# Chapter 4
# Research and Development: National Trends and International Comparisons

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# Highlights

## Trends in U.S. R&D Performance

**The total of U.S. research and development performance returned to current dollar growth in 2010 and 2011. On a constant dollar basis, however, U.S. total R&D in 2011 remains slightly below that for 2008, and the 2009 and 2010 levels are noticeably below the 2008 level.**

- Overall R&D performed in the United States totaled $406.7 billion (current dollars) in 2010, roughly the same as the 2009 level of $404.7 billion. U.S. R&D in 2011 totaled $424.4 billion, an increase of $17.7 billion.
- This growth in U.S. R&D expenditures in 2011 followed a 2-year period of stagnation (2009 and 2010). This resulted chiefly from a drop in business R&D in the face of the national and international financial crisis and economic downturn that started in late 2008.
- This seeming return to growth in 2011 is less apparent, however, when the U.S. R&D data are adjusted for inflation. On a constant dollar basis, the U.S. total R&D in 2011 is essentially equal to the 2008 level.

**The business sector continues to account for most of U.S. R&D performance and U.S. R&D funding.**

- The business sector performed $294 billion of R&D in 2011, or 69% of the U.S. total, drawing on business, federal sources, and other sources of R&D support. The business sector itself provided $267 billion of funding for R&D in 2011, or 63% of the U.S. total, most all of which supported R&D performed by business.
- Even with the declining levels of R&D expenditures in both 2009 and 2010, business R&D performance 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 $63 billion in 2011, or about 15% of the national total.
- The federal government is the second-largest funder of U.S. R&D, accounting for an estimated $126 billion, or 30% of U.S. total R&D performance in 2011.

**Most of U.S. basic research is conducted at universities and colleges and funded by the federal government. However, the largest share of U.S. total R&D is development, which is largely performed by the business sector. The business sector also performs the majority of applied research.**

- In 2011, basic research was about 18% ($75 billion) of total U.S. R&D performance, applied research was about 19% ($82 billion), and development was about 63% ($267 billion).
- Universities and colleges historically have been the main performers of U.S. basic research, and they accounted for about 55% of all U.S. basic research in 2011. The federal government remains the primary source of basic research funding, accounting for about 55% of all such funding in 2011.
- The business sector is the predominant performer of applied research, accounting for 57% of all U.S. applied research in 2011. Business is also the largest source of funding for applied research, providing 53% in 2011.
- Development is by far the largest component of U.S. R&D. Funding for development comes primarily from the business sector (78% in 2011); nearly all of the rest comes from the federal government.

## International Comparisons of R&D Performance

**The top three R&D-performing countries—United States, China, and Japan—accounted for over half of the estimated $1.435 trillion in global R&D in 2011.**

- The United States, the largest single R&D-performing country, accounted for just under 30% of the 2011 global total, down from 37% in 2001.
- The economies of East/Southeast and South Asia—including China, India, Japan, Malaysia, Singapore, South Korea, and Taiwan—represented 25% of the global R&D total in 2001 but accounted for 34% in 2011. China (15%) and Japan (10%) were the largest R&D performers in this group.
- The pace of real growth over the past 10 years in China's overall R&D remains exceptionally high at about 18% annually, adjusted for inflation.
- The European Union accounted for 22% total global R&D in 2011, down from 26% in 2001.

**High-income countries, which tend to emphasize production of high-technology goods and services, devote larger shares of their GDP to R&D.**

- The U.S. R&D/gross domestic product (GDP) ratio (or R&D intensity) was just over 2.8% in 2011 and has fluctuated between 2.6% and 2.9% during the past 10 years, largely reflecting changes in business R&D spending.
- In 2011, the United States ranked 10th in R&D intensity—surpassed by Israel, South Korea, Finland, Japan, Sweden, Denmark, Taiwan, Germany, and Switzerland. However, all of these economies performed much less R&D annually than the United States.
- Among the top European R&D-performing countries, Germany reported a 2.9% R&D/GDP ratio in 2011, France reported 2.2%, and the United Kingdom reported 1.8%.

- South Korea's R&D/GDP ratio moved upward to 4.0% in 2011. Japan's ratio was 3.4%. China's ratio remains comparatively low, somewhat above 1.8%, but has more than doubled from just under 1.0% in 2001.

## U.S. Business R&D

**In 2011, business R&D performance reached $294 billion, a record in current dollars but still below the 2008 peak when measured in inflation-adjusted dollars.**

- Total U.S. business R&D performance increased from 2010 to 2011 by 5%. However, when measured in inflation-adjusted dollars, 2011 business R&D performance of $259.4 billion is still below the 2008 peak of $267.7 billion, at the beginning of the most recent recession.
- Funding from business and other nonfederal sources increased 5.1% in constant dollars in 2011, the first such increase since 2008. On the other hand, federally funded business R&D as reported by performers dropped 10% in constant dollars in 2011 after a 15% decline in 2010.

## R&D by Multinational Companies

**The majority of R&D by U.S. multinational companies (MNCs) is still performed in the United States (84.1% of their $252 billion in R&D globally in 2010). Europe hosts the largest expenditures of R&D performed by majority-owned foreign affiliates (MOFAs) of U.S. MNCs, but affiliates in other regions, especially in Asia, are increasing their shares.**

- Parent companies of U.S. MNCs performed $212.5 billion of R&D in the United States, according to preliminary 2010 data. Their MOFAs performed $39.5 billion, so that U.S. MNCs as a whole performed $252.0 billion in R&D globally in 2010, up 2.2% from the $246.5 billion performed in 2009.
- European host countries accounted for 62% of U.S. MOFA R&D in 2010. Asia-Pacific was the second-largest host region for U.S. MOFA R&D with 21.1%, including 4.8% in Japan and a record high of 16.3% in the rest of the region. The Middle East and Latin America each accounted for about 5% in 2010, up from 3.0% and 3.4%, respectively, in 2007.
- Europe, Canada, and Japan have long hosted the majority of R&D by U.S. MOFAs. Seven of 13 countries with at least $1 billion in U.S. MOFA R&D in 2010 are in Europe. However, rapid growth in reported R&D by U.S. MOFAs in China, India, Brazil, and Israel has put these locations in the billion-dollar-plus category.
- U.S.-owned MOFA R&D in China more than doubled from 2005 to 2008, with year-to-year double-digit increases to a record $1.7 billion in 2008, although it declined to $1.5 billion by 2010. U.S. MOFA R&D tripled in India and more than doubled in Brazil from 2007 to 2010, growing much faster than U.S. MOFA production activity in those countries, according to preliminary 2010 statistics. Brazil's and India's U.S. MOFA R&D expenditures are now on par with affiliates in China.

## Federal R&D Performance and Funding

**Federal spending on R&D increased annually on both current and constant dollar bases from the late 1990s through FY 2010. Funding dropped in FY 2011, which was a noticeable departure from the recent trend.**

- Federal obligations for the total of R&D and R&D plant were $136 billion in FY 2011 ($132 billion for R&D and an additional $4 billion for R&D plant). The corresponding data for FYs 2009 and 2010 were higher: $145 billion and $147 billion, respectively.
- 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. Over the last two decades, the greatest change in federal R&D priorities has been the rise in health-related R&D.
- Fifteen federal departments and 12 other agencies engage in and/or fund R&D in the United States. Nine of these departments/agencies reported R&D spending in FY 2011 in excess of $1 billion, and the nine together accounted for 97% of all federal obligations for R&D that year: the Departments of Agriculture, Commerce, Defense, Energy, Health and Human Services, Homeland Security, and Transportation; the National Science Foundation; and the National Aeronautics and Space Administration.

## Federal Programs to Promote Technology Transfer and the Commercialization of Federal R&D

**The federal government has been active since the early 1980s in establishing policies and programs to better transfer and economically exploit the results of federally funded R&D.**

- The latest statistics suggest that the federal departments/agencies accounting for the largest portion of federal R&D continue to be active in their use of the technology transfer authorities provided by the Technology Innovation Act of 1980 (Stevenson-Wydler Act) and subsequent legislation.
- The levels of funding going to small, entrepreneurial companies engaged in R&D with eventual commercialization objectives, through the Small Business Innovation Research and Small Business Technology Transfer programs, are now vastly larger than when these programs were first initiated in, respectively, the early 1980s and the mid-1990s.

# Introduction

### Chapter Overview

This chapter discusses how different economic sectors—including business, the federal government, and universities and colleges—contributed to recent trends in research and development funding and performance. It emphasizes R&D in the business and federal sectors (chapter 5 covers academic R&D in detail).

The importance of these trends to national welfare is highlighted by the recent change in the U.S. gross domestic product (GDP) and related National Income and Product Accounts treating R&D as investment. The change recognizes R&D as a long-term contributor to GDP growth (see sidebar, "R&D in the U.S. National Income and Product Accounts").

In addition to U.S. R&D trends, this chapter presents international R&D comparisons at the national and economic sector levels. One major trend highlighted here is the particularly rapid expansion of R&D performance in Asia. The chapter also details the distribution of R&D performed by foreign affiliates of U.S. multinational companies (MNCs).

### Chapter Organization

This chapter is organized in eight sections covering national R&D totals, business activity, and government efforts in the United States and internationally. The first two sections cover U.S. and international comparisons in national R&D performance and funding.

The next three sections detail business sector R&D from the perspective of U.S. domestic activity, MNCs owned by U.S. parent companies or located in the United States, and cross-national industry R&D comparisons. The last three sections provide further detail on the R&D performed and/or funded by the U.S. federal government, compare the national government R&D priorities of the United States and the other major R&D-performing countries, and discuss several U.S. federal programs to promote technology transfer and commercialization.

## Trends in U.S. R&D Performance

The U.S. R&D system consists of a variety of performers and sources of funding. These include businesses, the federal government, universities and colleges, other government (nonfederal) agencies, 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. This section discusses the current levels and notable recent trends in overall U.S. R&D performance and funding. (Definitions for key terms in this section appear in this chapter's glossary. The sidebar "Measured and Unmeasured R&D" discusses the main data sources that provide the basis for this analysis. Appendix tables 4-1–4-9 provide additional core data on U.S. R&D funding and performance.)

## R&D in the U.S. National Income and Product Accounts

The most recent comprehensive revision of the U.S. GDP and related National Income and Product Accounts (NIPA), released July 2013 by the U.S. Bureau of Economic Analysis (BEA), includes a change to treat R&D as a fixed investment with long-term benefits. Prior to the change, NIPA considered R&D as an expense or as an intermediate input cost in the business sector and as consumption in the government and nonprofit sectors (BEA 2013). This update is one of several NIPA changes aimed at capturing the role of intangible assets in economic growth. Intangibles or intellectual property products include software, R&D, and entertainment, literary, and artistic originals. (For background on the July 2013 release, see http://www.bea.gov/national/an1.htm; for full, revised NIPA statistics, see http://www.bea.gov/national/index.htm#gdp.) The National Science Foundation's surveys serve as the primary data source for the R&D component of these revisions. For further details, see the forthcoming InfoBrief on incorporating R&D as investment in GDP statistics at http://www.nsf.gov/statistics.

