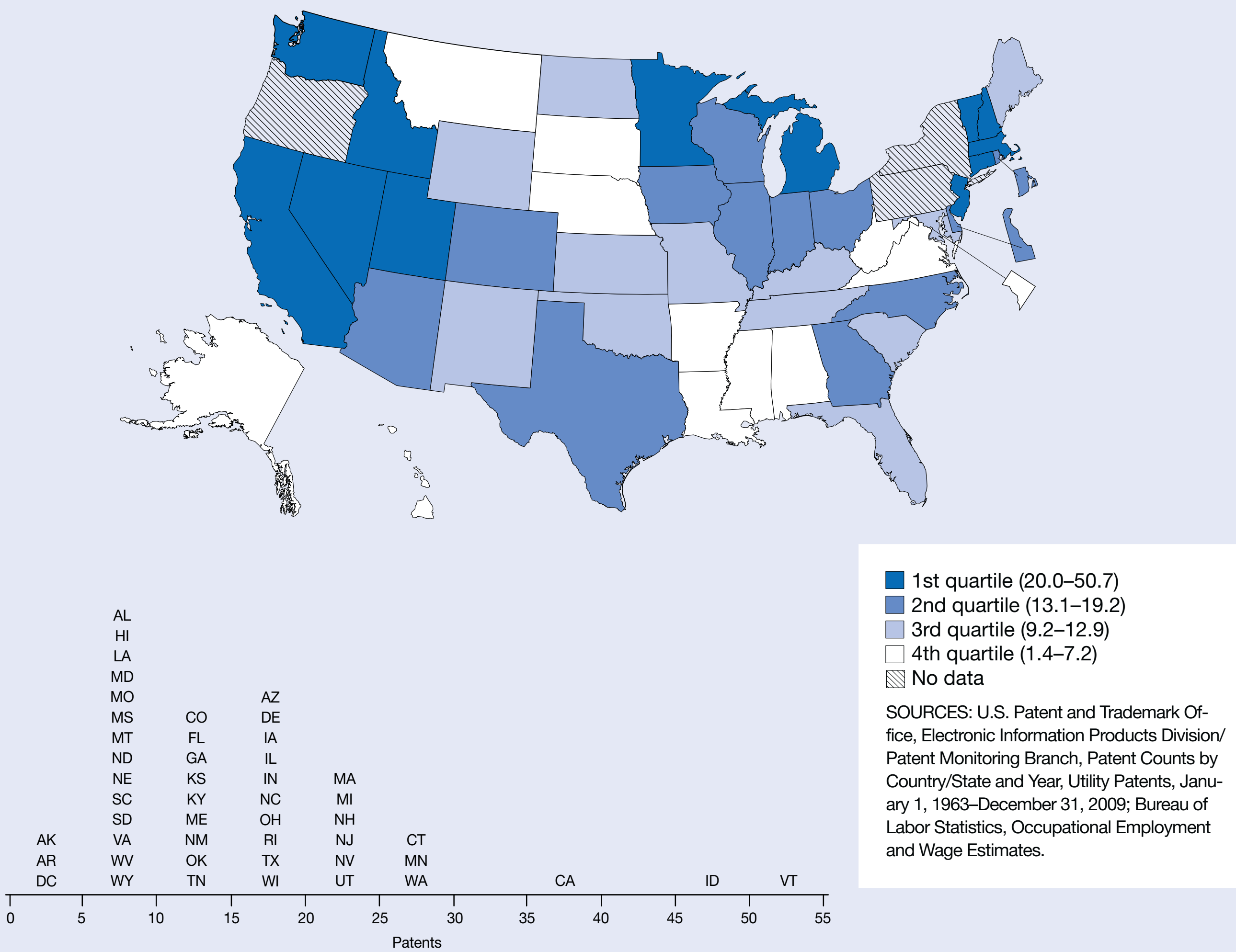
[a]Coefficients of variation for estimates of S&E doctorate holders in academia presented in appendix table 8-14.

SOURCES: U.S. Patent and Trademark Office, Technology Assessment and Forecast Branch, special tabulations of U.S. Colleges and Universities—Utility Patent Grants, Calendar Years 1969–2008; National Science Foundation, National Center for Science and Engineering Statistics, Survey of Doctorate Recipients (various years).

Science and Engineering Indicators 2012

Patents Awarded per 1,000 Individuals in Science and Engineering Occupations

Figure 8-51
Patents awarded per 1,000 individuals in science and engineering occupations: 2010



SOURCES: U.S. Patent and Trademark Office, Electronic Information Products Division/Patent Monitoring Branch, Patent Counts by Country/State and Year, Utility Patents, January 1, 1963–December 31, 2009; Bureau of Labor Statistics, Occupational Employment and Wage Estimates.

Findings

- About 108,000 utility patents were awarded to inventors residing in the United States in 2010, an increase from the 88,000 utility patents awarded in 2003.
- In 2010, the national average for this indicator was 19.4 patents per 1,000 individuals in an S&E occupation, higher than the average of 17.7 in 2003. Values for individual states varied widely, ranging from 1.8 to 50.7 patents per 1,000 individuals in S&E occupations in 2010.
- More than 25% of all 2010 U.S. utility patents were awarded to residents of California. Texas and New York were each awarded over 7,000 utility patents in 2010, representing nearly 14% of the total.

This indicator represents state patent activity normalized to the size of its S&E workforce, specifically employees in S&E occupations. People in S&E occupations include engineers and computer, mathematical, life, physical, and social scientists. Managers, technicians, elementary and secondary schoolteachers, and medical personnel are not included.

Although the U.S. Patent and Trademark Office (USPTO) grants several types of patents, this indicator covers only utility patents, commonly known as patents for inventions. Utility patents can be granted for any new, useful, or improved method, process, machine, device, manufactured item, or chemical compound and represent a key measure of intellectual property. USPTO classifies patents geographically according to the residence of the first-named inventor. Only U.S.-origin patents are included.

Data on individuals in S&E occupations come from a survey of workplaces that assigns workers to a state based on where they work. Estimates do not include self-employed persons and are developed by the Bureau of Labor Statistics.

Situations in which workers live in one state and work in another introduce some imprecision into the calculation of this indicator. The treatment of postsecondary teachers is another source of imprecision. Due to the way the data are collected, faculty teaching in S&E fields are not included as workers in S&E occupations. Estimates for states with smaller populations are generally less precise than estimates for states with larger populations.

Table 8-51
Patents awarded per 1,000 individuals in science and engineering occupations, by state: 2003, 2006, and 2010

State	Patents awarded			Individuals in S&E occupations			Patents/1,000 individuals in S&E occupations		
	2003	2006	2010	2003	2006	2010	2003	2006	2010
United States	87,864	89,795	107,765	4,961,550	5,407,710	5,549,980	17.7	16.6	19.4
Alabama	397	357	444	56,380	66,100	68,450	7.0	5.4	6.5
Alaska	37	36	28	10,600	10,720	15,430	3.5	3.4	1.8
Arizona	1,584	1,705	1,976	92,120	98,110	102,870	17.2	17.4	19.2
Arkansas	152	138	144	21,340	24,860	29,200	7.1	5.6	4.9
California	19,688	22,275	27,337	676,180	730,010	758,830	29.1	30.5	36.0
Colorado	2,069	2,118	2,135	124,140	133,730	143,210	16.7	15.8	14.9
Connecticut	1,667	1,652	1,875	81,380	79,380	74,990	20.5	20.8	25.0
Delaware	346	357	367	17,370	21,550	20,920	19.9	16.6	17.5
District of Columbia	49	63	82	54,890	64,120	59,870	0.9	1.0	1.4
Florida	2,563	2,600	2,978	221,070	246,190	239,600	11.6	10.6	12.4
Georgia	1,333	1,487	1,905	144,170	136,470	145,220	9.2	10.9	13.1
Hawaii	75	84	121	16,090	18,940	19,500	4.7	4.4	6.2
Idaho	1,803	1,663	1,095	22,150	NA	24,130	81.4	NA	45.4
Illinois	3,296	3,294	3,611	211,230	222,470	197,120	15.6	14.8	18.3
Indiana	1,385	1,165	1,492	78,410	80,110	90,710	17.7	14.5	16.4
Iowa	665	666	763	37,320	43,670	44,140	17.8	15.3	17.3
Kansas	428	492	615	51,970	48,620	48,970	8.2	10.1	12.6
Kentucky	439	413	536	45,230	44,680	48,790	9.7	9.2	11.0
Louisiana	390	321	304	41,900	40,180	44,200	9.3	8.0	6.9
Maine	150	142	211	15,020	15,950	17,470	10.0	8.9	12.1
Maryland	1,453	1,410	1,578	149,250	159,470	166,700	9.7	8.8	9.5
Massachusetts	3,908	4,011	4,923	184,690	198,670	208,160	21.2	20.2	23.7
Michigan	3,857	3,758	3,823	182,940	208,520	176,570	21.1	18.0	21.7
Minnesota	2,953	2,957	3,597	117,120	125,930	125,100	25.2	23.5	28.8
Mississippi	162	119	145	22,190	24,910	23,770	7.3	4.8	6.1
Missouri	823	721	975	84,150	96,420	102,300	9.8	7.5	9.5
Montana	121	121	105	11,450	13,010	14,620	10.6	9.3	7.2
Nebraska	185	186	214	30,710	32,500	30,930	6.0	5.7	6.9
Nevada	389	386	540	22,330	26,930	26,840	17.4	14.3	20.1
New Hampshire	677	602	725	23,430	27,680	29,200	28.9	21.7	24.8
New Jersey	3,522	3,172	3,874	161,420	176,460	185,360	21.8	18.0	20.9
New Mexico	390	344	434	33,600	30,800	36,130	11.6	11.2	12.0
New York	6,234	5,627	7,082	272,440	306,810	NA	22.9	18.3	NA
North Carolina	1,871	1,974	2,636	132,440	138,790	155,030	14.1	14.2	17.0
North Dakota	55	66	107	8,430	9,360	11,050	6.5	7.1	9.7
Ohio	3,183	2,630	3,230	177,100	185,190	195,840	18.0	14.2	16.5
Oklahoma	516	544	516	44,360	50,770	44,190	11.6	10.7	11.7
Oregon	1,665	2,060	2,040	61,230	64,520	NA	27.2	31.9	NA
Pennsylvania	3,182	2,842	3,351	185,560	214,910	NA	17.1	13.2	NA
Rhode Island	266	269	276	18,740	18,060	18,210	14.2	14.9	15.2
South Carolina	571	577	517	48,740	53,230	56,230	11.7	10.8	9.2
South Dakota	80	74	70	9,150	10,120	11,150	8.7	7.3	6.3
Tennessee	797	669	925	63,680	67,040	71,850	12.5	10.0	12.9
Texas	6,029	6,308	7,545	365,270	408,710	451,390	16.5	15.4	16.7
Utah	638	684	1,017	45,570	49,690	50,830	14.0	13.8	20.0
Vermont	429	437	642	11,420	12,780	12,670	37.6	34.2	50.7
Virginia	1,110	1,094	1,587	209,280	251,720	255,800	5.3	4.3	6.2
Washington	2,285	3,286	5,258	150,230	171,780	186,210	15.2	19.1	28.2
West Virginia	139	103	118	16,220	17,150	17,070	8.6	6.0	6.9
Wisconsin	1,787	1,688	1,814	93,320	96,860	99,240	19.1	17.4	18.3
Wyoming	71	48	82	6,130	7,640	8,260	11.6	6.3	9.9
Puerto Rico	27	25	24	19,940	23,850	20,850	1.4	1.0	1.2