### U.S. Total R&D and R&D Intensity

R&D performed in the United States totaled $424.4 billion (current dollars) in 2011, an increase of $17.7 billion over the previous year (table 4-1). The comparable total in 2008 was $406.6 billion, having increased $26.9 billion over the previous year. However, 2009 and 2010 were more difficult years for what has, over the longer term, been a mainly expanding U.S. R&D enterprise (figure 4-1). In 2009 and 2010, total U.S. R&D fluctuated narrowly around the 2008 level, showing little expansion ($404.7 billion in 2009; $406.7 billion in 2010). These circumstances resulted chiefly from a lowered level of business R&D in the face of the national and international financial crisis and economic downturn that started in late 2008 (figure 4-2).

The challenging path for U.S. R&D performance over the last several years is more apparent when the R&D expenditure figures are adjusted for inflation.[1] On a constant dollar basis, U.S. total R&D in 2010 was below the 2008 level (table 4-1). Furthermore, the 2011 level only barely returns to the 2008 level. Much the same is true for R&D performance by the business sector (which accounts for around two-thirds of all U.S. R&D performance), although even in 2011 this sector's R&D remains well below the 2008 level in inflation-adjusted terms (table 4-1).

U.S. total R&D grew by 4.4% in 2011, compared with a 3.9% expansion of GDP that year (table 4-2).[2] These relative changes better mirror what has been the "historical" pattern of R&D and GDP growth than the experiences of 2009 or 2010. As a matter of longer-term averages, the growth of U.S. total R&D has outpaced that of the nation's GDP—whether the averaging period is the past 5, 10, or 20 years (table 4-2). But, again, 2009 and 2010 were notably different experiences. U.S. total R&D dropped by 0.5% in 2009 mainly because of the hefty decline in R&D performed by the business sector (figure 4-2). GDP declined even more sharply that year, by 2.5%. GDP rebounded in 2010, growing by 4.2% over the 2009 level. R&D, however, did not match this pace, growing by only 0.5% over the 2009 level—held back by another year of decline in business sector R&D expenditures (figure 4-2). R&D's return to a more familiar pace of growth in 2011 owes much to the return of a relatively high rate of expansion of business sector R&D (table 4-2; figure 4-2). (Preliminary data for 2012, available too late to incorporate in this chapter's charts and tables, put the U.S. R&D total at $452.6 billion that year, an increase of 5.7% over the prior year, well ahead of the 4.0% pace of

## Measured and Unmeasured R&D

The statistics on U.S. R&D discussed in this section reflect the National Science Foundation's (NSF's) periodic National Patterns of R&D Resources reports and data series, which provide a comprehensive account of total U.S. R&D performance. The National Patterns data, in turn, derive from five major NSF surveys of the organizations that perform the bulk of U.S. R&D:

- Business R&D and Innovation Survey
- Higher Education R&D Survey
- Survey of Federal Funds for R&D
- Survey of R&D Expenditures at Federally Funded R&D Centers
- Survey of R&D Funding and Performance by Nonprofit Organizations

The National Patterns analysis integrates R&D spending and funding data from these separate surveys into U.S. R&D performance totals, which are then reported on a calendar-year basis and for the main performing sectors and funding sources.

Because of practical constraints in the surveys, 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.

The U.S. business R&D estimates are derived from a survey of R&D-performing companies with five or more employees. No estimates of R&D performance currently are available for companies with fewer than five employees. (NSF is in the process of designing and implementing a Microbusiness Innovation and Science and Technology Survey, which will collect data from companies with fewer than five employees.)

Until recently, the U.S. statistics for business R&D did not include social science R&D, and, likewise, R&D in the humanities and other non-S&E fields (such as law) was excluded from the U.S. academic R&D statistics. Other countries include both of these R&D components in their national statistics, making their national R&D expenditures relatively larger when compared with those of the United States. Both of these shortfalls are now addressed in the U.S. statistics. NSF's Business R&D and Innovation Survey—which replaced the previous Survey of Industrial R&D, starting with the 2008 data year—includes social science R&D. Also, the Higher Education R&D Survey—which replaced the previous Survey of R&D Expenditures at Universities and Colleges, starting with the 2010 academic fiscal year—directly includes non-S&E R&D expenditures in the reported academic R&D totals. (The academic R&D totals reported by the National Patterns statistics have been revised back to 2003 to include the non-S&E R&D expenditures.)

The statistics for academic R&D track research expenditures that are separately accounted for in both sponsored research and institutionally funded research. U.S. universities do not report funds for research that are not separately accounted for, such as estimates of faculty time spent on research. This can be a limitation in international R&D comparisons because such estimates are often included in the national statistics of other countries.

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 performed by state governments are collected in a biennial NSF/U.S. Census Bureau survey, but these amounts (typically totaling only several hundred million dollars annually) are not yet regularly included in the National Patterns totals. Moreover, 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 commissioned the National Research Council's Committee on National Statistics to review the methodologies used in preparing the National Patterns data. The review panel began work in mid-2011 and provided its report in early 2013.

GDP growth, and mainly again the result of increased business R&D. This continuation in 2012 of the strong pace of R&D growth in 2011 suggests a return to the longer-term trend of R&D expansion in the wake of the 2008–09 domestic and international economic downturns [Boroush 2013].)

A consequence of these shifting growth rates is that the R&D intensity of the national economy (the ratio of R&D expenditures to GDP) exhibited a noticeable decline in 2010 and 2011, compared with the earlier years (figure 4-3). (The ratio of total national R&D expenditures to GDP is often reported as a measure of the intensity of a nation's overall R&D effort and is widely used as an international benchmark for comparing countries' R&D systems.)

U.S. expenditures on R&D totaled 2.80% of GDP in 2010 and 2.81% in 2011. Both of these figures are lower than the 2.90% ratio that prevailed in 2009 (figure 4-3). Over the 10-year period from 2001 to 2011, the ratio has fluctuated to some degree year to year, between a low of 2.57% in 2004 and a high of 2.90% in 2009. The ratio had been rising since

Table 4-1
**U.S. R&D expenditures, by performing sector and source of funding: 2006–11**

| Sector | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|
| | Current $millions | | | | | |
| All performing sectors | 352,567 | 379,681 | 406,610 | 404,697 | 406,708 | 424,413 |
| Business | 247,669 | 269,267 | 290,681 | 282,393 | 278,977 | 294,093 |
| Federal government | 41,611 | 44,133 | 45,649 | 47,363 | 48,939 | 49,394 |
| Federal intramural[a] | 28,240 | 29,859 | 29,839 | 30,560 | 31,217 | 31,505 |
| FFRDCs | 13,371 | 14,274 | 15,810 | 16,804 | 17,985 | 17,889 |
| Industry administered[b] | 3,122 | 5,165 | 6,346 | 6,646 | 7,214 | 7,037 |
| U&C administered[b] | 7,306 | 5,567 | 4,766 | 5,052 | 5,315 | 5,294 |
| Nonprofit administered | 2,943 | 3,543 | 4,698 | 5,106 | 5,457 | 5,558 |
| Universities and colleges | 48,951 | 51,149 | 53,917 | 56,939 | 60,235 | 63,102 |
| Other nonprofit organizations | 14,336 | 15,132 | 16,363 | 18,002 | 18,294 | 17,825 |
| All funding sectors | 352,567 | 379,681 | 406,610 | 404,697 | 406,708 | 424,413 |
| Business | 227,110 | 246,741 | 258,691 | 247,274 | 249,182 | 267,290 |
| Federal government | 101,558 | 106,858 | 119,423 | 127,467 | 126,962 | 125,686 |
| Universities and colleges | 10,076 | 10,833 | 11,640 | 11,884 | 11,990 | 12,488 |
| Nonfederal government | 3,182 | 3,438 | 3,706 | 3,808 | 3,782 | 3,832 |
| Other nonprofit organizations | 10,641 | 11,810 | 13,151 | 14,264 | 14,793 | 15,117 |
| | Constant 2005 $millions | | | | | |
| All performing sectors | 341,532 | 357,426 | 374,472 | 368,815 | 366,434 | 374,394 |
| Business | 239,917 | 253,484 | 267,706 | 257,355 | 251,351 | 259,433 |
| Federal government | 40,308 | 41,546 | 42,041 | 43,164 | 44,330 | 43,572 |
| Federal intramural[a] | 27,356 | 28,109 | 27,480 | 27,850 | 28,126 | 27,792 |
| FFRDCs | 12,953 | 13,438 | 14,560 | 15,314 | 16,204 | 15,780 |
| Industry administered[b] | 3,024 | 4,862 | 5,844 | 6,057 | 6,499 | 6,207 |
| U&C administered[b] | 7,078 | 5,241 | 4,389 | 4,604 | 4,789 | 4,670 |
| Nonprofit administered | 2,851 | 3,335 | 4,327 | 4,653 | 4,916 | 4,903 |
| Universities and colleges | 47,419 | 48,151 | 49,656 | 51,891 | 54,270 | 55,665 |
| Other nonprofit organizations | 13,888 | 14,245 | 15,070 | 16,406 | 16,482 | 15,724 |
| All funding sectors | 341,532 | 357,426 | 374,472 | 368,815 | 366,434 | 374,394 |
| Business | 220,002 | 232,278 | 238,244 | 225,349 | 224,506 | 235,788 |
| Federal government | 98,379 | 100,595 | 109,984 | 116,165 | 114,390 | 110,873 |
| Universities and colleges | 9,760 | 10,198 | 10,720 | 10,831 | 10,802 | 11,016 |
| Nonfederal government | 3,083 | 3,237 | 3,413 | 3,471 | 3,408 | 3,381 |
| Other nonprofit organizations | 10,308 | 11,118 | 12,111 | 12,999 | 13,328 | 13,335 |

FFRDC = federally funded R&D center; U&C = university and college.

[a] Includes expenditures of federal intramural R&D and costs associated with administering extramural R&D.

[b] Los Alamos National Laboratory (some $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 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 1 July instead of 1 October.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources (annual series).

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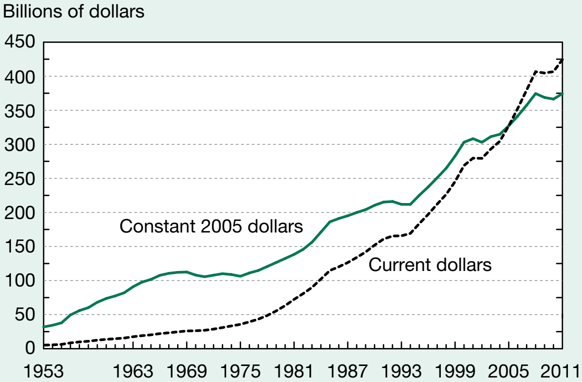
2004 (figure 4-3). The lower levels in 2010 and 2011 represent a noticeable reversal.

Most of the rise of the R&D/GDP ratio over the past several decades has come from the increase of nonfederal spending on R&D, particularly that by the business sector (figure 4-3). This reflects the growing role of business R&D in the national R&D system and, in turn, the growing prominence of R&D-derived goods and services in the national and global economies. By contrast, the ratio of federal R&D spending to GDP declined from the mid-1980s to the late 1990s, notably from cuts in defense-related R&D. There had been a gradual uptick through 2009, the result of increased federal spending on biomedical and national security R&D and the one-time incremental funding for R&D provided by the American Recovery and Reinvestment Act of 2009 (ARRA).

Figure 4-1
**U.S. total R&D expenditures: 1953–2011**




SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources (annual series). See appendix table 4-2.

*Science and Engineering Indicators 2014*

## Performers of R&D

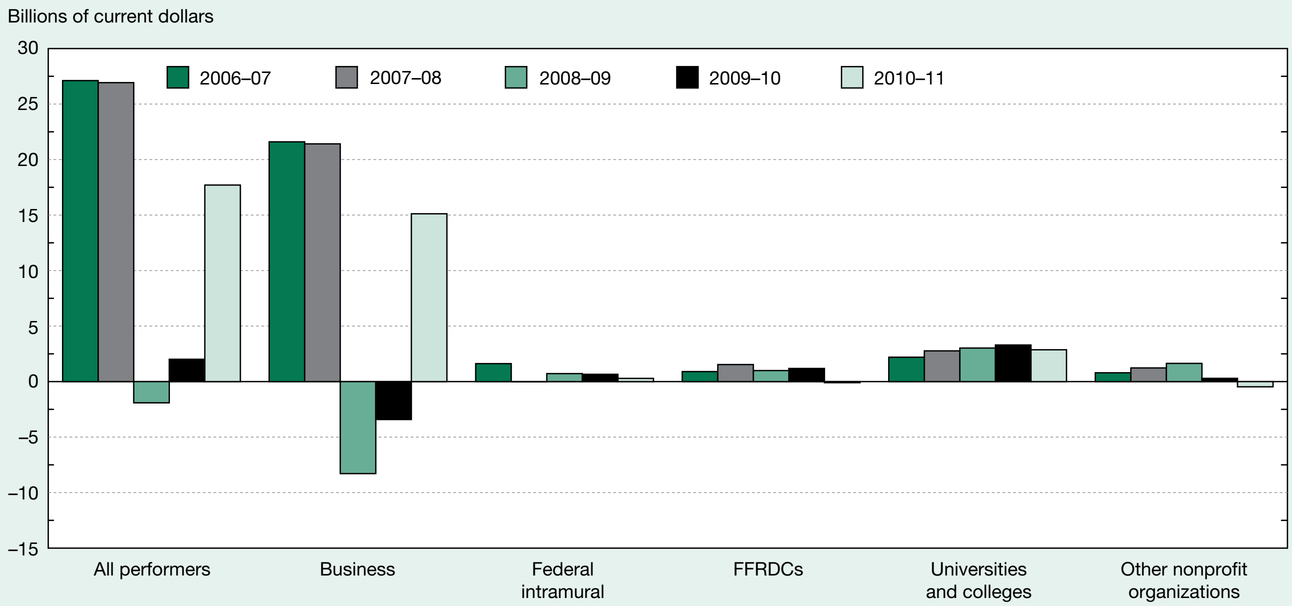
The National Science Foundation (NSF) tracks the R&D spending patterns of all the major performers in the overall U.S. R&D system: businesses, the intramural R&D activities of federal agencies, federally funded research and development centers (FFRDCs), universities and colleges, and other nonprofit organizations.

### *Business Sector*

In 2011, the business sector continued to be the largest performer of U.S. R&D, conducting $294.1 billion, or 69%, of the national total (table 4-1; figure 4-4). The 2011 level of business R&D performance rose over the 2010 level ($279.0 billion) and reversed apparent declines in 2009 and 2010. Over the 5-year period of 2006–11, business R&D performance grew an average of 3.5% annually, although somewhat behind the 3.8% rate of growth of overall U.S. R&D (table 4-2).

The business sector's predominance in the composition of national R&D has long been the case, with its annual

Figure 4-2
**Year-to-year changes in U.S. R&D expenditures, by performing sector: 2006–11**




FFRDC = federally funded R&D center.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources (annual series).

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share ranging between 68% and 74% over the 20-year period of 1991–2011 (figure 4-5).

### *Universities and Colleges*

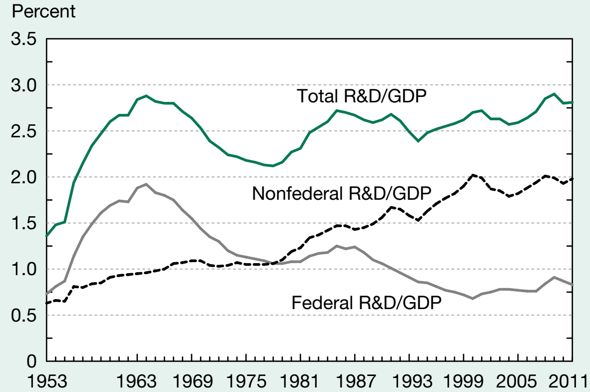
Academia is the second-largest performer of U.S. R&D. Universities and colleges performed $63.1 billion,[3] or 15%, of U.S. R&D in 2011 (table 4-1; figure 4-4). The total of academic R&D performance has increased by several billion dollars each year since 2006. Annual growth of R&D in this sector has averaged 5.2% over the period of 2006–11, well ahead of the rate of total national R&D (table 4-2).

Over the 20-year period of 1991–2011, the academic sector's share in U.S. R&D has ranged between 11% and 15% annually. Furthermore, as discussed below, universities and colleges have a special niche in the nation's R&D system: they performed more than half (55%) of the nation's basic research in 2011.

### *Federal Agencies and FFRDCs*

R&D performed by the federal government includes the activities of agency intramural laboratories and that of the FFRDCs. Federal intramural R&D performance includes the spending for both agency laboratory R&D and for agency activities to plan and administer intramural and extramural R&D projects. FFRDCs are R&D-performing organizations

Figure 4-3
**Ratio of U.S. R&D to gross domestic product, by federal and nonfederal funding for R&D: 1953–2011**




GDP = gross domestic product.

NOTE: 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).

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Table 4-2
**Annual rates of growth in U.S. R&D expenditures, total and by performing sectors: 1991–2011**
(Percent)

| | Longer-term trend | | | Most recent years | | |
|---|---|---|---|---|---|---|
| Expenditures and gross domestic product | 1991–2011 | 2001–11 | 2006–11 | 2008–09 | 2009–10 | 2010–11 |
| | Current dollars | | | | | |
| Total R&D, all performers | 5.0 | 4.3 | 3.8 | -0.5 | 0.5 | 4.4 |
| Business | 4.8 | 3.8 | 3.5 | -2.9 | -1.2 | 5.4 |
| Federal government | 3.8 | 4.2 | 3.5 | 3.8 | 3.9 | 0.4 |
| Federal intramural[a] | 3.7 | 3.5 | 2.2 | 2.4 | 2.2 | 0.9 |
| FFRDCs | 4.0 | 5.5 | 6.0 | 6.3 | 7.0 | -0.5 |
| Universities and colleges | 6.4 | 6.5 | 5.2 | 5.6 | 5.8 | 4.8 |
| Other nonprofit organizations | 6.9 | 4.8 | 4.5 | 10.0 | 1.6 | -2.6 |
| Gross domestic product | 4.7 | 3.9 | 2.4 | -2.5 | 4.2 | 3.9 |
| | Constant 2005 dollars | | | | | |
| Total R&D, all performers | 2.8 | 2.0 | 1.9 | -1.5 | -0.6 | 2.2 |
| Business | 2.7 | 1.5 | 1.6 | -3.9 | -2.3 | 3.2 |
| Federal government | 1.7 | 1.9 | 1.6 | 2.7 | 2.7 | -1.7 |
| Federal intramural[a] | 1.6 | 1.2 | 0.3 | 1.3 | 1.0 | -1.2 |
| FFRDCs | 1.9 | 3.2 | 4.0 | 5.2 | 5.8 | -2.6 |
| Universities and colleges | 4.2 | 4.1 | 3.3 | 4.5 | 4.6 | 2.6 |
| Other nonprofit organizations | 4.7 | 2.5 | 2.5 | 8.9 | 0.5 | -4.6 |
| Gross domestic product | 2.6 | 1.6 | 0.5 | -3.5 | 3.0 | 1.7 |

FFRDC = federally funded R&D center.

[a] Includes expenditures of federal intramural R&D and 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).

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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. (There were 40 FFRDCs in 2011; see appendix table 4-10). Each FFRDC is administered by an industrial firm, a university, a nonprofit institution, or a consortium.

The federal government conducted $49.4 billion, or 12%, of U.S. R&D in 2011 (table 4-1; figure 4-4). Of this amount, $31.5 billion (7% of the U.S. total) was intramural R&D performed by federal agencies in their own research facilities, and $17.9 billion (4%) was R&D performed by the 40 FFRDCs.

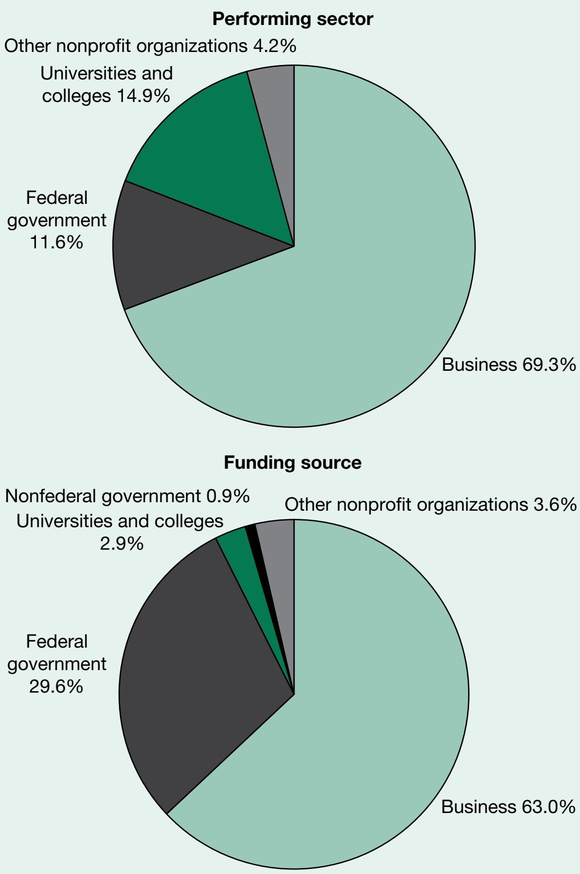
The federal total was up only barely in 2011 (an increase of $0.5 billion over the prior year). Over the 2006–11 period more generally, however, it has increased from $1 billion to $2 billion annually (table 4-1). In 1991, the federal performance share was 15%, but it gradually declined in the years since 2006, ranging annually between 11% and 12%.