NA = not available

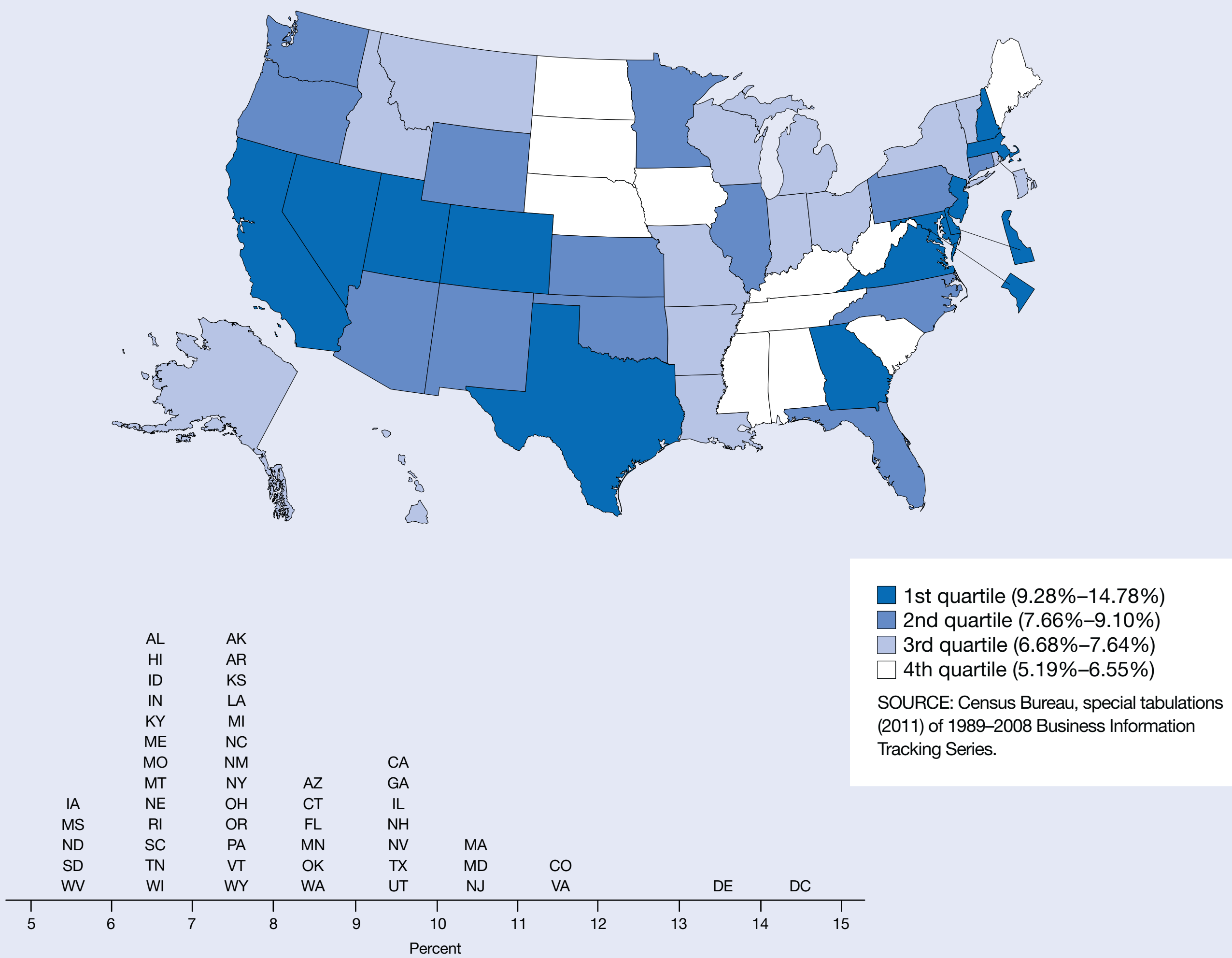
NOTES: Origin of utility patent determined by residence of first-named inventor. National totals for S&E occupations in the United States provided by Occupational Employment Statistics (OES) and include states with suppressed data. OES estimates for 2003, 2006, and 2010 S&E occupations based on May data.

SOURCES: U.S. Patent and Trademark Office, Electronic Information Products Division/Patent Technology Monitoring Branch, Patent Counts by Country/State and Year, Utility Patents, January 1, 1963–December 31, 2009; Bureau of Labor Statistics, Occupational Employment and Wage Estimates.

Science and Engineering Indicators 2012

High-Technology Establishments as a Percentage of All Business Establishments

Figure 8-52
High-technology establishments as a percentage of all business establishments: 2008



SOURCE: Census Bureau, special tabulations (2011) of 1989–2008 Business Information Tracking Series.

Findings

- The number of establishments in high-technology industries rose from about 590,000 in 2003 to more than 646,000 in 2008, an increase of 56,000 or 9%.
- The percentage of U.S. establishments in high-technology industries went from 8.17% to 8.52% of the total business establishments during the 2003–08 period, and most states showed an upward trend in the percentage of their establishments in high-technology industries.
- Between 2003 and 2008, the largest growth in the number of establishments in high-technology industries occurred in California and Florida, which added 8,700 and 6,200 establishments, respectively.
- The state distribution of this indicator is similar to that of three other indicators: bachelor's degree holders, S&E doctoral degree holders, and S&E occupations, all expressed as a share of the workforce.
- EPSCoR states have a lower average value on this indicator than non-EPSCoR states.

This indicator represents the portion of a state's business establishments that are classified as being part of high-technology industries. High-technology industries are defined as those in which the proportion of employees in technology-oriented occupations is at least twice the average proportion for all industries. High-technology occupations include scientific, engineering, and technician occupations that employ workers who generally possess in-depth knowledge of the theories and principles of science, engineering, and mathematics at a postsecondary level.

States often consider such industries desirable, in part because they tend to compensate workers better than other industries do. This indicator does not take into account establishment size. Each establishment with an employer identification number is counted without regard to the number of its employees.

The data pertaining to establishments for the years 2003 and later are based on their classification according to the 2002 edition of the North American Industry Classification System (NAICS). See table 8-A in the "Introduction" for a list of the 46 industries (by 4-digit NAICS code) that are defined as high technology. Data for years prior to 2003 are not directly comparable.

Table 8-52
High-technology establishments as a percentage of all business establishments, by state: 2003, 2006, and 2008

State	High-technology establishments			All business establishments			High-technology/business establishments (%)		
	2003	2006	2008	2003	2006	2008	2003	2006	2008
EPSCoR states	83,464	88,790	91,126	1,202,246	1,255,900	1,261,851	6.94	7.07	7.22
Non-EPSCoR states	504,364	541,875	551,958	6,001,637	6,308,168	6,304,793	8.40	8.59	8.75
Average EPSCoR state value	na	na	na	na	na	na	7.08	7.17	7.31
Average non-EPSCoR state value	na	na	na	na	na	na	8.23	8.40	8.57
United States	590,417	633,727	646,195	7,223,240	7,585,035	7,587,695	8.17	8.35	8.52
Alabama	6,347	6,613	6,754	99,453	103,236	103,690	6.38	6.41	6.51
Alaska	1,345	1,494	1,489	19,037	19,838	19,870	7.07	7.53	7.49
Arizona	10,433	11,942	12,269	120,966	137,532	139,876	8.62	8.68	8.77
Arkansas	4,012	4,373	4,675	64,058	66,647	66,558	6.26	6.56	7.02
California	77,614	85,514	86,312	822,751	875,682	876,984	9.43	9.77	9.84
Colorado	15,532	17,259	18,047	143,398	154,254	156,426	10.83	11.19	11.54
Connecticut	7,827	7,810	7,736	91,207	93,232	92,428	8.58	8.38	8.37
Delaware	3,964	3,700	3,407	24,739	25,563	25,134	16.02	14.47	13.56
District of Columbia	2,589	3,062	3,111	19,357	20,967	21,051	13.38	14.60	14.78
Florida	38,118	43,678	44,285	458,823	516,185	506,466	8.31	8.46	8.74
Georgia	18,820	20,825	21,402	208,350	225,577	227,233	9.03	9.23	9.42
Hawaii	2,097	2,325	2,294	30,950	33,063	32,862	6.78	7.03	6.98
Idaho	2,515	2,912	3,083	39,582	45,599	46,133	6.35	6.39	6.68
Illinois	27,606	28,821	29,265	310,589	320,756	321,441	8.89	8.99	9.10
Indiana	9,626	10,158	10,132	147,073	151,024	149,891	6.55	6.73	6.76
Iowa	4,316	4,548	4,659	80,745	82,542	82,207	5.35	5.51	5.67
Kansas	5,716	6,035	6,004	74,637	76,261	75,958	7.66	7.91	7.90
Kentucky	5,453	5,769	5,893	90,358	92,700	92,471	6.03	6.22	6.37
Louisiana	7,218	7,439	7,670	101,933	101,647	103,877	7.08	7.32	7.38
Maine	2,466	2,612	2,642	40,519	41,941	41,683	6.09	6.23	6.34
Maryland	13,428	14,632	15,009	132,782	140,021	138,416	10.11	10.45	10.84
Massachusetts	17,183	17,107	17,434	177,910	174,997	173,933	9.66	9.78	10.02
Michigan	16,937	17,049	16,773	236,221	235,245	228,890	7.17	7.25	7.33
Minnesota	12,834	13,348	13,257	145,364	150,896	148,641	8.83	8.85	8.92
Mississippi	3,269	3,336	3,469	59,565	60,442	60,793	5.49	5.52	5.71
Missouri	9,562	10,130	10,178	149,753	154,177	152,165	6.39	6.57	6.69
Montana	2,108	2,415	2,564	33,616	36,550	37,228	6.27	6.61	6.89
Nebraska	2,797	3,072	3,269	50,213	51,822	52,064	5.57	5.93	6.28
Nevada	5,387	5,975	6,024	53,080	61,061	61,721	10.15	9.79	9.76
New Hampshire	3,511	3,554	3,603	38,119	39,273	38,812	9.21	9.05	9.28
New Jersey	24,286	24,534	24,307	237,097	242,649	238,080	10.24	10.11	10.21
New Mexico	3,322	3,553	3,635	43,386	45,814	46,091	7.66	7.76	7.89
New York	35,926	37,346	38,308	500,559	514,992	517,873	7.18	7.25	7.40
North Carolina	14,869	16,908	17,582	207,500	221,898	224,757	7.17	7.62	7.82
North Dakota	964	1,035	1,117	20,371	21,286	21,514	4.73	4.86	5.19
Ohio	19,875	20,347	20,127	269,202	269,398	263,353	7.38	7.55	7.64
Oklahoma	6,859	7,301	7,536	85,633	89,440	91,186	8.01	8.16	8.26
Oregon	7,500	8,083	8,525	102,462	110,317	111,266	7.32	7.33	7.66
Pennsylvania	22,266	23,486	23,930	297,040	303,507	302,568	7.50	7.74	7.91
Rhode Island	1,976	2,059	2,076	29,172	30,322	29,713	6.77	6.79	6.99
South Carolina	5,869	6,551	6,978	98,735	105,060	106,501	5.94	6.24	6.55
South Dakota	1,206	1,266	1,397	24,314	25,419	25,624	4.96	4.98	5.45
Tennessee	8,196	8,772	8,882	129,458	134,776	136,321	6.33	6.51	6.52
Texas	45,062	47,520	49,419	481,804	508,092	521,383	9.35	9.35	9.48
Utah	5,474	6,531	6,913	60,011	68,612	71,301	9.12	9.52	9.70
Vermont	1,453	1,535	1,548	21,747	22,261	22,067	6.68	6.90	7.01
Virginia	18,868	21,678	22,482	182,783	196,849	197,376	10.32	11.01	11.39
Washington	13,171	14,411	15,116	166,229	179,368	181,688	7.92	8.03	8.32
West Virginia	2,257	2,308	2,343	40,225	40,480	39,579	5.61	5.70	5.92
Wisconsin	9,035	9,438	9,609	141,560	145,590	143,830	6.38	6.48	6.68
Wyoming	1,353	1,558	1,656	18,804	20,175	20,722	7.20	7.72	7.99
Puerto Rico	NA	NA	NA	NA	NA	NA	NA	NA	NA

na = not applicable; NA = not available

EPSCoR = Experimental Program to Stimulate Competitive Research

NOTE: For explanation of EPSCoR and non-EPSCoR averages, see chapter introduction.

SOURCE: Census Bureau, special tabulations (2011) of 1989–2008 Business Information Tracking Series.

Science and Engineering Indicators 2012

Net High-Technology Business Formations as a Percentage of All Business Establishments

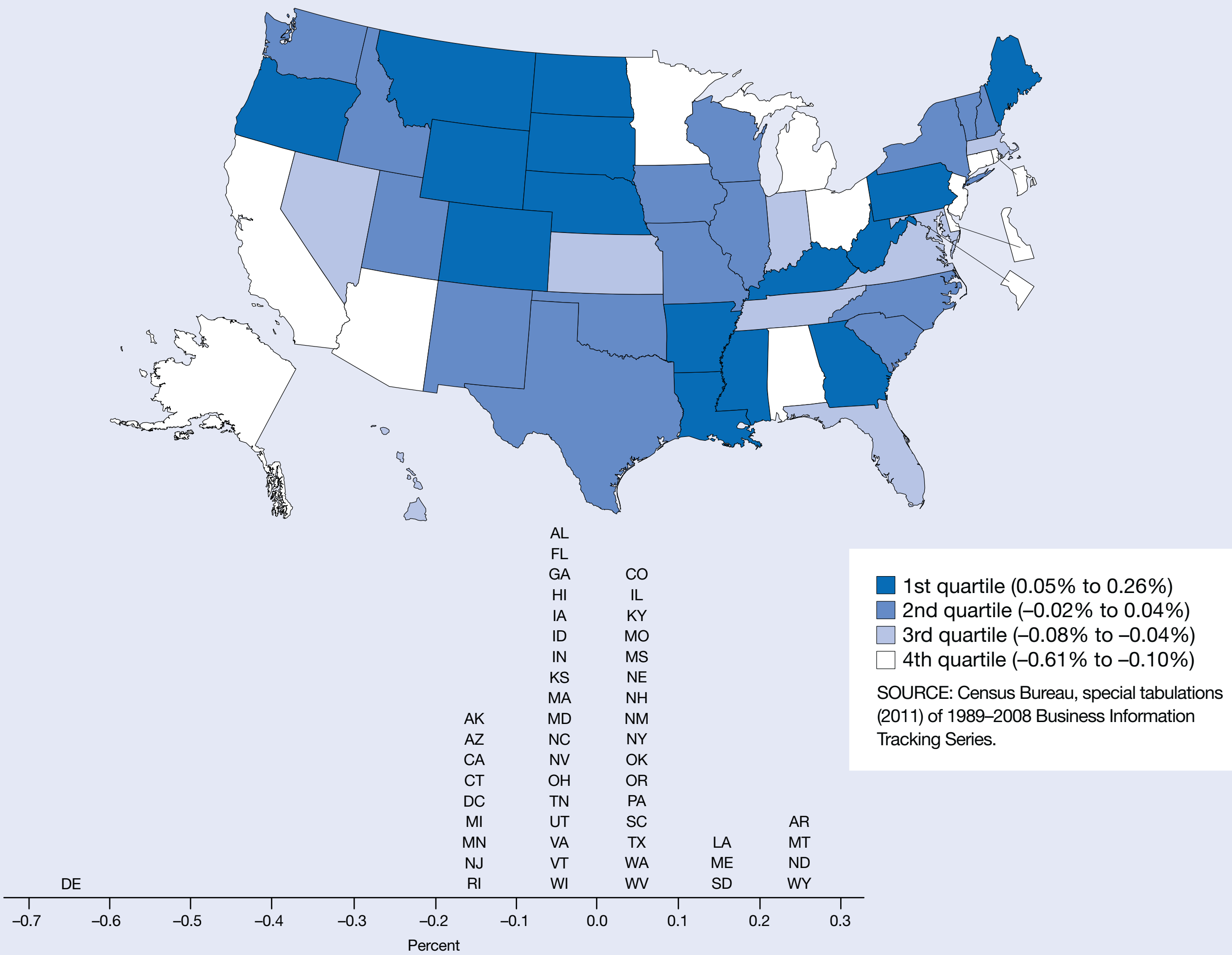


Figure 8-53
Net high-technology business formations as a percentage of all business establishments: 2008

SOURCE: Census Bureau, special tabulations (2011) of 1989–2008 Business Information Tracking Series.