The volume of the federal government's R&D performance is relatively small compared with that of the U.S. business sector. Even so, the $49.4 billion performance total in 2011 exceeded the total national R&D expenditures of every country except China, Japan, Germany, South Korea, and France.[4]

### Other Nonprofit Organizations

R&D performed in the United States by nonprofit organizations other than universities and certain FFRDCs was estimated at $17.8 billion in 2011 (table 4-1). This was 4%

Figure 4-4
**Shares of U.S. total R&D expenditures, by performing sector and funding source: 2011**




NOTES: National R&D expenditures are estimated to be $424.4 billion in 2011. Federal performing sector includes federal agencies and federally funded R&D 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 4-2 and 4-6.

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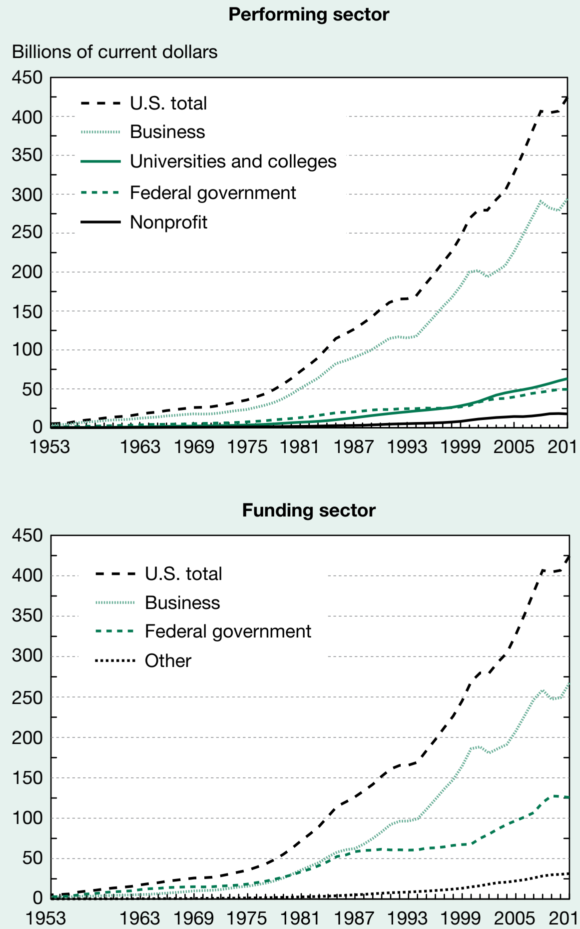
Figure 4-5
**U.S. R&D, by performing and funding sectors: 1953–2011**




NOTES: Federal performers of R&D include federal agencies and federally funded R&D 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 4-2 and 4-6.

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of U.S. R&D in 2011, a share that has been largely the same since 2000 (figure 4-4).

### *Geographic Location of R&D*

The sidebar "Location of R&D Performance, by State," summarizes the leading geographic locations of U.S. R&D performance. For additional R&D indicators at the state level, see chapter 8.

## 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 nonfederal government agencies, academic institutions, and other nonprofit organizations. The mix of funding sources varies by performer.

### *R&D Funding by Business*

The business sector is the predominant source of funding for the R&D performed in the United States. In 2011, business sector funding accounted for $267.3 billion, or 63% of the $424.4 billion of total U.S. R&D performance (table 4-1; figure 4-4).

Nearly all of the business sector's funding for R&D (98%) is directed toward business R&D performance (table 4-3).[5] The small remainder goes to academic and other nonprofit performers.

The business sector's predominant role in the nation's R&D funding began in the early 1980s, when the support it provided started to exceed 50% of all U.S. R&D funding (figure 4-6). This business sector share moved up annually until reaching 69% in 2000. However, this share has declined somewhat in the years since, amid rising federal R&D funding, to 64% in 2006 and 63% in 2011.

## Location of R&D Performance, by State

### Distribution of R&D expenditures among the U.S. states

In 2010, 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, Massachusetts, Texas, Maryland, New Jersey, New York, Washington, Illinois, Michigan, and Pennsylvania (table 4-A).* California alone accounted for 22% of the U.S. total, almost 4 times as much as Massachusetts, the next highest state. The top 20 states accounted for 84% of the R&D total; the 20 lowest-ranking states accounted for around 5% (appendix tables 4-11 and 4-12).

The states with the biggest R&D expenditures are not necessarily those with the greatest intensity of R&D. Among those with the highest R&D/GDP ratios in 2010 were New Mexico, Maryland, Massachusetts,

Table 4-A
**Top 10 U.S. states in R&D performance, by sector and intensity: 2010**

| | All R&D[a] | | Sector ranking | | | R&D intensity (R&D/GDP ratio) | | |
|---|---|---|---|---|---|---|---|---|
| Rank | State | Amount (current $millions) | Business | Universities and colleges | Federal intramural and FFRDCs[b] | State | R&D/GDP (%) | GDP (current $billions) |
| 1 | California | 81,005 | California | California | Maryland | New Mexico | 8.07 | 77.1 |
| 2 | Massachusetts | 20,657 | New Jersey | New York | California | Maryland | 6.28 | 293.3 |
| 3 | Texas | 19,504 | Texas | Texas | New Mexico | Massachusetts | 5.47 | 377.8 |
| 4 | Maryland | 18,429 | Massachusetts | Maryland | Virginia | Washington | 4.91 | 339.8 |
| 5 | New Jersey | 17,876 | Washington | Pennsylvania | District of Columbia | California | 4.31 | 1,877.6 |
| 6 | New York | 17,141 | Illinois | Massachusetts | Massachusetts | Michigan | 3.99 | 368.4 |
| 7 | Washington | 16,685 | Michigan | North Carolina | Tennessee | Missouri | 3.80 | 243.4 |
| 8 | Illinois | 15,820 | New York | Illinois | Alabama | New Jersey | 3.72 | 480.4 |
| 9 | Michigan | 14,702 | Pennsylvania | Ohio | Washington | Delaware | 3.64 | 64.0 |
| 10 | Pennsylvania | 13,074 | Missouri | Michigan | Illinois | New Hampshire | 3.50 | 61.6 |

FFRDC = federally funded R&D center; GDP = gross domestic product.

[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 the 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.

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### R&D Funding by the Federal Government

The federal government is the second-largest source of overall funding for U.S. R&D. It is a major source for most U.S. performer sectors except private businesses, where the federal role, while not negligible, is substantially overshadowed by the business sector's own funds.

Funds from the federal government accounted for $125.7 billion, or 30%, of U.S. total R&D in 2011 (table 4-1; figure 4-4). This funding was mainly directed to federal, business, and academic performers, but other nonprofit organizations were also recipients (table 4-3).

Federal funding accounted for all of the $31.5 billion of federal intramural R&D performance in 2011 and nearly all of the $17.9 billion of R&D performed by FFRDCs. (Nonfederal support for FFRDC R&D has been around $0.4 billion in recent years, or less than 1% of total support; see appendix table 4-10.)

Federal funding to the business sector accounted for $31.3 billion of business R&D performance in 2011, or 11% of the sector's R&D total that year (table 4-3). Federal funds to academia supported $38.7 billion (61%) of the $63.1 billion spent on academic R&D in 2011. For the R&D performed by other nonprofit organizations, $6.3 billion (about 35%) of this sector's $17.8 billion of performance was supported by federal funds.

The federal government was once the leading sponsor of the nation's R&D, funding some 67% of all U.S. R&D in 1964 (figure 4-6). The federal share decreased in subsequent years to 49% in 1979, on down to a historical low of 25% in 2000. However, changing business conditions and expanded federal funding for health, defense, and counterterrorism R&D pushed the federal funding share above 30% in 2009 and 2010 and to nearly 30% in 2011. Similarly, through the early 1960s, more than half of the nation's business-performed R&D had been funded by the federal government. This share then declined in subsequent years to below 10% in 2000, but it increased again to 11% by 2011 (appendix table 4-2).

## Location of R&D Performance, by State—continued

and Washington (table 4-A). New Mexico is the location of a number of major government research facilities. Maryland is the site of many government research facilities and growing research universities. Massachusetts benefits from both leading research universities and thriving high-technology industries. Washington State is home to government research facilities, leading research universities, and high-technology industries. California has relatively high R&D intensity and benefits from the presence of Silicon Valley, other high-technology industries, federal R&D, and leading research universities, but it is still fifth on this list.

### 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 R&D facilities, 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 2010, R&D performed by the business sector accounted for about 69% of the U.S. total R&D 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. Missouri, 10th in business sector R&D, surpasses Maryland in the business R&D ranking.

University-performed R&D accounts for 16% 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 R&D facilities and FFRDCs)—about 13% of the U.S. total—is more concentrated geographically than that in other sectors. Only five jurisdictions—Maryland, California, New Mexico, Virginia, and the District of Columbia—account for 63% of all federal R&D performance.† This figure rises to 80% when the other 5 of the top 10 performers—Massachusetts, Tennessee, Alabama, Washington, and Illinois—are included.

Federal R&D accounts for the bulk of total R&D in several states, including New Mexico (84%), which is home to the nation's two largest FFRDCs (Los Alamos and Sandia National Laboratories), and Tennessee (42%), which is home to Oak Ridge National Laboratory. The high figures for Maryland (58%), the District of Columbia (72%), and Virginia (45%) reflect the concentration of federal facilities and federal R&D administrative offices in the national capital area.

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* The latest data available on the distribution of U.S. R&D performance by state are for 2010 (appendix table 4-11). Total U.S. R&D expenditures that year are estimated at $406.7 billion. Of this total, $377.0 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 $11.3 billion in 2010) 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.

Table 4-3
**U.S. R&D expenditures, by performing sector, source of funds, and character of work: 2011**

| Performing sector and character of work | Source of funds ($millions) Total | Business | Federal government | Universities and colleges | Nonfederal government | Other nonprofit organizations | Total expenditures (% distribution) |
|---|---|---|---|---|---|---|---|
| R&D | 424,413 | 267,290 | 125,686 | 12,488 | 3,832 | 15,117 | 100.0 |
| Business | 294,093 | 262,784 | 31,309 | * | * | * | 69.3 |
| Federal government | 49,394 | * | 49,394 | * | * | * | 11.6 |
| Federal intramural | 31,505 | * | 31,505 | * | * | * | 7.4 |
| FFRDCs | 17,889 | * | 17,889 | * | * | * | 4.2 |
| Industry administered | 7,037 | * | 7,037 | * | * | * | 1.7 |
| U&C administered | 5,294 | * | 5,294 | * | * | * | 1.2 |
| Nonprofit administered | 5,558 | * | 5,558 | * | * | * | 1.3 |
| Universities and colleges | 63,102 | 3,173 | 38,710 | 12,488 | 3,832 | 4,899 | 14.9 |
| Other nonprofit organizations | 17,825 | 1,333 | 6,274 | * | * | 10,218 | 4.2 |
| Percent distribution by source | 100.0 | 63.0 | 29.6 | 2.9 | 0.9 | 3.6 | na |
| Basic research | 74,961 | 15,072 | 40,913 | 7,828 | 2,402 | 8,744 | 100.0 |
| Business | 13,020 | 12,343 | 677 | * | * | * | 17.4 |
| Federal government | 11,467 | * | 11,467 | * | * | * | 15.3 |
| Federal intramural | 4,875 | * | 4,875 | * | * | * | 6.5 |
| FFRDCs | 6,592 | * | 6,592 | * | * | * | 8.8 |
| Industry administered | 2,761 | * | 2,761 | * | * | * | 3.7 |
| U&C administered | 2,212 | * | 2,212 | * | * | * | 3.0 |
| Nonprofit administered | 1,619 | * | 1,619 | * | * | * | 2.2 |
| Universities and colleges | 40,952 | 1,989 | 25,662 | 7,828 | 2,402 | 3,071 | 54.6 |
| Other nonprofit organizations | 9,521 | 740 | 3,108 | * | * | 5,673 | 12.7 |
| Percent distribution by source | 100.0 | 20.1 | 54.6 | 10.4 | 3.2 | 11.7 | na |
| Applied research | 82,379 | 43,947 | 30,311 | 3,255 | 999 | 3,866 | 100.0 |
| Business | 47,186 | 42,782 | 4,404 | * | * | * | 57.3 |
| Federal government | 12,885 | * | 12,885 | * | * | * | 15.6 |
| Federal intramural | 7,747 | * | 7,747 | * | * | * | 9.4 |
| FFRDCs | 5,138 | * | 5,138 | * | * | * | 6.2 |
| Industry administered | 2,223 | * | 2,223 | * | * | * | 2.7 |
| U&C administered | 1,314 | * | 1,314 | * | * | * | 1.6 |
| Nonprofit administered | 1,602 | * | 1,602 | * | * | * | 1.9 |
| Universities and colleges | 16,614 | 827 | 10,256 | 3,255 | 999 | 1,277 | 20.2 |
| Other nonprofit organizations | 5,693 | 338 | 2,766 | * | * | 2,590 | 6.9 |
| Percent distribution by source | 100.0 | 53.3 | 36.8 | 4.0 | 1.2 | 4.7 | na |
| Development | 267,074 | 208,271 | 54,461 | 1,405 | 431 | 2,506 | 100.0 |
| Business | 233,887 | 207,659 | 26,228 | * | * | * | 87.6 |
| Federal government | 25,041 | * | 25,041 | * | * | * | 9.4 |
| Federal intramural | 18,884 | * | 18,884 | * | * | * | 7.1 |
| FFRDCs | 6,158 | * | 6,158 | * | * | * | 2.3 |
| Industry administered | 2,053 | * | 2,053 | * | * | * | 0.8 |
| U&C administered | 1,768 | * | 1,768 | * | * | * | 0.7 |
| Nonprofit administered | 2,336 | * | 2,336 | * | * | * | 0.9 |
| Universities and colleges | 5,536 | 357 | 2,792 | 1,405 | 431 | 551 | 2.1 |
| Other nonprofit organizations | 2,610 | 255 | 400 | * | * | 1,955 | 1.0 |
| Percent distribution by source | 100.0 | 78.0 | 20.4 | 0.5 | 0.2 | 0.9 | na |

* = small to negligible amount, included as part of the funding provided by other sectors; na = not applicable.

FFRDC = federally funded R&D center; U&C = university and college.

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.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources (annual series).

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### R&D Funding from Other Sources

The balance of R&D funding from other sources is small: $31.4 billion in 2011, or about 7% of all U.S. R&D performance that year. Of this amount, $12.5 billion (3%) was academia's own institutional funds, all of which remain in the academic sector; $3.8 billion (1%) was from state and local governments, primarily supporting academic research; and $15.1 billion (4%) was from other nonprofit organizations, the majority of which funds this sector's own R&D. In addition, some funds from the nonprofit sector support academic R&D.

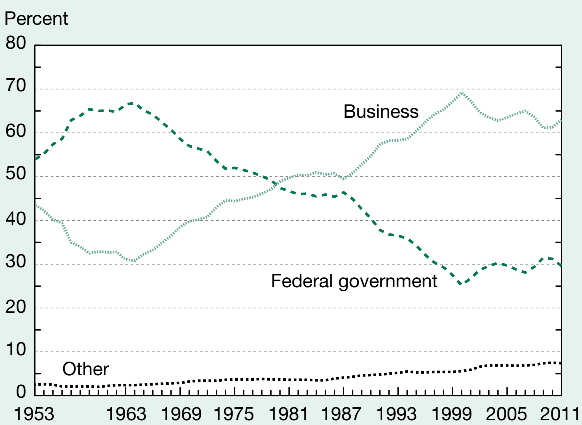
The share of R&D funding from these sources has been gradually increasing over the 2006–11 period (figure 4-6). In 2006, these other sources accounted for just under 7% of U.S. total R&D.

## R&D, by Character of Work

R&D encompasses a wide range of activities: from research yielding fundamental knowledge in the physical, life, and social sciences; to research addressing national defense needs and such critical societal issues as global climate change, energy efficiency, and health care; to the development of platform or general-purpose technologies that can enable the creation and commercial application of new and improved goods and services. The most widely applied classification of these activities characterizes R&D as "basic research," "applied research," or "(experimental) development" (OMB 2012b; OECD 2002; NSF 2006). (For definitions of these terms, see this chapter's glossary.) These categories have been criticized as reinforcing the idea that creating new knowledge and innovation is a linear process beginning with basic research, followed by applied research and development, and ending with the production and diffusion of new technology. However, alternative classifications that involve measureable distinctions and capture major differences in types of R&D have yet to emerge. Despite the recognized limitations of the basic research-applied research-development classification framework, it remains useful in providing indications of differences in the motivation, expected time horizons, outputs, and types of investments associated with R&D projects.

The most recent character-of-work cross-section in NSF's R&D expenditures and funding data covers 2011.[6] Basic research activities accounted for 18% ($75.0 billion) of the $424.4 billion of total U.S. R&D that year. Applied research was 19% ($82.4 billion); development was 63% ($267.1 billion) (table 4-3; figure 4-7).

Figure 4-6
**U.S. total R&D expenditures, by source of funds: 1953–2011**




NOTE: 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 4-6.

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### Basic Research

Universities and colleges remain the primary performers of U.S. basic research, accounting for 55% of the $75.0 billion in 2011 (table 4-3). The business sector performed about 17%; the federal government (agency intramural labs and FFRDCs) performed 15%; and other nonprofit organizations performed 13%.

The federal government continues as the prime source of funding for basic research, accounting for about 55% of all such funding in 2011 (table 4-3). The business sector was the second-largest performer at 20%, but although its $15.1 billion of funding for basic research is small compared to its $267.3 billion of funding for all R&D that year, the contribution is particularly significant to the national R&D as a whole. Universities and colleges themselves provide about 10% of basic research funding. Other nonprofit organizations provide 12%.

In choosing whether to perform basic research, businesses consider various factors, such as the extent of appropriability of results, the commercialization risks involved, and the uncertainties of investment returns over business-acceptable time horizons. Despite the risks and uncertainties involved, many companies believe that company engagement in basic research can help them develop human capital, attract and retain talent, absorb external knowledge, and strengthen innovation capacity. Businesses that invest most heavily in basic research tend to be in industries that are most directly tied to ongoing scientific and technological advances, such as the pharmaceuticals and scientific R&D service industries.

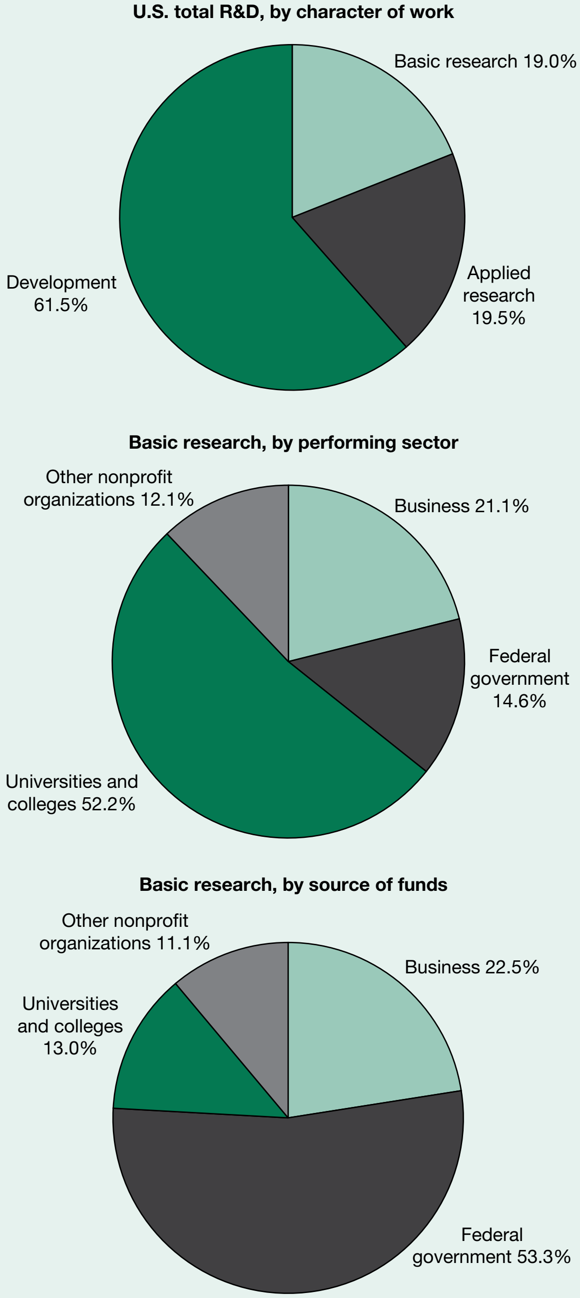
### Applied Research

The business sector performed 57% of the $82.4 billion of applied research in 2011 (table 4-3). Universities and colleges accounted for 20%; the federal government (federal agency intramural labs and FFRDCs) accounted for 16%; and nonprofit organizations accounted for 7%.

Businesses provided the bulk of funding (53%) for applied research in 2011. The federal government provided 37%. Academia, nonfederal governments, and other nonprofit organizations contributed 4%, 1%, and 5%, respectively.

Industries that perform relatively large amounts of applied research include chemicals and aerospace. Federal funding for applied research is spread broadly across all the

Figure 4-7
**U.S. R&D by character of work, basic research by performing sector, and basic research by source of funds: 2011**




NOTES: National R&D expenditures were estimated at $424.4 billion in 2011. National basic research expenditures were estimated at $75.0 billion in 2011. Federal performers include federal agencies and federally funded R&D centers. State and local government support to industry is included in industry support for industry performance. State and local government support to universities and colleges is included in universities and colleges support of performance by universities and colleges.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources (annual series). See appendix tables 4-3–4-5 and 4-7.