Findings

- In 2008, about 2,800 more businesses in high-technology industries ceased operations than were formed in the United States. From a base of approximately 7.6 million total business establishments, 76,033 new business establishments were formed in high-technology industries and 78,801 ceased operations in those same industries.
- The effect of the business downturn became evident in 2008 as 30 states plus the District of Columbia had more businesses in high-technology industries ceasing operations than were being formed.
- The 7 top-ranking states on this indicator were EPSCoR states. However, the largest numbers of net new businesses were formed in Texas and Pennsylvania.

The business base of a state is constantly changing as new businesses form and others cease to function. The term net business formations refers to the difference between the number of businesses that are formed and the number that cease operations during any particular year.

The ratio of the number of net business formations that occur in high-technology industries to the number of business establishments in a state indicates the changing role of high-technology industries in a state's economy. High positive values indicate an increasingly prominent role for these industries.

The data on business establishments in high-technology industries are based on their classification according to the 2002 edition of the North American Industry Classification System (NAICS). See table 8-A in the "Introduction" for a list of the 46 industries (by 4-digit NAICS code) that are defined as high technology. Data for years prior to 2003 are not directly comparable.

Changes in company name, ownership, or address are not counted as business formations or business deaths. Net business formations cannot be used to directly link the number of high-technology business establishments in different years because the primary industry of some establishments may have changed during the period.

Table 8–53
Net high-technology business formations as a percentage of all business establishments, by state: 2004, 2006, and 2008

State	Net high-technology business formations			All business establishments			High-technology formations/business establishments (%)		
	2004	2006	2008	2004	2006	2008	2004	2006	2008
United States	11,598	14,031	–2,768	7,366,978	7,585,035	7,587,695	0.16	0.18	–0.04
Alabama	63	134	–65	100,521	103,236	103,690	0.06	0.13	–0.06
Alaska	22	66	–32	19,309	19,838	19,870	0.11	0.33	–0.16
Arizona	357	446	–236	125,330	137,532	139,876	0.28	0.32	–0.17
Arkansas	123	98	131	65,127	66,647	66,558	0.19	0.15	0.20
California	1,099	2,633	–973	838,615	875,682	876,984	0.13	0.30	–0.11
Colorado	490	509	148	146,937	154,254	156,426	0.33	0.33	0.09
Connecticut	–47	44	–124	92,710	93,232	92,428	–0.05	0.05	–0.13
Delaware	–52	–78	–153	25,344	25,563	25,134	–0.21	–0.31	–0.61
District of Columbia	66	195	–25	19,503	20,967	21,051	0.34	0.93	–0.12
Florida	1,743	1,009	–322	483,693	516,185	506,466	0.36	0.20	–0.06
Georgia	642	734	–228	214,200	225,577	227,233	0.30	0.33	–0.10
Hawaii	51	90	–14	31,538	33,063	32,862	0.16	0.27	–0.04
Idaho	54	151	–10	41,205	45,599	46,133	0.13	0.33	–0.02
Illinois	452	243	65	315,093	320,756	321,441	0.14	0.08	0.02
Indiana	208	164	–78	149,050	151,024	149,891	0.14	0.11	–0.05
Iowa	12	150	–14	81,334	82,542	82,207	0.01	0.18	–0.02
Kansas	160	114	–31	75,600	76,261	75,958	0.21	0.15	–0.04
Kentucky	116	42	46	91,598	92,700	92,471	0.13	0.05	0.05
Louisiana	–38	195	121	102,866	101,647	103,877	–0.04	0.19	0.12
Maine	81	31	49	41,131	41,941	41,683	0.20	0.07	0.12
Maryland	475	278	–56	135,699	140,021	138,416	0.35	0.20	–0.04
Massachusetts	156	193	–141	175,426	174,997	173,933	0.09	0.11	–0.08
Michigan	44	27	–408	237,392	235,245	228,890	0.02	0.01	–0.18
Minnesota	185	39	–278	148,276	150,896	148,641	0.12	0.03	–0.19
Mississippi	7	83	52	60,364	60,442	60,793	0.01	0.14	0.09
Missouri	195	279	–7	153,584	154,177	152,165	0.13	0.18	0.00
Montana	108	98	80	34,570	36,550	37,228	0.31	0.27	0.21
Nebraska	64	98	32	50,803	51,822	52,064	0.13	0.19	0.06
Nevada	169	207	–32	55,713	61,061	61,721	0.30	0.34	–0.05
New Hampshire	30	13	0	38,707	39,273	38,812	0.08	0.03	0.00
New Jersey	–80	38	–393	240,013	242,649	238,080	–0.03	0.02	–0.17
New Mexico	37	98	–1	44,071	45,814	46,091	0.08	0.21	0.00
New York	702	274	20	509,873	514,992	517,873	0.14	0.05	0.00
North Carolina	514	692	–53	212,457	221,898	224,757	0.24	0.31	–0.02
North Dakota	–1	34	43	20,763	21,286	21,514	0.00	0.16	0.20
Ohio	204	111	–273	271,078	269,398	263,353	0.08	0.04	–0.10
Oklahoma	75	236	22	87,180	89,440	91,186	0.09	0.26	0.02
Oregon	156	141	93	104,966	110,317	111,266	0.15	0.13	0.08
Pennsylvania	474	278	177	300,832	303,507	302,568	0.16	0.09	0.06
Rhode Island	67	8	–54	29,900	30,322	29,713	0.22	0.03	–0.18
South Carolina	175	230	25	100,947	105,060	106,501	0.17	0.22	0.02
South Dakota	16	9	42	24,693	25,419	25,624	0.06	0.04	0.16
Tennessee	39	372	–75	131,355	134,776	136,321	0.03	0.28	–0.06
Texas	401	1,221	231	489,782	508,092	521,383	0.08	0.24	0.04
Utah	283	382	–16	62,644	68,612	71,301	0.45	0.56	–0.02
Vermont	42	22	–4	22,072	22,261	22,067	0.19	0.10	–0.02
Virginia	845	986	–162	188,533	196,849	197,376	0.45	0.50	–0.08
Washington	346	476	52	170,848	179,368	181,688	0.20	0.27	0.03
West Virginia	16	–13	19	40,732	40,480	39,579	0.04	–0.03	0.05
Wisconsin	215	66	–12	143,739	145,590	143,830	0.15	0.05	–0.01
Wyoming	37	85	54	19,262	20,175	20,722	0.19	0.42	0.26
Puerto Rico	NA	NA	NA	NA	NA	NA	NA	NA	NA

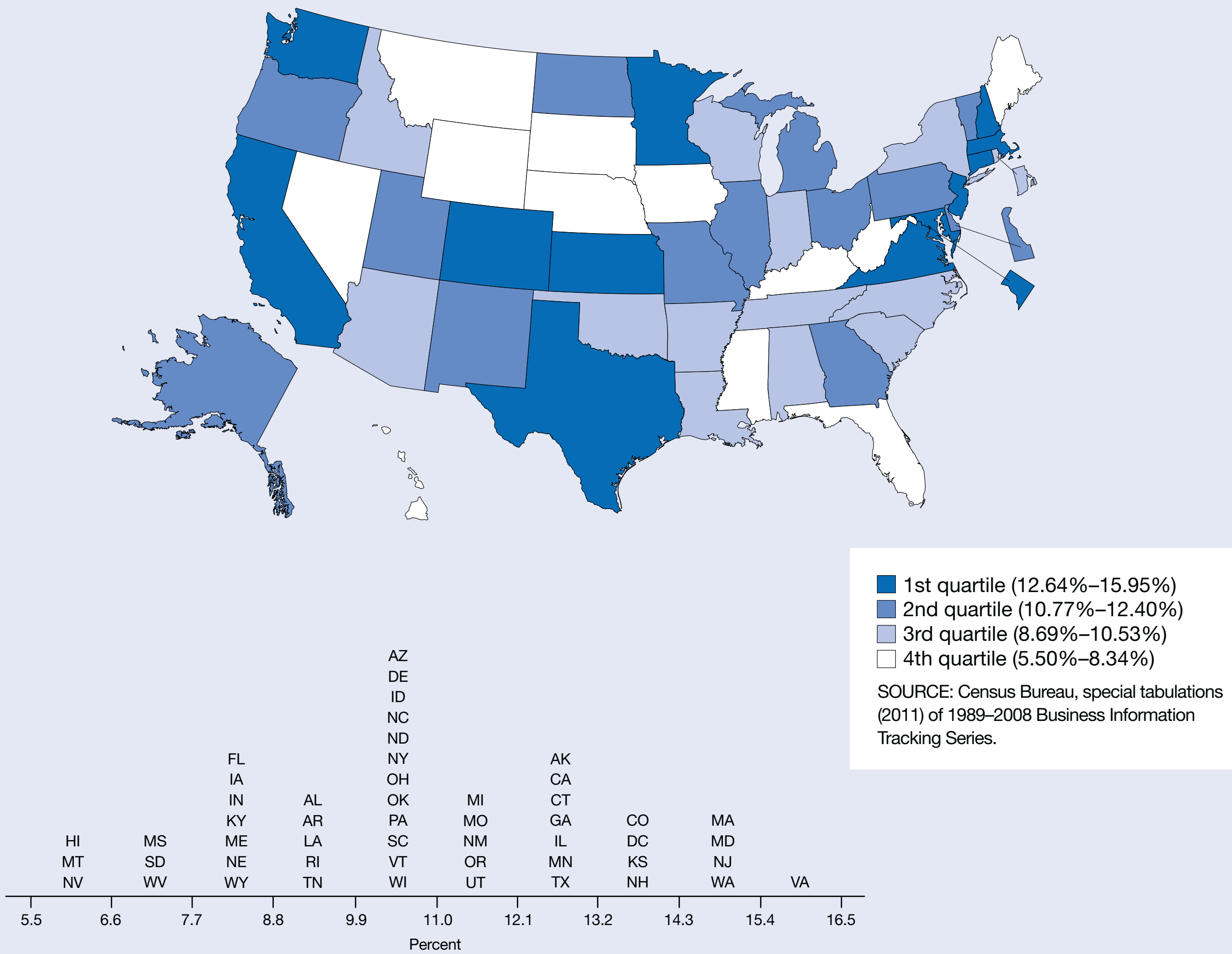
NA = not available

SOURCE: Census Bureau, special tabulations (2011) of 1989–2008 Business Information Tracking Series.

Science and Engineering Indicators 2012

Employment in High-Technology Establishments as a Percentage of Total Employment

Figure 8-54
Employment in high-technology establishments as a percentage of total employment: 2008



SOURCE: Census Bureau, special tabulations (2011) of 1989–2008 Business Information Tracking Series.

Findings

- Employment in high-technology industries in the United States increased slightly from 13.6 million in 2003 to 13.9 million in 2008.
- Nationwide, the value of this indicator declined from 11.96% in 2003 to 11.47% in 2008.
- On this indicator, states varied greatly in 2008, ranging from 5.5% to 16.0% of their workforce employed in high-technology industries.
- During the 2003–08 period, Michigan and New York recorded the largest net losses of jobs in high-technology industries, while Texas, Virginia, Florida, and Georgia posted the largest net gains of jobs in high-technology industries.
- States were distributed similarly on the high-technology employment and high-technology establishment indicators.

This indicator represents the extent to which a state's workforce is employed in high-technology industries. High-technology industries are defined as those in which the proportion of employees in technology-oriented occupations is at least twice the average proportion for all industries. High-technology occupations include scientific, engineering, and technician occupations that employ workers who generally possess in-depth knowledge of the theories and principles of science, engineering, and mathematics at a postsecondary level.

The data pertaining to establishments are based on their classification according to the 2002 edition of the North American Industry Classification System (NAICS). See table 8-A in the "Introduction" for a list of the 46 industries (by 4-digit NAICS code) that are defined as high technology. Data on total employment and NAICS industry establishment employment are provided by the Census Bureau and differ from workforce data provided by the Bureau of Labor Statistics. Total employment refers to all U.S. business establishments with paid employees, but does not include crop and animal production, rail transportation, the postal service, public administration, or most government employees.