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performers, with the largest amounts (in 2011) going to universities and colleges, federal intramural labs, the business sector, and FFRDCs (table 4-3).

### *Development*

The business sector dominates in development, performing 88% of the $267.1 billion that the United States devoted to development in 2011 (table 4-3).[7] The federal government (agency intramural labs, FFRDCs) accounted for another 9%—much of it was defense related, with the federal government being the main consumer. By contrast, academia and other nonprofit organizations perform very little development, respectively 2% and 1% of the total in 2011.

The business sector provided about three-quarters (78%) of development funding ($208.3 billion) in 2011, nearly all of it in support of development activities by businesses (table 4-3). The federal government provided 20% ($54.5 billion) of the funding, with more than half going to the business sector—especially in defense-related industries—and most of the remainder going to federal intramural labs and FFRDCs. Universities and colleges, other nonprofit organizations, and nonfederal government agencies provided small amounts of funding to support performance of development activities.

## International Comparisons of R&D Performance

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 Organisation for Economic Co-operation and Development (OECD) cover the organization's 34 member countries and 7 nonmembers (OECD 2013). The United Nations Educational, Scientific and Cultural Organization's (UNESCO's) Institute for Statistics provides data on additional countries (UNESCO 2013). The discussion in this section draws on both of these data sets.

Cross-national comparisons of R&D expenditures and funding necessarily involve currency conversions. The analysis in this section uses the international convention of converting foreign currencies into U.S. dollars via purchasing power parity (PPP) exchange rates (for a discussion of this methodology, see the sidebar, "Comparing International R&D Expenditures").

### Global Pattern of R&D Expenditures

Worldwide R&D expenditures totaled an estimated $1,435 billion (current PPP dollars) in 2011.[8] The corresponding estimate for 5 years earlier in 2006 is $1,051 billion. Ten years earlier, in 2001, it was $753 billion. By these figures, growth in total global R&D has been rapid,

## 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: (1) express national R&D expenditures as a percentage of gross domestic product (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 selecting 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 nontraded 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 R&D expenditures in 2010 (as reported to the OECD) are $178 billion in PPP terms but only $104 billion using MERs.

However, PPPs for large developing countries such as China and India 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 unresolved 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. (2007:312) concluded 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."

averaging 6.4% annually over the 5-year period and 6.7% annually over the 10-year period.

Overall, global R&D performance remains highly concentrated in three geographic regions: North America, Asia, and Europe (figure 4-8). North America (United States, Canada, Mexico) accounted for 32% ($462 billion) of worldwide R&D performance in 2011; the combination of East/Southeast and South Asia (including China, Taiwan, Japan, India, South Korea) accounted for 34% ($492 billion); and Europe, including (but not limited to) European Union (EU; see "Glossary" for member countries) countries accounted for 24% ($345 billion). The remainder, around 10%, reflects the R&D of countries in the regions of Central and South America, Central Asia, the Middle East, Australia/Oceania, and Africa.

The geographic concentration of R&D is more apparent when looking at specific countries (table 4-4). Three countries account for more than half of global R&D. The United States is by far the largest R&D performer ($429 billion in 2011), accounting for just under 30% of the global total, but down from 37% in 2001. China was the second-largest performer ($208 billion) in 2011, accounting for about 15% of the global total. Japan is third at 10% ($147 billion). The largest EU performers spend comparatively less: Germany ($93 billion, 7%), France ($52 billion, 4%), and the United Kingdom ($40 billion, 3%). R&D spending by South Korea has also been rising in recent years and accounted for 4% ($60 billion) of the global total in 2011. Taken together, these top seven countries account for about 72% of total global R&D. The Russian Federation, Taiwan, Brazil, Italy, Canada, India, Australia, and Spain make up the next tier of performers, with total R&D expenditures ranging from $20 billion to $35 billion. The top seven countries, along with the second group of eight economies, together account for 84% of current global R&D.

The generally vigorous pace at which total global R&D continues to grow is certainly one of the prominent developments, a reflection of the growing knowledge-intensiveness of the economic competition among the world's nations. The other major trend is the particularly rapid expansion of R&D performance in the regions of East/Southeast and South Asia, including economies such as China, India, Japan, Malaysia, Singapore, South Korea, Taiwan, and Thailand. The R&D performed in these two Asian regions represented only 25% of total global R&D in 2001 but increased to 34% in 2011, including China (15%) and Japan (10%).

China continues to exhibit the world's most dramatic R&D growth pattern (figure 4-9; appendix table 4-13). 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 growth over the past 10 years (2001–11) in China's overall R&D remains exceptionally high at 20.7% annually (still very high, at 18.1% per year, when adjusted for inflation).

The rate of growth in South Korea's R&D has also been quite high, averaging 10.9% annually over the same 10-year period. The growth in Japan's R&D has been much slower, at an annual average rate of 3.5%.

By comparison, while the United States remains atop the list of the world's R&D-performing nations, its pace of growth in R&D performance has averaged 4.4% over the same 2001–11 period, and its share of global R&D has declined from 37% to 30%. Total R&D by EU nations has been growing over the same 10 years at an annual average rate of 5.0%. The pace of growth during the same period for Germany (5.5%), France (3.8%), and the United Kingdom (3.1%) has been somewhat slower. The EU countries accounted for 22% of total global R&D in 2011, down from 26% in 2001.[9]

## Comparison of Country R&D Intensities

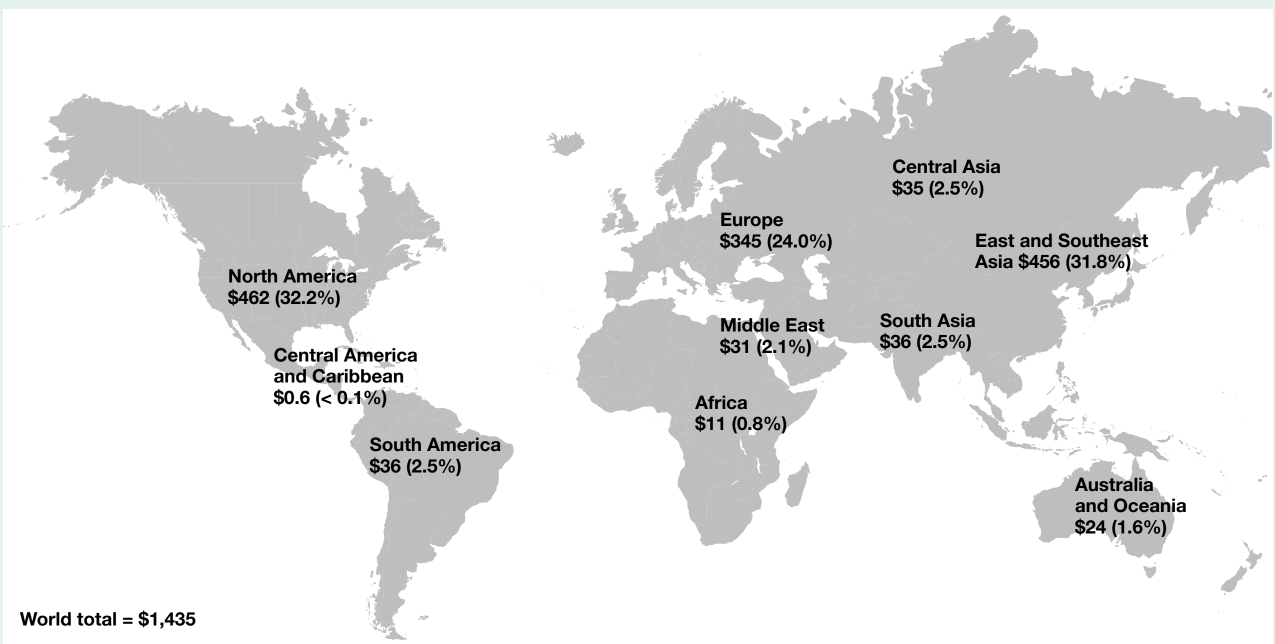
R&D intensity provides another basis for international comparisons of R&D performance. This metric does not require conversion of a country's currency to a standard international benchmark (dollars), but it does provide a means to adjust for differences in the sizes of national economies.

The U.S. R&D/GDP ratio was somewhat over 2.8% in 2011 (table 4-4). At this level, the United States is 10th among the economies tracked by the OECD and UNESCO. Israel continues to have the highest ratio at 4.4%. South Korea is now second at 4.0%, and Finland is third at 3.8%. Japan and Sweden are both around 3.4%. Denmark is at 3.1%, and Taiwan is at 3.0%. Germany and Switzerland, both at 2.9%, are slightly ahead of the United States. By way of comparison, the United States was eighth in R&D intensity in the data for 2007; it has been gradually slipping in the world rank for this indicator in recent years.

The R&D/GDP ratio in the United States has ranged from 1.4% in 1953 to well above 2.8% in 1963–67 to a historical high of 2.9% in 2009. Over the 10-year period from 2001 to 2011, the ratio fluctuated between a low of 2.6% in 2004 to a high of 2.9% in 2009 (figure 4-10; appendix table 4-13). The ratio has generally been rising since 2004, but the drop in 2010 to 2.8% is a noticeable departure.

Most of the growth over time in the U.S. R&D/GDP ratio can be attributed to increases in nonfederal R&D spending, primarily that financed by business. Nonfederally financed R&D increased from about 0.6% of GDP in 1953 to 2.0% of GDP in 2011. 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 4-8
**Global R&D expenditures, by region: 2011**
Billions of U.S. PPP dollars




PPP = purchasing power parity.

NOTES: Foreign currencies are converted to U.S. dollars through PPPs. Some country figures are estimated. Countries are grouped according to the regions described by *The World Factbook*, available at www.cia.gov/library/publications/the-world-factbook/index.html.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, estimates (August 2013). Based on data from the Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators* (2013/1); and the United Nations Educational, Scientific and Cultural Organization Institute for Statistics, http://stats.uis.unesco.org/unesco/ReportFolders/ReportFolders.aspx, table 25, accessed 2 August 2013.

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Table 4-4
**International comparisons of gross domestic expenditures on R&D and R&D share of gross domestic product, by region/country/economy: 2011 or most recent year**

| Region/country/economy | GERD (PPP $millions) | GERD/GDP (%) |
|---|---|---|
| North America | | |
| United States (2011)[a] | 429,143.0 | 2.85 |
| Canada (2011) | 24,289.3 | 1.74 |
| Mexico (2011) | 8,209.4 | 0.43 |
| South America | | |
| Brazil (2010) | 25,340.2 | 1.16 |
| Argentina (2011) | 4,640.6 | 0.65 |
| Chile (2010) | 1,331.4 | 0.42 |
| Colombia (2010) | 856.7 | 0.16 |
| Europe | | |
| Germany (2011) | 93,055.5 | 2.88 |
| France (2011) | 51,891.0 | 2.24 |
| United Kingdom (2011) | 39,627.1 | 1.77 |
| Italy (2011) | 24,812.1 | 1.25 |
| Spain (2011) | 19,763.1 | 1.33 |
| Netherlands (2011) | 14,581.5 | 2.04 |
| Sweden (2011) | 13,216.2 | 3.37 |
| Switzerland (2008) | 10,525.2 | 2.87 |
| Austria (2011) | 9,761.9 | 2.75 |
| Belgium (2011) | 8,719.4 | 2.04 |
| Finland (2011) | 7,634.8 | 3.78 |
| Denmark (2011) | 7,052.4 | 3.09 |
| Poland (2011) | 6,227.9 | 0.76 |
| Czech Republic (2011) | 5,086.5 | 1.85 |
| Norway (2011) | 5,006.7 | 1.66 |
| Portugal (2011) | 4,037.6 | 1.49 |
| Ireland (2011) | 3,223.0 | 1.70 |
| Hungary (2011) | 2,581.9 | 1.21 |
| Ukraine (2011) | 2,400.0 | 0.73 |
| Greece (2007) | 1,866.8 | 0.60 |
| Romania (2011) | 1,648.5 | 0.50 |
| Slovenia (2011) | 1,387.8 | 2.47 |
| Belarus (2011) | 1,074.1 | 0.76 |
| Slovak Republic (2011) | 882.3 | 0.68 |
| Luxembourg (2011) | 656.2 | 1.43 |
| Croatia (2011) | 642.9 | 0.75 |
| Serbia (2011) | 633.9 | 0.73 |
| Bulgaria (2011) | 632.6 | 0.57 |
| Middle East | | |
| Turkey (2011) | 10,826.9 | 0.86 |
| Israel (2011) | 9,822.7 | 4.38 |
| Iran (2008) | 6,432.2 | 0.79 |
| Africa | | |
| South Africa (2009) | 4,416.2 | 0.87 |
| Egypt (2011) | 2,230.6 | 0.43 |
| Morocco (2010) | 1,115.6 | 0.73 |
| Tunisia (2009) | 1,055.9 | 1.10 |
| Central Asia | | |
| Russian Federation (2011) | 35,045.1 | 1.09 |
| South Asia | | |
| India (2007) | 24,305.9 | 0.76 |
| Pakistan (2011) | 1,618.5 | 0.33 |
| East and Southeast Asia | | |
| China (2011) | 208,171.8 | 1.84 |
| Japan (2011) | 146,537.3 | 3.39 |
| South Korea (2011) | 59,890.0 | 4.03 |
| Taiwan (2011) | 26,493.1 | 3.02 |
| Singapore (2011) | 7,060.2 | 2.23 |
| Malaysia (2011) | 4,953.4 | 1.07 |
| Thailand (2009) | 1,355.8 | 0.25 |
| Indonesia (2009) | 802.3 | 0.08 |
| Australia, Oceania | | |
| Australia (2010) | 20,578.1 | 2.20 |
| New Zealand (2011) | 1,772.1 | 1.30 |
| Selected country groups | | |
| European Union (2011) | 320,455.9 | 1.94 |
| OECD (2011) | 1,034,024.3 | 2.37 |
| G20 (2011) | 1,323,147.2 | 2.02 |

G20 = Group of Twenty; 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 the National Science Foundation's protocol for tallying U.S. total R&D.

NOTES: The table includes countries with annual GERD of $500 million or more. Year of data is listed in parentheses. Foreign currencies are converted to dollars through PPPs. Countries are grouped according to the regions described by *The World Factbook*, www.cia.gov/library/publications/the-world-factbook/index.html. No countries in the Central American and 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: Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators* (2013/1); United Nations Educational, Scientific and Cultural Organization Institute for Statistics, http://stats.uis.unesco.org/unesco/ReportFolders/ReportFolders.aspx, table 25, accessed August 2013.

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Among the other top seven R&D-performing countries, most had increasing R&D/GDP ratios over the 2000–11 period (figure 4-10). However, for some, the rise was modest at best, and for others, it was quite large. France exhibited only a bare increase over this period: from 2.2% in 2001 to somewhat over 2.2% in 2011. The United Kingdom's ratio was also rather flat over the same period, around 1.8%. For Germany, the ratio increased from 2.5% in 2001 to 2.9% in 2011. Japan was also in the modest increase category: from 3.1% in 2001 to 3.4% in 2011. (Japan's rising ratio reflects in part the confluence of declining GDP and largely flat R&D spending.) The high-risers were China and South Korea. China's ratio doubled over the period: from just under 1.0% in 2001 to somewhat above 1.8% in 2011. South Korea's ratio increased from 2.5% in 2001 to 4.0% in 2011.

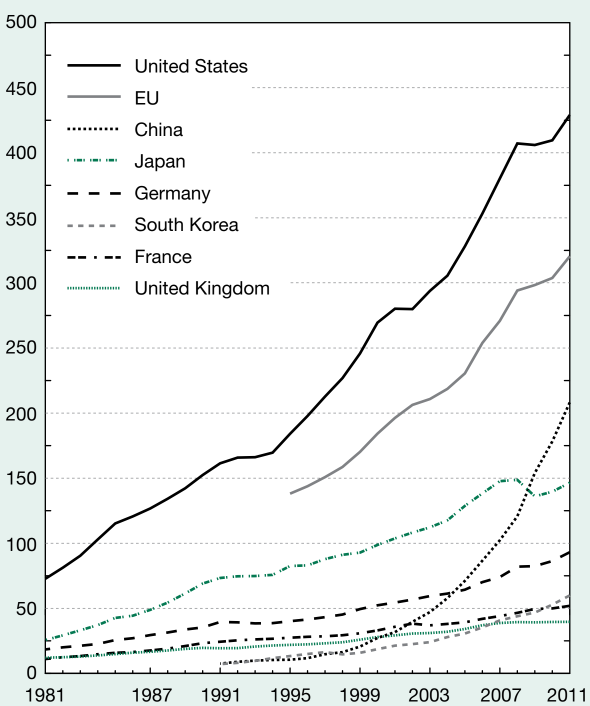
In addition to the United States, countries in Nordic and Western Europe and the most advanced areas of Asia have R&D/GDP ratios above 1.5%. This pattern broadly reflects the global distribution of wealth and level of economic development. Countries with high incomes tend to emphasize the production 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.

## Comparative Composition of Country R&D Performance

The business sector is the predominant R&D performer for the top seven R&D-performing nations (table 4-5; appendix table 4-14). For the United States, the business sector accounted for 69% of gross expenditures on R&D in 2011. Japan's business sector was the highest, accounting for 77% of the country's overall R&D performance. China (76%) and South Korea (77%) were also well above the U.S. level. Germany, at 67%, was close to the level of the United States. France and the United Kingdom were somewhat lower, at, respectively, 63% and 62%.

Figure 4-9
**Gross domestic expenditures on R&D by the United States, EU, and selected other countries: 1981–2011**

Billions of current PPP dollars




EU = European Union; PPP = purchasing power parity.

NOTES: Data are not available for all countries in all years. Data for the United States in this figure reflect international standards for calculating gross expenditures on R&D, which vary slightly from the National Science Foundation's approach to tallying U.S. total R&D. Data for Japan for 1996 onward may not be consistent with earlier data because of changes in methodology. EU data for all years are based on the current 27 EU member countries.

SOURCE: Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators* (2013/1). See appendix table 4-13.

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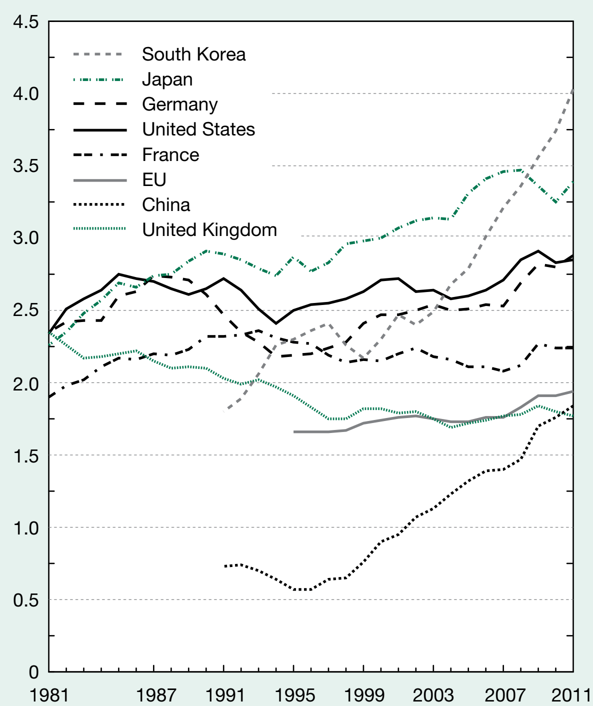
Figure 4-10
**Gross expenditures on R&D as share of GDP, for the United States, EU, and selected other countries: 1981–2011**

Percent




EU = European Union; GDP = gross domestic product.

NOTES: Data are not available for all countries in all years. The table includes the top seven R&D-performing countries. Figures for the United States reflect international standards for calculating gross expenditures on R&D, which differ slightly from the National Science Foundation's protocol for tallying U.S. total R&D. Data for Japan for 1996 onward may not be consistent with earlier data because of changes in methodology.

SOURCE: Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators* (2013/1). See appendix table 4-13.

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The R&D performed by the government ranges over 8%–16% of total national R&D for the leading seven countries. Japan (8%) and the United Kingdom (9%) are on the lower end of this range. China (16%), Germany (15%), and France (14%) are at the high end. The United States and South Korea lie in between.

Academic R&D ranges from 8% to 27% of total national R&D performance for these countries. China has the lowest ratio, at 8%. The United Kingdom has the highest, at 27%. The United States (15%), Japan (13%), and South Korea (10%) have lower shares; Germany (18%) and France (21%) have higher shares.

With regard to the funding of R&D, the business sector is again the predominant source for the top seven R&D-performing nations (table 4-5). In 2011, funding for about 77% 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 66%–74% range. R&D funding from business is lower, but still predominant, in the United States (59%) and France (54%). The corresponding figure for the United Kingdom (45%) is notably lower.

Government is the second major source of R&D funding for these seven countries. France is the highest, at 37%. The lowest is Japan, at 16%. The United States (31%), the United Kingdom (32%), and Germany (30%) are on the higher side. South Korea (25%) and China (22%) are in between.

Funding from abroad refers to funding from businesses, universities, governments, and other organizations located outside of the country. Among the top seven R&D-performing countries, the United Kingdom is the most notable in this category, with 17% of R&D funding coming from abroad. France is also comparatively high, at nearly 8%. Germany and the United States are both around 4%, and the rest are much lower. (For the United States, the funding from abroad reflects foreign funding for domestic R&D performance by the business and higher education sectors.)