Table 8-54
Employment in high-technology establishments as share of total employment, by state: 2003, 2006, and 2008

State	Employment in high-technology establishments			Total employment			High-technology/ Total employment (%)		
	2003	2006	2008	2003	2006	2008	2003	2006	2008
United States	13,563,122	13,733,632	13,870,679	113,373,663	119,892,505	120,933,454	11.96	11.45	11.47
Alabama	152,879	162,197	162,713	1,597,265	1,713,185	1,714,898	9.57	9.47	9.49
Alaska	21,851	27,306	30,794	216,707	241,568	248,274	10.08	11.30	12.40
Arizona	234,603	246,648	243,159	1,997,990	2,334,665	2,334,785	11.74	10.56	10.41
Arkansas	95,180	93,648	93,991	988,822	1,041,868	1,025,872	9.63	8.99	9.16
California	1,781,830	1,826,638	1,785,871	12,986,496	13,830,274	13,746,493	13.72	13.21	12.99
Colorado	274,979	272,952	291,442	1,883,883	2,018,905	2,121,945	14.60	13.52	13.73
Connecticut	210,114	198,450	200,106	1,550,615	1,585,660	1,551,373	13.55	12.52	12.90
Delaware	52,349	47,749	42,178	385,098	388,178	389,927	13.59	12.30	10.82
District of Columbia	54,314	57,297	61,916	422,912	446,502	466,152	12.84	12.83	13.28
Florida	576,274	618,540	614,504	6,548,276	7,534,165	7,367,042	8.80	8.21	8.34
Georgia	413,384	428,272	448,230	3,386,590	3,622,522	3,633,902	12.21	11.82	12.33
Hawaii	25,777	28,848	28,500	458,952	512,488	518,052	5.62	5.63	5.50
Idaho	55,706	59,082	56,624	466,379	546,108	537,706	11.94	10.82	10.53
Illinois	646,285	619,777	662,391	5,204,887	5,356,504	5,463,437	12.42	11.57	12.12
Indiana	219,598	224,644	227,568	2,540,554	2,672,558	2,619,567	8.64	8.41	8.69
Iowa	102,387	96,190	105,099	1,232,709	1,295,143	1,317,765	8.31	7.43	7.98
Kansas	155,023	146,849	169,118	1,109,699	1,142,487	1,185,876	13.97	12.85	14.26
Kentucky	121,838	125,204	129,162	1,471,622	1,551,791	1,570,686	8.28	8.07	8.22
Louisiana	137,029	143,846	145,702	1,603,492	1,592,682	1,654,417	8.55	9.03	8.81
Maine	35,184	37,934	40,028	488,788	508,061	508,905	7.20	7.47	7.87
Maryland	315,887	326,546	333,584	2,088,552	2,231,888	2,235,033	15.12	14.63	14.93
Massachusetts	460,984	496,630	464,759	2,974,164	3,043,643	3,076,457	15.50	16.32	15.11
Michigan	499,133	475,350	424,066	3,884,881	3,817,762	3,637,690	12.85	12.45	11.66
Minnesota	315,994	329,927	318,203	2,381,860	2,475,859	2,517,847	13.27	13.33	12.64
Mississippi	66,566	64,558	64,420	912,004	940,329	944,776	7.30	6.87	6.82
Missouri	254,299	263,494	272,023	2,387,245	2,467,626	2,472,861	10.65	10.68	11.00
Montana	20,296	26,958	23,651	302,932	342,461	359,721	6.70	7.87	6.57
Nebraska	68,975	64,779	66,152	774,858	789,117	805,633	8.90	8.21	8.21
Nevada	61,847	66,875	72,942	970,678	1,165,243	1,156,305	6.37	5.74	6.31
New Hampshire	63,264	64,914	79,105	540,132	577,322	595,473	11.71	11.24	13.28
New Jersey	550,224	550,515	556,378	3,578,674	3,644,967	3,646,897	15.38	15.10	15.26
New Mexico	60,399	68,627	72,838	571,057	628,472	641,010	10.58	10.92	11.36
New York	823,992	790,696	758,087	7,415,430	7,531,772	7,622,956	11.11	10.50	9.94
North Carolina	349,424	358,501	370,028	3,337,552	3,523,954	3,585,005	10.47	10.17	10.32
North Dakota	20,584	22,450	33,096	258,878	278,395	304,892	7.95	8.06	10.85
Ohio	531,491	518,835	514,408	4,769,406	4,824,859	4,728,989	11.14	10.75	10.88
Oklahoma	132,887	141,575	137,334	1,184,312	1,276,743	1,335,467	11.22	11.09	10.28
Oregon	152,140	161,641	166,086	1,338,380	1,461,339	1,482,627	11.37	11.06	11.20
Pennsylvania	566,406	549,180	564,569	5,028,650	5,189,349	5,233,871	11.26	10.58	10.79
Rhode Island	35,806	41,020	42,046	427,369	440,715	433,626	8.38	9.31	9.70
South Carolina	163,373	170,200	167,198	1,550,227	1,631,690	1,654,494	10.54	10.43	10.11
South Dakota	18,890	20,202	22,551	299,723	325,045	337,830	6.30	6.22	6.68
Tennessee	219,898	245,517	225,724	2,298,836	2,472,939	2,493,070	9.57	9.93	9.05
Texas	1,158,481	1,144,997	1,210,285	8,049,300	8,709,575	9,232,889	14.39	13.15	13.11
Utah	99,856	114,815	124,399	900,331	1,038,879	1,114,776	11.09	11.05	11.16
Vermont	29,402	27,001	29,372	256,401	263,759	272,847	11.47	10.24	10.77
Virginia	459,017	502,890	508,097	2,932,471	3,173,767	3,186,112	15.65	15.85	15.95
Washington	401,413	347,710	387,407	2,292,462	2,420,633	2,536,196	17.51	14.36	15.28
West Virginia	46,635	45,284	45,280	561,317	583,033	592,356	8.31	7.77	7.64
Wisconsin	233,967	253,499	259,072	2,382,979	2,481,998	2,496,839	9.82	10.21	10.38
Wyoming	15,008	16,375	18,423	180,866	204,058	221,835	8.30	8.02	8.30
Puerto Rico	NA	NA	NA	NA	NA	NA	NA	NA	NA

NA = not available

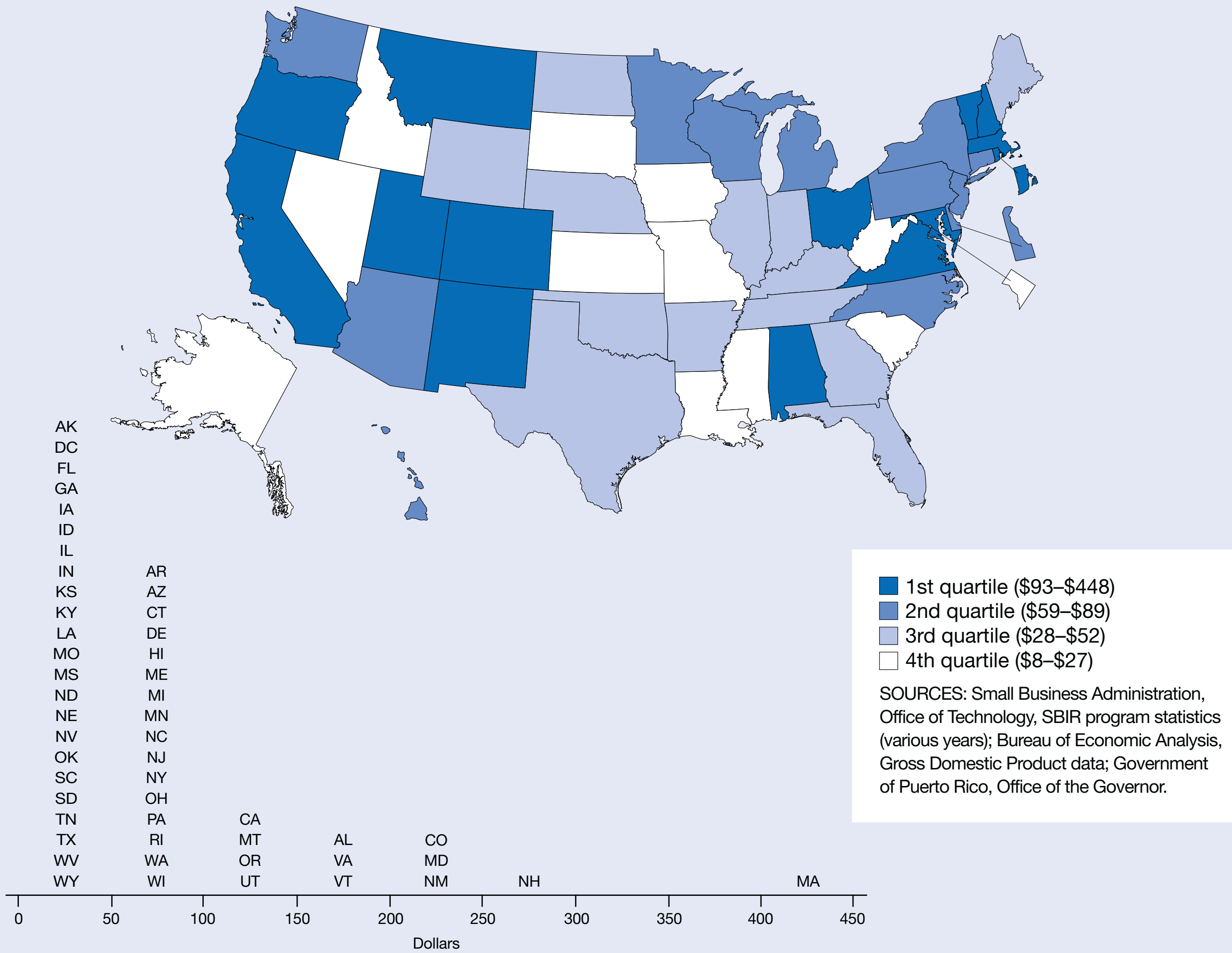
SOURCE: Census Bureau, special tabulations (2011) of 1989–2008 Business Information Tracking Series.

Science and Engineering Indicators 2012

Average Annual Federal Small Business Innovation Research Funding per $1 Million of Gross Domestic Product

Figure 8-55

Average annual federal Small Business Innovation Research funding per $1 million of gross domestic product: 2008–10



SOURCES: Small Business Administration, Office of Technology, SBIR program statistics (various years); Bureau of Economic Analysis, Gross Domestic Product data; Government of Puerto Rico, Office of the Governor.

Findings

- The SBIR program remained unchanged in size at about $1.2 billion both in 2000-2002 and in 2008–10 despite significantly higher spending in 2004–2006.
- Over the 3 year period of 2008–2010, SBIR funds were concentrated in relatively few states; the total of annual state awards range from less than $1 million to $246 million.
- Many of the states with the highest rankings on this indicator are locations of federal laboratories or well-recognized academic research institutions from which innovative small businesses have emerged.
- States with a high ranking on this indicator also tended to rank high on the high-technology and venture capital indicators.

Funds awarded through the federal Small Business Innovation Research (SBIR) program support technological innovation in companies with 500 or fewer employees. Awards are made to evaluate the feasibility and scientific merit of new technology (Phase 1–up to $150,000) and to develop the technology to a point where it can be commercialized (Phase 2–up to $750,000). The total award dollars include both Phase 1 and Phase 2 SBIR awards.

Because of year-to-year fluctuations, this indicator is calculated using 3-year averages. The 3-year average annual SBIR award dollars won by small businesses in a state are divided by the 3-year average annual gross domestic product for the same period. All data are expressed in current dollars. A high value indicates that small business firms in a state are doing cutting-edge development work that attracts federal support.

Table 8-55
Average annual federal Small Business Innovation Research funding per $1 million of gross domestic product, by state: 2000–02, 2004–06, and 2008–10

State	Average SBIR funding ($thousands) 2000–02	2004–06	2008–10	Average state GDP ($millions) 2000–02	2004–06	2008–10	SBIR funding ($)/ $1 million GDP 2000–02	2004–06	2008–10
United States	1,234,995	1,904,499	1,258,785	10,224,860	12,551,462	14,279,027	121	152	88
Alabama	23,221	39,143	26,688	120,421	150,815	169,693	193	260	157
Alaska	480	345	793	27,516	38,017	48,056	17	9	16
Arizona	25,485	33,842	19,436	169,727	223,697	254,591	150	151	76
Arkansas	1,663	7,103	5,156	71,008	88,432	100,286	23	80	51
California	255,855	391,456	245,846	1,347,048	1,687,989	1,886,626	190	232	130
Colorado	61,513	85,830	58,409	179,766	216,425	254,174	342	397	230
Connecticut	19,923	26,823	18,742	167,173	198,636	230,256	119	135	81
Delaware	4,636	6,662	3,556	42,926	54,230	60,538	108	123	59
District of Columbia	5,069	3,725	1,472	63,259	82,698	99,847	80	45	15
Florida	26,348	41,292	30,486	507,821	677,240	742,762	52	61	41
Georgia	12,353	18,234	14,148	304,529	362,604	400,819	41	50	35
Hawaii	3,716	7,796	4,921	42,830	56,749	66,102	87	137	74
Idaho	2,365	3,994	1,252	36,692	47,750	54,769	64	84	23
Illinois	17,782	24,985	21,848	486,319	572,784	640,175	37	44	34
Indiana	6,048	15,759	11,505	202,128	240,248	266,395	30	66	43
Iowa	2,985	4,091	3,034	95,298	120,190	137,906	31	34	22
Kansas	3,808	5,359	2,569	88,939	105,782	125,016	43	51	21
Kentucky	3,280	4,406	5,886	116,894	139,389	158,217	28	32	37
Louisiana	2,585	5,002	2,669	136,238	191,291	212,470	19	26	13
Maine	3,098	9,264	2,607	38,156	45,872	50,551	81	202	52
Maryland	60,481	97,376	64,011	195,088	247,143	287,360	310	394	223
Massachusetts	181,889	250,946	165,114	280,962	323,833	368,297	647	775	448
Michigan	21,110	43,732	27,485	341,731	372,353	376,426	62	117	73
Minnesota	18,182	24,292	19,635	194,424	237,233	263,765	94	102	74
Mississippi	2,524	3,364	755	67,551	81,735	96,193	37	41	8
Missouri	4,967	9,959	5,725	186,134	216,371	241,105	27	46	24
Montana	6,847	8,460	4,539	22,839	30,069	35,635	300	281	127
Nebraska	2,259	4,003	2,404	59,339	72,889	87,027	38	55	28
Nevada	4,315	6,847	1,608	79,282	113,213	127,652	54	60	13
New Hampshire	15,483	22,097	16,847	45,109	53,672	59,383	343	412	284
New Jersey	35,400	48,903	32,895	363,315	431,713	480,947	97	113	68
New Mexico	19,955	24,172	17,663	51,974	67,821	77,906	384	356	227
New York	48,783	84,178	72,144	801,591	962,740	1,120,908	61	87	64
North Carolina	16,220	32,246	30,515	291,887	353,857	411,965	56	91	74
North Dakota	1,900	1,861	1,253	19,258	24,692	32,663	99	75	38
Ohio	50,697	79,947	43,551	387,263	442,611	470,118	131	181	93
Oklahoma	3,718	7,918	4,797	95,791	121,670	147,260	39	65	33
Oregon	14,792	28,485	18,417	114,930	146,903	172,029	129	194	107
Pennsylvania	42,299	79,624	44,611	408,829	483,960	553,805	103	165	81
Rhode Island	4,297	7,803	4,458	35,746	44,517	48,027	120	175	93
South Carolina	5,327	6,527	4,355	119,900	141,993	160,910	44	46	27
South Dakota	1,184	503	475	25,587	31,560	38,814	46	16	12
Tennessee	9,971	10,435	8,364	184,826	224,988	248,817	54	46	34
Texas	45,318	87,373	46,517	761,387	977,950	1,185,415	60	89	39
Utah	11,446	14,424	11,255	72,145	91,277	112,731	159	158	100
Vermont	2,956	5,061	3,823	18,822	22,778	24,960	157	222	153
Virginia	73,712	100,364	75,508	277,582	353,956	412,148	266	284	183
Washington	30,253	49,405	29,865	231,737	279,233	335,525	131	177	89
West Virginia	2,292	5,009	1,655	43,004	52,028	61,575	53	96	27
Wisconsin	11,944	21,382	16,402	183,789	219,114	242,343	65	98	68
Wyoming	2,262	2,695	1,116	18,348	26,752	38,068	123	101	29
Puerto Rico	219	453	NA	NA	NA	NA	NA	NA	NA

NA = not available

GDP = gross domestic product; SBIR = Small Business Innovation Research

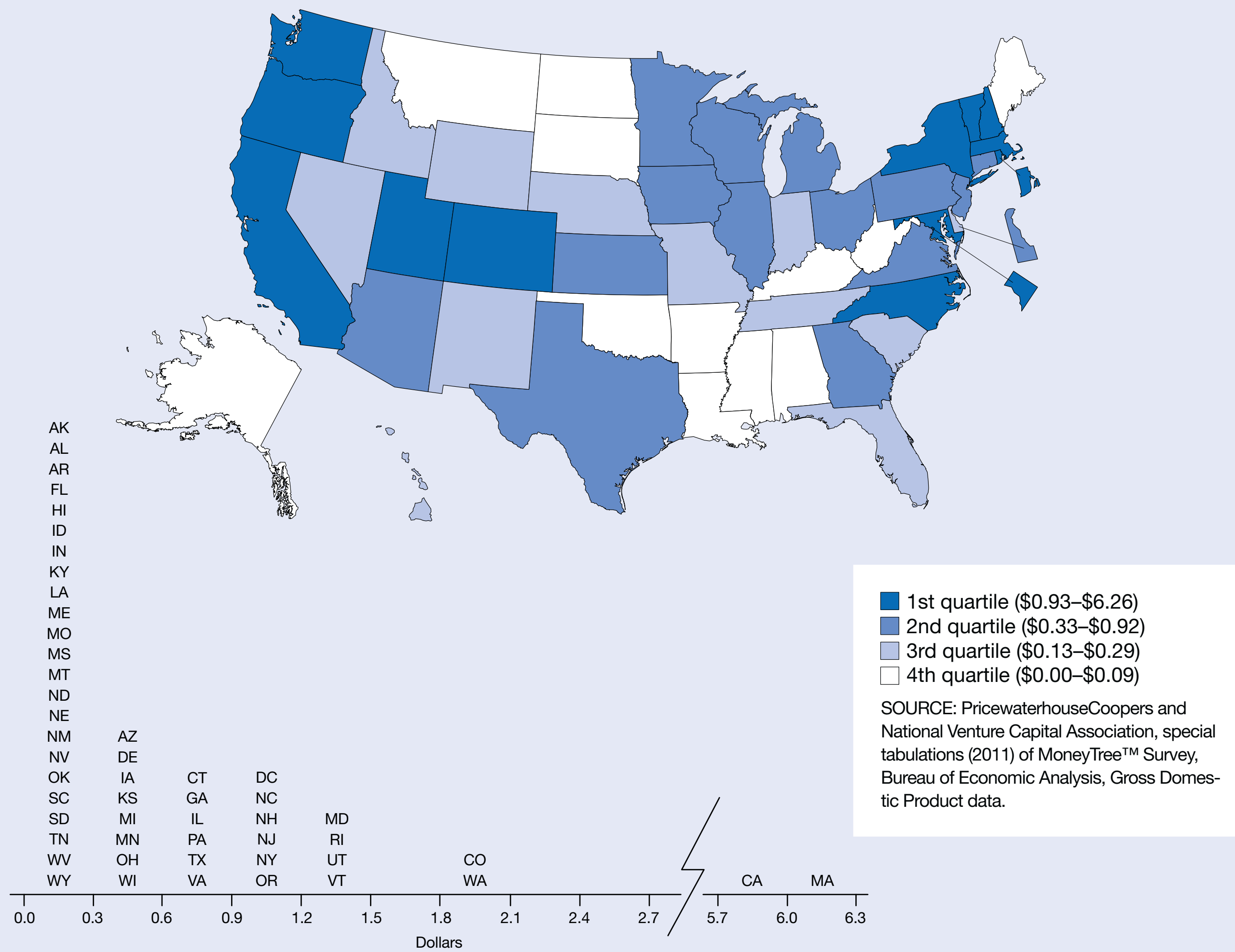
NOTE: GDP reported in current dollars.

SOURCES: Small Business Administration, Office of Technology, SBIR program statistics (various years); Bureau of Economic Analysis, Gross Domestic Product data; Government of Puerto Rico, Office of the Governor.

Science and Engineering Indicators 2012

Venture Capital Disbursed per $1,000 of Gross Domestic Product

Figure 8-56
Venture capital disbursed per $1,000 of gross domestic product: 2010



SOURCE: PricewaterhouseCoopers and National Venture Capital Association, special tabulations (2011) of MoneyTree™ Survey, Bureau of Economic Analysis, Gross Domestic Product data.

Findings

- The total amount of venture capital invested in the United States has been highly volatile during the past decade. In 2000, it was at $105 billion, decreasing to $22 billion in 2010. The average value for this indicator for the United States was $10.59 in 2000 and $1.50 in 2010.
- Venture capital investment is concentrated in relatively few states. Companies in California received 50% of the total venture capital disbursed in the United States in 2010, followed by companies in Massachusetts with 11%. Four states reported no venture capital investment in 2010.
- In 2010, the value of this indicator across states ranged from $0.0 to $6.26.
- The average indicator value for EPSCoR states was substantially lower than that for non-EPSCoR states. The state distribution of venture capital was similar to indicators of high-technology business activity.

Venture capital represents an important source of funding for startup companies. It supports the growth and expansion of these companies early in their development, before they establish a predictable sales history that would qualify them for other types of financing.

This indicator represents the relative magnitude of venture capital investments in a state after adjusting for the size of the state's economy. The indicator is expressed as dollars of venture capital disbursed per $1,000 of gross domestic product. High values indicate that companies in those states are successfully attracting venture capital to fuel their growth. Access to venture capital financing varies greatly among states.

Venture capital data measure cash-for-equity investments by the professional venture capital community in private emerging companies in the United States. Data exclude debt, buy-outs, recapitalizations, IPOs, and other forms of private equity that do not involve cash. Results are updated periodically. All data are subject to change at any time.

Table 8-56
Venture capital disbursed per $1,000 of gross domestic product, by state: 2000, 2005, and 2010

	Venture capital disbursed ($millions)			State GDP ($millions)			Venture capital ($)/$1,000 GDP		
State	2000	2005	2010	2000	2005	2010	2000	2005	2010
United States	104,678	23,115	21,799	9,884,171	12,554,535	14,551,782	10.59	1.84	1.50
Alabama	266	20	1	116,014	151,096	172,567	2.30	0.13	0.00
Alaska	4	0	0	25,913	37,824	49,120	0.14	0.00	0.00
Arizona	34	13	83	161,901	222,968	253,609	0.21	0.06	0.33
Arkansas	626	123	5	68,146	88,227	102,566	9.18	1.40	0.05
California	43,034	11,011	10,978	1,317,343	1,691,991	1,901,088	32.67	6.51	5.77
Colorado	4,165	644	468	171,930	217,412	257,641	24.22	2.96	1.81
Connecticut	1,509	202	200	163,943	197,055	237,261	9.21	1.02	0.84
Delaware	135	7	31	40,957	54,749	62,280	3.29	0.13	0.50
District of Columbia	478	28	96	58,269	82,837	103,288	8.21	0.33	0.93
Florida	2,687	329	186	481,115	680,277	747,735	5.58	0.48	0.25
Georgia	2,325	254	333	294,479	363,154	403,070	7.90	0.70	0.83
Hawaii	203	12	11	41,372	56,869	66,760	4.91	0.21	0.17
Idaho	20	8	8	36,091	48,675	55,435	0.54	0.16	0.14
Illinois	2,358	277	575	474,444	569,544	651,518	4.97	0.49	0.88
Indiana	269	104	69	198,020	239,575	275,676	1.36	0.43	0.25
Iowa	31	32	52	93,287	120,258	142,698	0.33	0.27	0.36
Kansas	265	2	42	85,742	105,164	127,170	3.09	0.02	0.33
Kentucky	202	32	12	113,108	139,336	163,269	1.78	0.23	0.07
Louisiana	113	4	18	131,430	197,163	218,853	0.86	0.02	0.08
Maine	140	5	2	36,395	45,587	51,643	3.85	0.10	0.04
Maryland	1,820	488	357	182,953	248,139	295,304	9.95	1.97	1.21
Massachusetts	10,312	2,583	2,373	272,680	323,301	378,729	37.82	7.99	6.26
Michigan	337	81	152	336,786	375,260	384,171	1.00	0.22	0.39
Minnesota	1,039	242	140	188,449	238,367	270,039	5.51	1.02	0.52
Mississippi	20	10	0	65,615	81,500	97,461	0.30	0.12	0.00
Missouri	590	56	61	180,982	216,633	244,016	3.26	0.26	0.25
Montana	17	27	2	21,629	30,088	36,067	0.77	0.91	0.05
Nebraska	143	13	12	57,233	72,504	89,786	2.50	0.18	0.13
Nevada	31	159	29	75,907	114,771	125,650	0.41	1.38	0.23
New Hampshire	751	92	57	44,067	53,653	60,283	17.03	1.72	0.94
New Jersey	3,290	887	451	349,334	429,985	487,335	9.42	2.06	0.92
New Mexico	21	76	23	50,262	67,776	79,678	0.42	1.13	0.29
New York	6,835	1,127	1,339	770,621	961,941	1,159,540	8.87	1.17	1.15
North Carolina	1,825	395	456	281,418	354,973	424,935	6.49	1.11	1.07
North Dakota	6	0	0	18,250	24,672	34,685	0.33	0.00	0.00
Ohio	976	140	157	381,175	444,715	477,699	2.56	0.31	0.33
Oklahoma	53	0	13	91,292	120,662	147,543	0.58	0.00	0.09
Oregon	793	134	174	112,974	143,349	174,151	7.02	0.94	1.00
Pennsylvania	2,873	482	508	395,811	482,324	569,679	7.26	1.00	0.89
Rhode Island	75	76	65	33,522	44,169	49,234	2.23	1.73	1.32
South Carolina	448	3	21	115,392	141,929	164,445	3.88	0.02	0.13
South Dakota	0	0	0	24,009	31,641	39,893	0.01	0.00	0.00
Tennessee	453	89	52	177,582	224,522	254,806	2.55	0.39	0.20
Texas	6,094	1,175	891	732,987	970,997	1,207,494	8.31	1.21	0.74
Utah	674	192	143	69,483	90,748	114,538	9.69	2.12	1.25
Vermont	46	35	33	18,033	22,773	25,620	2.57	1.55	1.28
Virginia	3,310	526	375	261,894	356,852	423,860	12.64	1.47	0.89
Washington	2,790	837	613	227,828	279,405	340,460	12.25	3.00	1.80
West Virginia	5	11	4	41,419	51,964	64,642	0.11	0.20	0.06
Wisconsin	192	69	122	177,638	218,923	248,265	1.08	0.31	0.49
Wyoming	0	4	10	17,047	26,238	38,527	0.00	0.15	0.26
Puerto Rico	NA	NA	4	69,208	86,157	NA	NA	NA	NA

NA = not available

GDP = gross domestic product

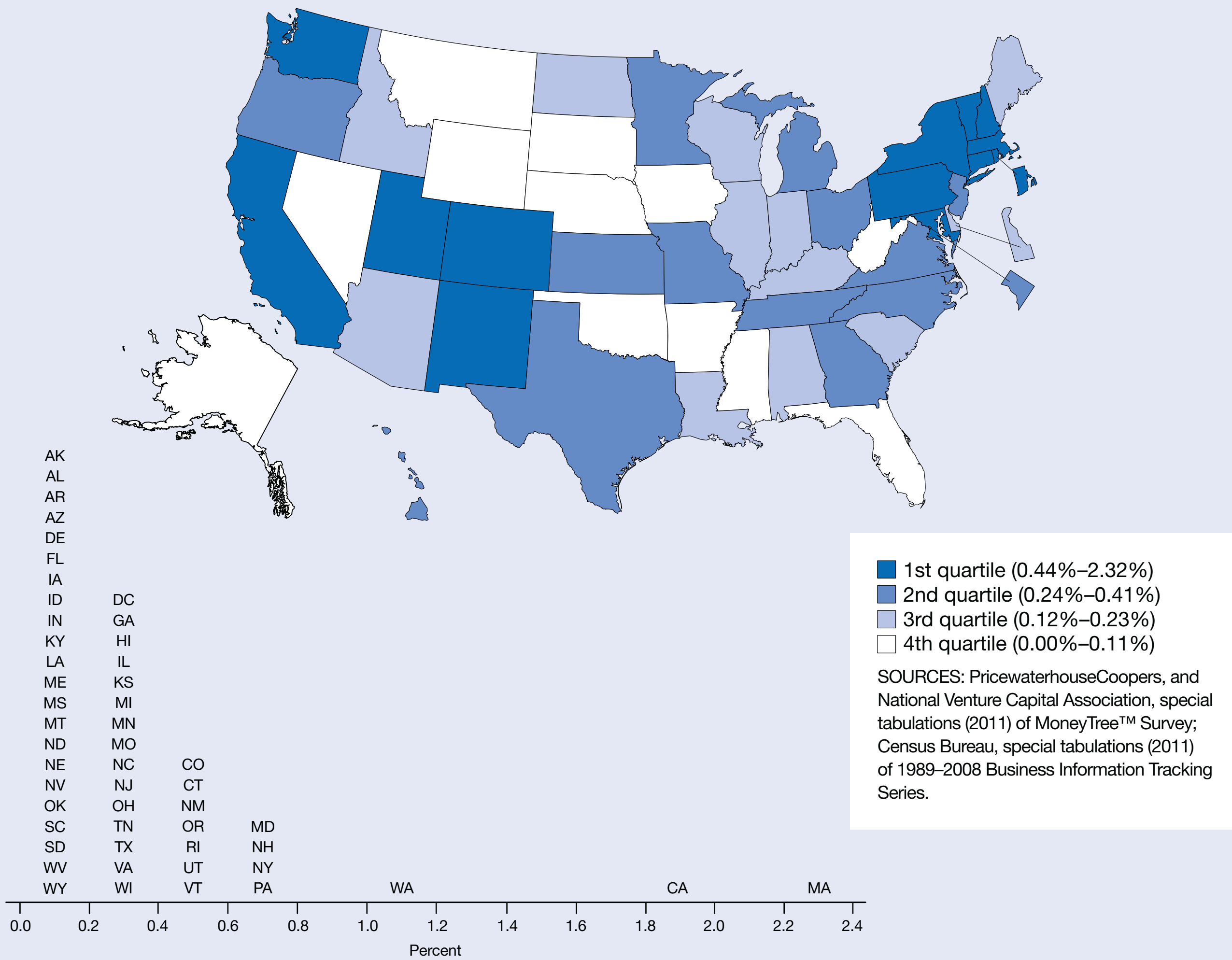
NOTE: GDP reported in current dollars.

SOURCES: PricewaterhouseCoopers and National Venture Capital Association, special tabulations (2011) of MoneyTree™ Survey; Bureau of Economic Analysis, Gross Domestic Product data; United Nations Statistics Division.

Science and Engineering Indicators 2012

Venture Capital Deals as a Percentage of High-Technology Business Establishments

Figure 8-57
Venture capital deals as a percentage of high-technology business establishments: 2008



SOURCES: PricewaterhouseCoopers, and National Venture Capital Association, special tabulations (2011) of MoneyTree™ Survey; Census Bureau, special tabulations (2011) of 1989–2008 Business Information Tracking Series.

Findings

- The number of venture capital deals that involved U.S. companies increased from about 2,900 deals in 2003 to more than 3,800 deals in 2008.
- In 2008, venture capital deals were concentrated in only a few states. Indicator values ranged from a low of zero to a high of 2.32% with a median value of 0.24%.
- Companies in high-technology industries located in Massachusetts were the most successful in accessing venture capital investments in 2008, with a 2.32% rate. California companies in high-technology industries obtained venture capital investment at a rate of 1.80% and Washington companies attained a rate of 1.08%. No other states reached a rate of 1.00%.
- In 2008, companies in EPSCoR states tended to receive little venture capital investment, and no venture capital deals were reported in three EPSCoR states.

This indicator represents the extent to which high-technology companies in a state receive venture capital investments. The value of the indicator is calculated by dividing the number of venture capital deals by the number of companies operating in high-technology industries in that state. High values indicate that high-technology companies in a state are frequently using venture capital to facilitate their growth and development. In most cases, a company will not receive more than one infusion of venture capital in a given year.

Venture capital data measure cash-for-equity investments by the professional venture capital community in private emerging companies in the United States. Data exclude debt, buy-outs, recapitalizations, IPOs, and other forms of private equity that do not involve cash. Results are updated periodically. All data are subject to change at any time. Venture capital investment can help to grow a high-technology company.

Data on business establishments operating in high-technology industries for the years 2003 and later are based on their classification according to the 2002 edition of the North American Industry Classification System (NAICS). See table 8-A in the "Introduction" for a list of the 46 industries (by 4-digit NAICS code) that are defined as high technology. Data for years prior to 2003 are not directly comparable.

Table 8-57
Venture capital deals as a percentage of high-technology business establishments, by state: 2003, 2006, and 2008

State	Venture capital deals			High-technology establishments			Venture capital deals/ high-technology establishments (%)		
	2003	2006	2008	2003	2006	2008	2003	2006	2008
United States	2,903	3,672	3,806	590,417	633,727	646,195	0.49	0.58	0.59
Alabama	9	7	8	6,347	6,613	6,754	0.14	0.11	0.12
Alaska	0	0	0	1,345	1,494	1,489	0.00	0.00	0.00
Arizona	16	29	20	10,433	11,942	12,269	0.15	0.24	0.16
Arkansas	3	6	0	4,012	4,373	4,675	0.07	0.14	0.00
California	1,122	1,549	1,552	77,614	85,514	86,312	1.45	1.81	1.80
Colorado	72	98	100	15,532	17,259	18,047	0.46	0.57	0.55
Connecticut	34	30	34	7,827	7,810	7,736	0.43	0.38	0.44
Delaware	1	3	6	3,964	3,700	3,407	0.03	0.08	0.18
District of Columbia	6	8	11	2,589	3,062	3,111	0.23	0.26	0.35
Florida	61	56	36	38,118	43,678	44,285	0.16	0.13	0.08
Georgia	55	81	80	18,820	20,825	21,402	0.29	0.39	0.37
Hawaii	6	10	6	2,097	2,325	2,294	0.29	0.43	0.26
Idaho	5	1	6	2,515	2,912	3,083	0.20	0.03	0.19
Illinois	58	55	67	27,606	28,821	29,265	0.21	0.19	0.23
Indiana	8	15	16	9,626	10,158	10,132	0.08	0.15	0.16
Iowa	1	2	5	4,316	4,548	4,659	0.02	0.04	0.11
Kansas	2	7	23	5,716	6,035	6,004	0.03	0.12	0.38
Kentucky	3	7	10	5,453	5,769	5,893	0.06	0.12	0.17
Louisiana	1	3	10	7,218	7,439	7,670	0.01	0.04	0.13
Maine	2	4	4	2,466	2,612	2,642	0.08	0.15	0.15
Maryland	84	110	97	13,428	14,632	15,009	0.63	0.75	0.65
Massachusetts	378	395	405	17,183	17,107	17,434	2.20	2.31	2.32
Michigan	17	18	43	16,937	17,049	16,773	0.10	0.11	0.26
Minnesota	58	39	47	12,834	13,348	13,257	0.45	0.29	0.35
Mississippi	4	1	0	3,269	3,336	3,469	0.12	0.03	0.00
Missouri	23	13	24	9,562	10,130	10,178	0.24	0.13	0.24
Montana	1	0	2	2,108	2,415	2,564	0.05	0.00	0.08
Nebraska	2	3	3	2,797	3,072	3,269	0.07	0.10	0.09
Nevada	6	7	6	5,387	5,975	6,024	0.11	0.12	0.10
New Hampshire	32	21	28	3,511	3,554	3,603	0.91	0.59	0.78
New Jersey	88	94	90	24,286	24,534	24,307	0.36	0.38	0.37
New Mexico	5	9	19	3,322	3,553	3,635	0.15	0.25	0.52
New York	119	209	235	35,926	37,346	38,308	0.33	0.56	0.61
North Carolina	76	62	51	14,869	16,908	17,582	0.51	0.37	0.29
North Dakota	2	0	2	964	1,035	1,117	0.21	0.00	0.18
Ohio	25	41	52	19,875	20,347	20,127	0.13	0.20	0.26
Oklahoma	2	6	5	6,859	7,301	7,536	0.03	0.08	0.07
Oregon	21	31	35	7,500	8,083	8,525	0.28	0.38	0.41
Pennsylvania	90	128	171	22,266	23,486	23,930	0.40	0.55	0.71
Rhode Island	10	7	10	1,976	2,059	2,076	0.51	0.34	0.48
South Carolina	4	3	11	5,869	6,551	6,978	0.07	0.05	0.16
South Dakota	1	1	1	1,206	1,266	1,397	0.08	0.08	0.07
Tennessee	22	11	21	8,196	8,772	8,882	0.27	0.13	0.24
Texas	165	188	146	45,062	47,520	49,419	0.37	0.40	0.30
Utah	22	39	33	5,474	6,531	6,913	0.40	0.60	0.48
Vermont	6	9	9	1,453	1,535	1,548	0.41	0.59	0.58
Virginia	80	89	81	18,868	21,678	22,482	0.42	0.41	0.36
Washington	81	143	164	13,171	14,411	15,116	0.61	0.99	1.08
West Virginia	5	3	1	2,257	2,308	2,343	0.22	0.13	0.04
Wisconsin	8	20	19	9,035	9,438	9,609	0.09	0.21	0.20
Wyoming	1	1	1	1,353	1,558	1,656	0.07	0.06	0.06
Puerto Rico	1	2	NA	NA	NA	NA	NA	NA	NA

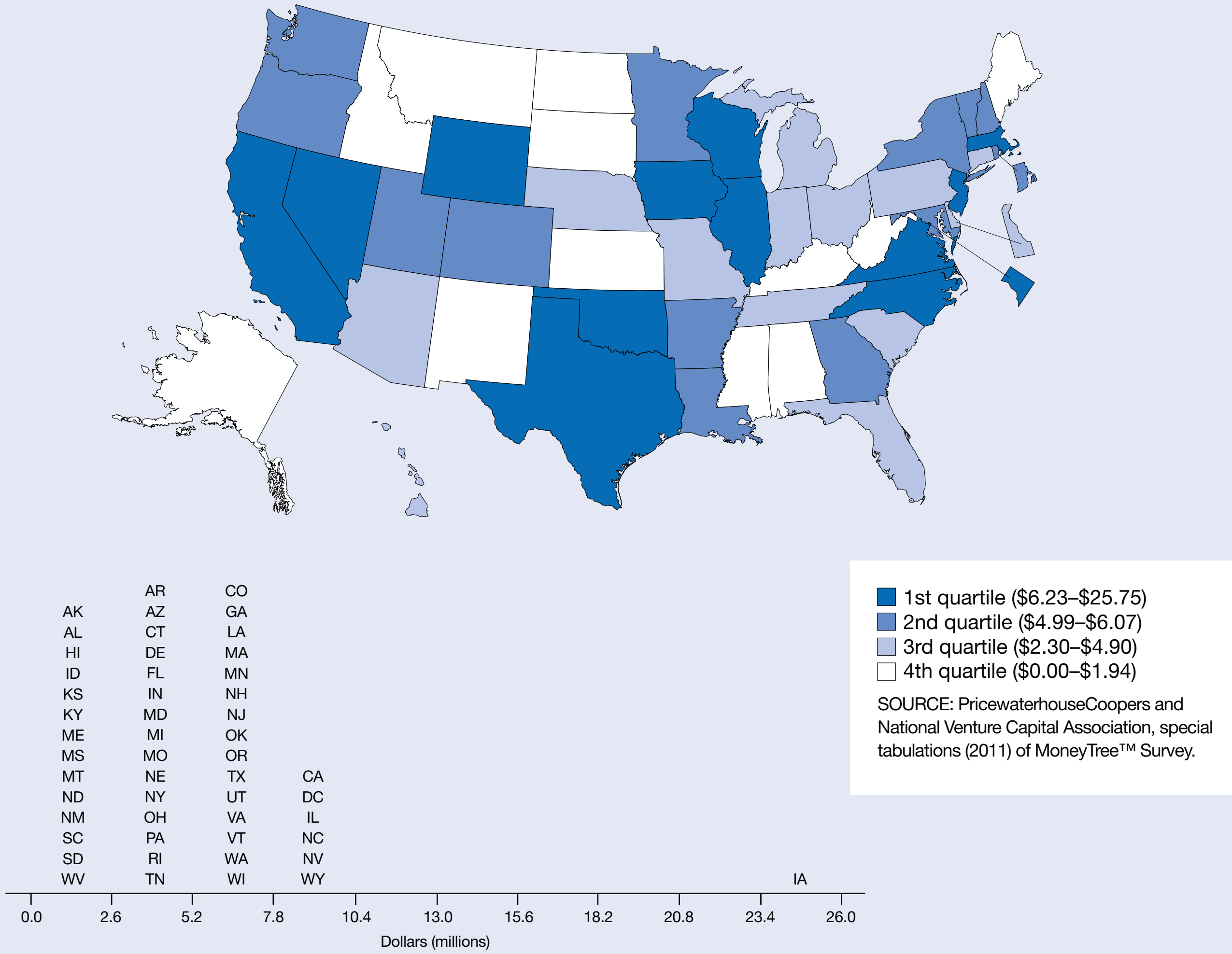
NA = not available

SOURCES: PricewaterhouseCoopers and National Venture Capital Association, special tabulations (2011) of MoneyTree™ Survey; Census Bureau, special tabulations (2011) of 1989–2008 Business Information Tracking Series.

Science and Engineering Indicators 2012

Venture Capital Disbursed per Venture Capital Deal

Figure 8-58
Venture capital disbursed per venture capital deal: 2010



SOURCE: PricewaterhouseCoopers and National Venture Capital Association, special tabulations (2011) of MoneyTree™ Survey.

Findings

- In 2010, the size of the average venture capital investment in the United States was about $6.7 million per deal. This is a decline from $13 million per deal in 2000 expressed in current dollars. The size of venture capital deals has not changed appreciably since 2005.
- After a high venture capital investment in 2000 of over 7,800 deals, the total number of deals has remained essentially constant for the second half of the decade at 3,152 in 2005 and 3,266 in 2010.
- In 2010, the state distribution on this indicator was skewed from a high value of $26 million per deal to a low of zero, with a median value of about $5 million per deal. The value of this indicator continued to show a high level of variability from year to year and among states.

This indicator represents the average size of the venture capital investments being made in a state. The indicator is expressed as the total dollars of venture capital invested in millions divided by the number of companies receiving venture capital. The availability of venture capital may vary widely based on stage of investment, type of company, and numerous other factors.

Venture capital data measure cash-for-equity investments by the professional venture capital community in private emerging companies in the United States. Data exclude debt, buy-outs, recapitalizations, IPOs, and other forms of private equity that do not involve cash. Results are updated periodically. All data are subject to change at any time.

This indicator provides some measure of the magnitude of investment that developing companies in a state have attracted from venture capital sources. Some states have relatively few venture capital deals taking place in a given year; thus, the value of this indicator may show large fluctuations on a year-to-year basis. Twenty states reported fewer than 10 venture capital deals in 2010. In such states, a single large or small venture capital investment can substantially affect the value of this indicator.

Table 8-58
Venture capital disbursed per venture capital deal, by state: 2000, 2005, and 2010

State	Venture capital disbursed ($millions)			Venture capital deals			Venture capital/deal ($millions)		
	2000	2005	2010	2000	2005	2010	2000	2005	2010
United States	104,678	23,115	21,799	7,873	3,152	3,266	13.30	7.33	6.67
Alabama	266	20	1	28	3	2	9.51	6.73	0.30
Alaska	4	0	0	1	0	0	3.50	0.00	0.00
Arizona	626	123	83	64	25	17	9.77	4.94	4.88
Arkansas	34	13	5	5	2	1	6.86	6.30	5.00
California	43,034	11,011	10,978	2,938	1,310	1,289	14.65	8.40	8.52
Colorado	4,165	644	468	218	76	77	19.10	8.47	6.07
Connecticut	1,509	202	200	116	32	52	13.01	6.30	3.85
Delaware	135	7	31	4	3	9	33.68	2.40	3.45
District of Columbia	478	28	96	44	11	11	10.87	2.52	8.77
Florida	2,687	329	186	185	55	39	14.52	5.98	4.76
Georgia	2,325	254	333	223	63	63	10.43	4.04	5.29
Hawaii	203	12	11	3	4	5	67.67	2.98	2.30
Idaho	20	8	8	4	2	4	4.88	4.00	1.94
Illinois	2,358	277	575	199	54	60	11.85	5.14	9.59
Indiana	269	104	69	26	10	14	10.35	10.36	4.90
Iowa	31	32	52	4	4	2	7.70	8.03	25.75
Kansas	265	2	42	22	4	36	12.04	0.43	1.16
Kentucky	202	32	12	14	3	14	14.41	10.67	0.85
Louisiana	113	4	18	15	4	3	7.51	1.00	5.98
Maine	140	5	2	15	2	5	9.35	2.25	0.44
Maryland	1,820	488	357	175	101	70	10.40	4.84	5.10
Massachusetts	10,312	2,583	2,373	766	366	351	13.46	7.06	6.76
Michigan	337	81	152	53	19	33	6.36	4.25	4.59
Minnesota	1,039	242	140	109	43	26	9.53	5.64	5.37
Mississippi	20	10	0	3	2	0	6.50	5.00	0.00
Missouri	590	56	61	49	10	14	12.05	5.60	4.35
Montana	17	27	2	3	2	2	5.57	13.70	0.96
Nebraska	143	13	12	10	3	3	14.31	4.37	3.83
Nevada	31	159	29	10	9	3	3.08	17.61	9.53
New Hampshire	751	92	57	56	24	10	13.40	3.85	5.69
New Jersey	3,290	887	451	185	74	71	17.79	11.99	6.35
New Mexico	21	76	23	8	15	13	2.64	5.09	1.78
New York	6,835	1,127	1,339	605	129	266	11.30	8.74	5.03
North Carolina	1,825	395	456	153	51	57	11.93	7.74	8.00
North Dakota	6	0	0	1	0	0	6.10	0.00	0.00
Ohio	976	140	157	77	38	52	12.67	3.68	3.02
Oklahoma	53	0	13	9	0	2	5.83	0.00	6.50
Oregon	793	134	174	68	26	33	11.66	5.17	5.26
Pennsylvania	2,873	482	508	254	99	153	11.31	4.86	3.32
Rhode Island	75	76	65	9	13	13	8.29	5.87	4.99
South Carolina	448	3	21	13	1	8	34.43	2.70	2.59
South Dakota	0	0	0	1	0	0	0.30	0.00	0.00
Tennessee	453	89	52	45	21	18	10.07	4.22	2.89
Texas	6,094	1,175	891	466	168	143	13.08	6.99	6.23
Utah	674	192	143	61	28	25	11.04	6.86	5.72
Vermont	46	35	33	4	5	6	11.60	7.04	5.47
Virginia	3,310	526	375	275	87	51	12.03	6.04	7.36
Washington	2,790	837	613	254	126	116	10.98	6.64	5.29
West Virginia	5	11	4	2	5	4	2.25	2.10	0.94
Wisconsin	192	69	122	21	16	19	9.13	4.28	6.41
Wyoming	0	4	10	0	4	1	0.00	1.00	10.00
Puerto Rico	NA	NA	4	10	1	1	NA	NA	4.49

NA = not available

NOTE: Venture capital amounts reported in current dollars.

SOURCE: PricewaterhouseCoopers and National Venture Capital Association, special tabulations (2011) of MoneyTree™ Survey.

Science and Engineering Indicators 2012

Appendix
Methodology and Statistics

Introduction

Science and Engineering Indicators (SEI) contains data compiled from a variety of sources. The purpose of this appendix is to explain the methodological and statistical criteria used to assess possible data sources for inclusion in SEI and to develop statements about the data. It also provides some basic information about how statistical procedures and reasoning are applied.

The first section describes the statistical considerations that are part of the selection process for data sets to be included in SEI. The next section discusses the different types of data (e.g., sample surveys, censuses, and administrative records) used in the report and provides some information about each type. A section on data accuracy follows, discussing factors that can affect accuracy at all stages of the survey process. The last section discusses the statistical testing employed to determine whether differences between sample survey-based estimates are *statistically significant*, i.e., greater than could be expected by chance. The appendix concludes with a glossary of statistical terms commonly used or referred to in the text.

Selection of Data Sources

Four criteria guide the selection of data for SEI:

- **Representativeness**. Data should represent national or international populations of interest.
- **Relevance.** Data sources should include indicators central to the functioning of the science and technology enterprise.
- **Timeliness.** Data that are not part of a time series should be timely, i.e., substantial and unmeasured changes in the population under study should not have occurred since the data were collected.
- **Statistical and methodological quality.** Survey methods used to acquire data should provide sufficient assurance that statements based on statistical analysis of the data are valid and reliable.

Data that are collected by U.S. government agencies and that are products of the federal statistical system meet rigorous statistical and methodological criteria as described below. Unless otherwise indicated, these data are representative of the nation as a whole and of the demographic, organizational, or geographic subgroups that comprise it.

For data collected by governments in other countries and nongovernment sources, including private survey firms and academic researchers, methodological information is examined to assess conformity with the criteria U.S. federal agencies typically use. Government statistical agencies in the developed world cooperate extensively in developing data quality standards and improving international comparability for key data, and methodological information about the data generated by this international statistical system is relatively complete.

Methodological information about data from nongovernmental sources and from governmental agencies outside the international statistical system is often less well documented. These data are evaluated and must meet basic scientific standards for representative sampling of survey respondents and adequate and unbiased coverage of the population under study, and the resulting measurements must be sufficiently relevant and meaningful to warrant publication despite methodological uncertainties that remain after the documentation has been scrutinized. The most important statistical criteria are described in general terms below and in greater detail in the following sections.

Many data sources that contain pertinent information about some segment of the S&E enterprise are not cited in SEI because their coverage of the United States as a nation is partial in terms of geography, incomplete in terms of segments of the population, or otherwise not representative. For example, data may be available only for a limited number of states or studies may be based on populations not representative of the United States as a whole. Similarly, data for other countries should cover and be representative of the entire country. (In some cases, data that have limited coverage or are otherwise insufficiently representative are referenced in sidebars.)

Data included in SEI must be of high quality. Data quality can be measured in a variety of ways, some of which are described in the following sections. Some key dimensions of quality include:

- **Validity.** Data have *validity* to the degree that they accurately measure the phenomenon they are supposed to represent.
- **Reliability.** Data have *reliability* to the degree that the same results would be produced if the same measurement or procedure were performed multiple times on the same population.
- **Lack of bias.** Data are *unbiased* to the degree that estimates from the data do not deviate from the population value of a phenomenon in a systematic fashion.

Data Sources

Much of the data cited in SEI come from surveys. Surveys strive to measure characteristics of target populations. To generalize survey results correctly to the population of interest, a survey's *target population* must be rigorously defined and the criteria determining membership in the population must be applied consistently in determining which units to include in the survey.

Some surveys are censuses (also known as *universe surveys*), in which the survey attempts to obtain data for all population units. The decennial census, in which the target population is all U.S. residents, is the most familiar census survey. SEI uses data from the Survey of Earned Doctorates, an annual census of individuals who earn doctorates from accredited U.S. institutions, for information about the numbers and characteristics of new U.S. doctorate holders.

Other surveys are *sample surveys*, in which data are obtained for only a representative portion of the population units. The Survey of Recent College Graduates, which gathers data on individuals who recently received bachelor's or master's degrees in science, engineering, and health fields from U.S. institutions, is an example of a sample survey.

A sample is a *probability sample* if each unit in the sampling frame has a known, nonzero probability of being selected for the sample. Probability samples are necessary for inferences about a population to be evaluated statistically. Except for some Asian surveys referenced in chapter 7, sample surveys included in SEI use probability sampling. In *nonprobability sampling*, a sample is selected haphazardly, purposively, or conveniently, and inferences about the population cannot be evaluated statistically. Internet surveys and phone-in polls that elicit responses from self-selected individuals are examples of nonprobability sample surveys.

In sample surveys, once a survey's target population has been defined, the next step is to establish a list of all members of that target population (i.e., a *sampling frame*). Members of the population must be selected from this list in a scientific manner so that it will be possible to generalize from the sample to the population as a whole. Surveys frequently sample from lists that to varying extents omit members of the target population, because complete lists are typically unavailable.

Surveys may be conducted of individuals or of organizations, such as businesses, universities, or government agencies. Surveys of organizations are often referred to as *establishment surveys.* An example of an establishment survey used in SEI is the Survey of Research and Development Expenditures at Universities and Colleges.

Surveys may be longitudinal or cross-sectional. In a *longitudinal survey*, the same individuals (or organizations) are surveyed repeatedly. The primary purpose of longitudinal surveys is to investigate how individuals or organizations change over time. The Survey of Doctorate Recipients is a longitudinal sample survey of individuals who received research doctorates from U.S. institutions. SEI uses results from this survey to analyze the careers of doctorate holders.

Cross-sectional surveys provide a "snapshot" at a given point of time. When conducted periodically, cross-sectional surveys produce repeated snapshots of a population, enabling analysis of how the population changes over time. However, because the same individuals or organizations are not included in each survey cycle, cross-sectional surveys cannot, in general, track changes for specific individuals or organizations. National and international assessments of student achievement in K–12 education, such as those discussed in chapter 1, are examples of repeated cross-sectional surveys. Most of the surveys cited in SEI are conducted periodically, although the frequency with which they are conducted varies.

Some of the data in SEI come from *administrative records* (data previously collected for the purpose of administering various programs). Examples of data drawn directly from administrative records in SEI include patent data from the records of government patent offices; bibliometric data on publications in S&E journals, compiled from information collected and published by the journals themselves; and data on foreign S&E workers temporarily in the United States, drawn from the administrative records of immigration agencies.

Many of the establishment surveys that SEI uses depend heavily, although indirectly, on administrative records. Universities and corporations that respond to surveys about their R&D activities often use administrative records developed for internal management or income tax reporting purposes to respond to these surveys.

Surveys are conducted using a variety of modes (e.g., mail, telephone, the Internet, or in person). They can be self or interviewer administered. Many surveys are conducted in more than one mode. For example, the Survey of Graduate Students and Postdoctorates in Science and Engineering, a census of establishments (university departments) from which students earn S&E graduate degrees, collects most of its data via a Web-based questionnaire but also allows respondents to answer a paper questionnaire. The National Survey of College Graduates, a longitudinal sample survey that collects data on individuals with S&E-related degrees and/or occupations, is initially conducted by sending a paper questionnaire by mail. Later, potential participants who did not respond to the questionnaire are contacted via telephone or in person.

Data Accuracy

Accurate information is a primary goal of censuses and sample surveys. Accuracy can be defined as the extent to which results deviate from the true values of the characteristics in the target population. Statisticians use the term "error" to refer to this deviation. Good survey design seeks to minimize survey error.

Statisticians usually classify the factors affecting the accuracy of survey data into two categories: nonsampling and sampling errors. *Nonsampling error* applies to all surveys, including censuses, whereas *sampling error* applies only to sample surveys. The sources of nonsampling error in surveys have analogues for administrative records: the processes through which such records are created affect the degree to which the records accurately indicate the characteristics of relevant populations (e.g., patents, journal articles, immigrant scientists and engineers).

Nonsampling Error

Nonsampling error refers to error related to survey design, data collection, and processing procedures. Each stage of the survey process is a potential source of nonsampling error. For most types, there is no practical method of measuring the extent of nonsampling error. A brief description of five sources of nonsampling error follows. Although for convenience the descriptions occasionally refer to samples, they apply equally to censuses.

Specification Error. Survey questions often do not perfectly measure the concept for which they are intended as indicators. For example, the number of patents is not the same as the amount of invention.

Frame Error. The sampling frame, the list of the target population members used for selecting survey respondents, is often inaccurate. If the frame has omissions or other flaws, the survey is less representative because coverage of the target population is incomplete. Frame errors often require extensive effort to correct.

Nonresponse Error. Nonresponse errors occur because not all members of the sample respond to the survey. *Response rates* indicate what proportion of sample members respond to the survey. Other things being equal, lower response rates create a greater possibility that, had nonrespondents supplied answers to the questionnaire, the survey estimates would have been different.

Nonresponse can cause *nonresponse bias*, which occurs when the people or establishments that respond to a question, or to the survey as a whole, differ in systematic ways from those who do not respond. For example, in surveys of national populations, complete or partial nonresponse is often more likely among lower-income or less-educated respondents. Evidence of nonresponse bias is an important factor in decisions about whether survey data should be included in SEI.

Managers of high-quality surveys, such as those in the U.S. federal statistical system, do research on nonresponse patterns to assess whether and how nonresponse might bias survey estimates. SEI notes instances where reported data may be subject to substantial nonresponse bias.

The response rate does not indicate whether a survey has a problem of nonresponse bias. Surveys with high response rates sometimes have substantial nonresponse bias, and surveys with relatively low response rates, if nonrespondents do not differ from respondents on important variables, may have relatively little.

Measurement Error. There are many sources of measurement error, but respondents, interviewers, and survey questionnaires are the most important. Knowingly or unintentionally, respondents may provide incorrect information. Interviewers may inappropriately influence respondents' answers or record their answers incorrectly. The questionnaire can be a source of error if there are ambiguous, poorly worded, or confusing questions, instructions, or terms, or if the questionnaire layout is confusing.

In addition, the records or systems of information that a respondent may refer to, the mode of data collection, and the setting for the survey administration may contribute to measurement error. Perceptions about whether data will be treated as confidential may affect the accuracy of survey responses to sensitive questions about business profits or personal incomes.

Processing Error. Processing errors include errors in recording, checking, coding, and preparing survey data to make them ready for analysis.

Sampling Error

Sampling error is probably the best-known source of survey error and the most commonly reported measure of a survey's precision or accuracy. Unlike nonsampling error, sampling error can be quantitatively estimated in most scientific sample surveys.

Chance is involved in selecting the members of a sample. If the same, random procedures were used repeatedly to select samples from the population, numerous samples would be selected, each containing different members of the population with different characteristics. Each sample would produce different population estimates. When there is great variation among the samples drawn from a given population, the sampling error is high and there is a large chance that the survey estimate is far from the true population value. In a census, because the entire population is surveyed, there is no sampling error.

Sampling error is reduced when samples are large, and most of the surveys used in SEI have large samples. Sampling error is not a function of the percentage of the population in the sample (when the population is large) or the population size but is a function of the sample size, the variability of the measure of interest, and the methods used to produce estimates from the sample data.

Sampling error is measured by the standard error of the estimate, sometimes called the "margin of error." The standard error of an estimate measures how closely the estimate from a particular sample approximates the average result of all possible samples. The standard error of the estimate is expressed as a range in the size of the difference (e.g., ±2%) between the sample estimate and the average result of all possible samples.

Statistical Testing for Data From Sample Surveys

Statistical tests determine whether differences observed in sample survey data could have happened by chance, i.e., as the result of random variation in which people or establishments in the population were sampled. Differences that are very unlikely to have been produced by chance variations in sample selection are termed *statistically significant.* When SEI reports statements about differences on the basis of sample surveys, the differences are statistically significant at the .05 level. This means that, if there were no true difference in the population, the chance of drawing a sample with the observed difference would be no more than 5%.

A statistically significant difference is not necessarily large, important, or significant in the usual sense of the word. It is simply a difference that cannot be attributed to chance variation in sampling. With the large samples common in SEI data, extremely small differences can be found to be statistically significant. Conversely, quite large differences may not be statistically significant if the sample or population sizes of the groups being compared are small. Occasionally, apparently large differences are noted in the text as not being statistically significant to alert the reader that these differences may have occurred by chance.

Numerous differences are apparent in every table in SEI that reports sample data. The tables permit comparisons between different groups in the survey population and in the same population in different years. It would be impractical to test and indicate the statistical significance of all possible comparisons in tables involving sample data.

As explained in "About Science and Engineering Indicators" at the beginning of this volume, SEI presents indicators. It does not model the dynamics of the S&E enterprise, although analysts could construct models using the data in SEI. Accordingly, SEI does not make use of statistical procedures suitable for causal modeling and does not compute effect sizes for models that might be constructed using these data.

Glossary

Most glossary definitions are drawn from U.S. Office of Management and Budget, Office of Statistical Policy (2006), "Standards and Guidelines for Statistical Surveys" and U.S. Bureau of the Census (2006), "Organization of Metadata, Census Bureau Standard Definitions for Surveys and Census Metadata." In some cases, glossary definitions are somewhat more technical and precise than those in the text, where fine distinctions are omitted to improve readability.

Administrative records: Data collected for the purpose of carrying out various programs (e.g., tax collection).

Bias: Systematic deviation of the survey estimated value from the true population value. Refers to systematic errors that can occur with any sample under a specific design.

Coverage: Extent to which all elements on a frame list are members of the population and to which every element in a population appears on the frame list once and only once.

Coverage error: Discrepancy between statistics calculated on the frame population and the same statistics calculated on the target population. *Undercoverage* errors occur when target population units are missed during frame construction, and *overcoverage* errors occur when units are duplicated or enumerated in error.

Cross-sectional sample survey: Based on a representative sample of respondents drawn from a population at a particular point in time.

Estimate: A numerical value for a population parameter derived from information collected from a survey and/ or other sources.

Estimation error: Difference between a survey estimate and the true value of the parameter in the target population.

Frame: A mapping of the universe elements (i.e., sampling units) onto a finite list (e.g., the population of schools on the day of the survey).

Item nonresponse: Occurs when a respondent fails to respond to one or more relevant item(s) on a survey.

Longitudinal sample survey: Follows the experiences and outcomes over time of a representative sample of respondents (i.e., a cohort).

Measurement error: Difference between observed values of a variable recorded under similar conditions and some fixed true value (e.g., errors in reporting, reading, calculating, or recording a numerical value).

Nonresponse bias: Occurs when the observed value deviates from the population parameter due to differences between respondents and nonrespondents. Nonresponse bias may occur as a result of not obtaining 100% response from the selected units.

Nonresponse error: Overall error observed in estimates caused by differences between respondents and nonrespondents. Consists of a variance component and nonresponse bias.

Nonsampling error: Includes measurement errors due to interviewers, respondents, instruments, and mode; nonresponse error; coverage error; and processing error.

Population: See "target population."

Precision of survey results: How closely results from a sample can reproduce the results that would be obtained from a complete count (i.e., census) conducted using the same techniques. The difference between a sample result and the result from a complete census taken under the same conditions is an indication of the precision of the sample result.

Probabilistic methods: Any of a variety of methods for survey sampling that gives a known, nonzero probability of selection to each member of a target population. The advantage of probabilistic sampling methods is that sampling error can be calculated. Such methods include random sampling, systematic sampling, and stratified sampling. They do not include convenience sampling, judgment sampling, quota sampling, and snowball sampling.

Reliability: Degree to which a measurement technique would yield the same result each time it is applied. A measurement can be both reliable and inaccurate.

Response bias: Deviation of the survey estimate from the true population value due to measurement error from the data collection. Potential sources of response bias include the respondent, the instrument, and the interviewer.

Response rates: Measure the proportion of the sample frame represented by the responding units in each study.

Sample design: Sampling plan and estimation procedures.

Sampling error: Error that occurs because all members of the frame population are not measured. It is associated with the variation in samples drawn from the same frame population. The sampling error equals the square root of the variance.

Standard error: Standard deviation of the sampling distribution of a statistic. Although the standard error is used to estimate sampling error, it includes some nonsampling error.

Statistical significance: Attained when a statistical procedure applied to a set of observations yields a *p* value that exceeds the level of probability at which it is agreed that the null hypothesis will be rejected.

Target population: Any group of potential sample units or individuals, businesses, or other entities of interest.

Unit nonresponse: Occurs when a respondent fails to respond to all required response items (i.e., fails to fill out or return a data collection instrument).

Universe survey: Involves the collection of data covering all known units in a population (i.e., a census).

Validity: Degree to which an estimate is likely to be true and free of bias (systematic errors).

List of Appendix Tables

Detailed appendix tables are available online at http://www.nsf.gov/statistics/indicators/appendix/.

Chapter 1. Elementary and Secondary Mathematics and Science Education

Chapter 2. Higher Education in Science and Engineering

Chapter 3. Science and Engineering Labor Force

Chapter 4. Research and Development: National Trends and International Comparisons

Chapter 5. Academic Research and Development

Chapter 6. Industry, Technology, and the Global Marketplace

Chapter 7. Science and Technology: Public Attitudes and Understanding

Chapter 8. State Indicators

Index

A

D

E

F

M

N

S

T

www.nsf.gov/statistics/indicators/

The complete *Science and Engineering Indicators 2012* report, appendix tables, and related resources are available on the Web at www.nsf.gov/statistics/indicators/.

To obtain printed copies of *Science and Engineering Indicators 2012* (NSB 12-01), use NSF's online publication request form, http://www.nsf.gov/publications/orderpub.jsp, or call (703) 292-7827.

Scan this code for direct access to online content. (Requires a mobile device with camera and QR/ Barcode scanner app.)