Another dimension in which to compare countries is the extent of total national R&D performance directed to basic research. None of the other top seven R&D-performing countries come close to the United States in its $74 billion of support for basic research in 2011 (table 4-6). The next closest is Japan, at $18 billion, and then France, at $13 billion. The U.S. basic research share (17%) is also high among this group, although it is exceeded by France (25%). China has the lowest share of basic research (5%) in this group of countries.

Table 4-5

**Gross expenditures on R&D for selected countries, by performing sector and funding sources: 2011 or most recent year**

| Country | GERD PPP ($billions) | Share of total (%) | | | |
|---|---|---|---|---|---|
| | | Business | Government | Higher education | Private nonprofit |
| | | R&D performance | | | |
| United States (2011)[a] | 429.1 | 68.5 | 12.7 | 14.6 | 4.3 |
| China (2011) | 208.2 | 75.7 | 16.3 | 7.9 | 0.0 |
| Japan (2011) | 146.5 | 77.0 | 8.4 | 13.2 | 1.5 |
| Germany (2011) | 93.1 | 67.3 | 14.7 | 18.0 | ** |
| South Korea (2011) | 59.9 | 76.5 | 11.7 | 10.1 | 1.6 |
| France (2011) | 51.9 | 63.4 | 14.1 | 21.2 | 1.2 |
| United Kingdom (2011) | 39.6 | 61.5 | 9.3 | 26.9 | 2.4 |
| | | R&D funding sources | | | |
| United States (2011)[a, b] | 429.1 | 58.6 | 31.2 | 6.4 | 3.8 |
| China (2011) | 208.2 | 73.9 | 21.7 | NA | 1.3 |
| Japan (2011) | 146.5 | 76.5 | 16.4 | 6.6 | 0.5 |
| Germany (2010) | 93.1 | 65.6 | 30.3 | 0.2 | 3.9 |
| South Korea (2011) | 59.9 | 73.7 | 24.9 | 1.2 | 0.2 |
| France (2010) | 51.9 | 53.5 | 37.0 | 1.8 | 7.6 |
| United Kingdom (2011) | 39.6 | 44.6 | 32.2 | 6.2 | 17.0 |

** = included in data for other performing sectors; NA = not available.

GERD = gross expenditures on R&D; PPP = purchasing power parity.

[a] Figures for the United States in this table reflect international standards for calculating GERD, which vary slightly from the National Science Foundation's protocol for tallying U.S. total R&D.

[b] The data for U.S. funding from abroad include foreign funding for business R&D and higher education R&D.

NOTES: The table includes the top seven R&D-performing countries. Percentages may not add to 100 due to rounding. Data years are listed in parentheses.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources (annual series); Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators* (2013/1).

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Table 4-6
**Basic research as a share of gross expenditures on R&D, for selected countries: 2011**

| Country | GERD PPP ($billions) | Basic research PPP ($billions) | Basic research Share (%) |
|---|---|---|---|
| United States[a] | 429.1 | 74.3 | 17.3 |
| China | 208.2 | 9.9 | 4.7 |
| Japan | 146.5 | 18.0 | 12.3 |
| Germany | 93.1 | NA | NA |
| South Korea | 59.9 | 10.8 | 18.1 |
| France | 51.9 | 13.1 | 25.3 |
| United Kingdom | 39.6 | 4.3 | 10.8 |

NA = not available.

GERD = gross expenditures on R&D; PPP = purchasing power parity.

[a] Figures for the United States in this table reflect international standards for calculating gross expenditures on R&D, which vary slightly from the National Science Foundation's protocol for tallying U.S. total R&D.

NOTES: The table includes the top seven R&D-performing countries. Percentages may not add to 100 due to rounding.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources (annual series); Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators* (2013/1).

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## U.S. Business R&D

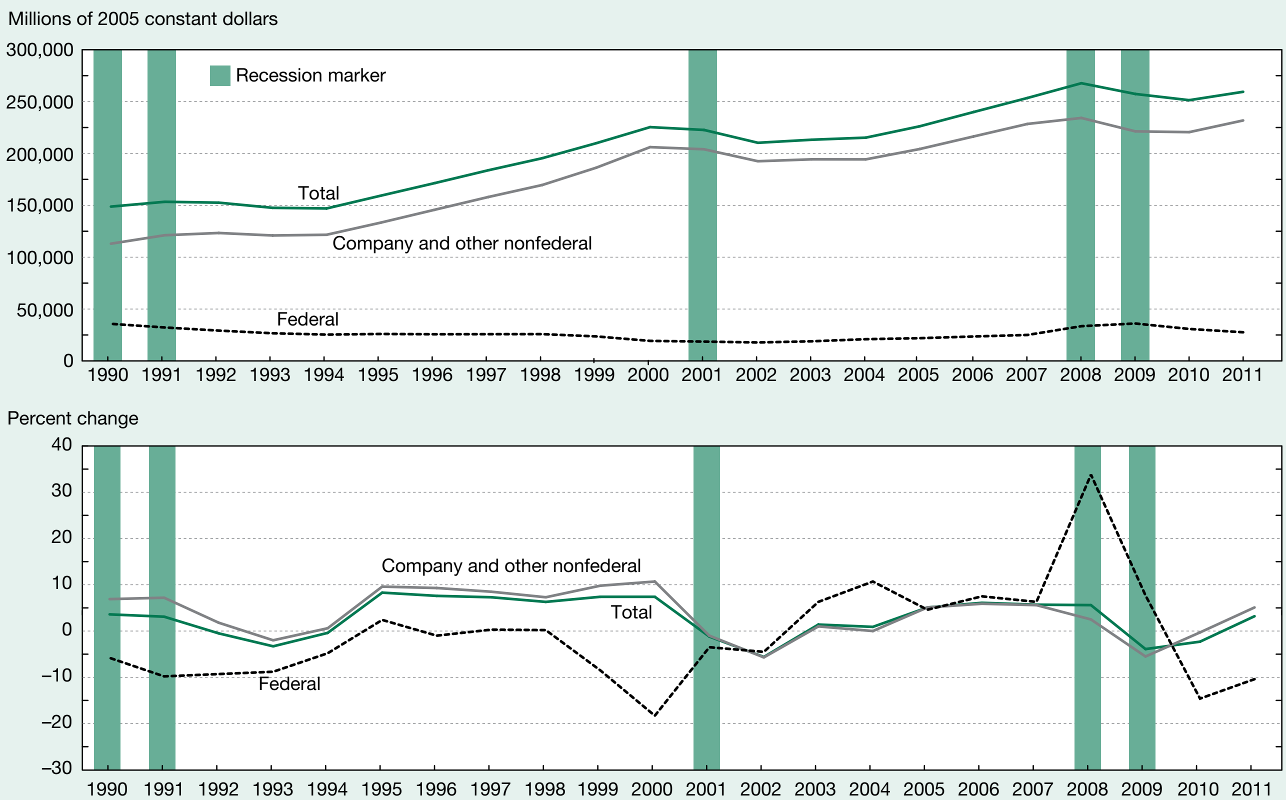
Total U.S. business R&D performance reached a record $294.1 billion in 2011, a 5% increase from 2010 according to statistics from the Business R&D and Innovation Survey (BRDIS). However, measured in inflation-adjusted dollars, the 2011 business R&D performance of $259.4 billion (up 3% from 2010) is still below the 2008 peak of $267.7 billion, at the beginning of the most recent recession.[10] Over the past two decades, constant dollar U.S. business R&D performance follows peaks and troughs timed close to business cycle changes, short-term up-and-down movements in constant dollar GDP (figure 4-11).[11]

The company size distribution of U.S. business R&D performance has changed little since 2008. In 2011, large companies (those with 25,000 domestic employees or more) performed 35% of U.S. business R&D. Companies with 5 to 499 employees performed about 20% (appendix table 4-15).[12]

Business and other nonfederal funding sources increased 5.1% in constant dollars in 2011, the first such increase since 2008. On the other hand, federally funded business R&D as reported by performers dropped 10% in constant dollars in 2011 after a 15% decline in 2010, following increases in 2008 and 2009.

The rest of this section focuses on recent industry-level data measured in current dollars. See appendix tables 4-15–4-22.

Figure 4-11
**U.S. business R&D, by major source of funds: 1990–2011**




SOURCE: National Science Foundation, National Center for Science and Engineering Statistics and U.S. Census Bureau, Survey of Industrial R&D and Business R&D and Innovation Survey (annual series).

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## Recent Trends in Domestic Business R&D

Trends in U.S. business R&D performance are driven by five industries (called "top industries" below) that together accounted for $239.0 billion, or 81%, of domestic business R&D performance in 2011: computer and electronic product manufacturing, chemicals manufacturing (including pharmaceuticals), transportation equipment (including aerospace), information (including software publishers), and professional, scientific, and technical (PST) services.

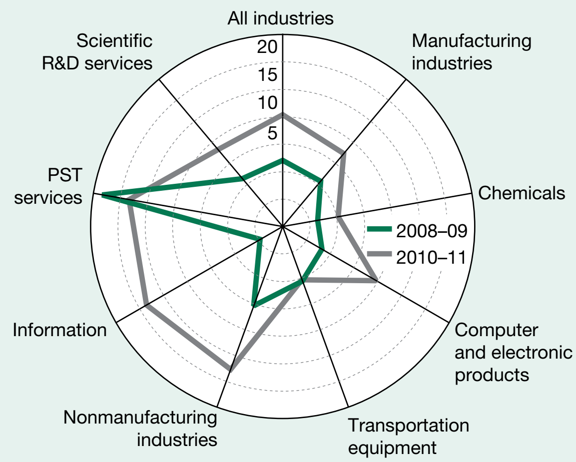
Manufacturing industries historically account for the largest share of U.S. business R&D performance (68% in 2011). However, between 2010 and 2011, nonmanufacturing industries' R&D grew faster (12.7%) than manufacturing R&D (2.4%). Indeed, the largest growth in domestic R&D performance among the top five industries in 2011 occurred in information services (13.6%) and PST services (13.4%). Computer and electronic product manufacturing increased by 4.7%. The other two top industries posted drops in R&D expenditures: chemicals (4.7% decrease, including 7.0% decline in pharmaceuticals) and transportation equipment (4.7% decrease) (figure 4-12; appendix table 4-15).

Overall, domestic R&D performance bounced back by 5.4% from 2010 to 2011 after declining 2.9% during the recession years from 2008 to 2009. Company and other nonfederal funding sources increased 7.4% in 2010–11 after declining 4.5% in 2008–09. In contrast, federal sources decreased 8.5% in 2010–11.

At the same time, federal funding accounted for only 10.6% of domestic business R&D in 2011, down from 12.3% in 2010. This funding source is also highly concentrated in some industries, based on 2010 detailed statistics. The highest shares of federal funding for domestic business R&D are in transportation equipment manufacturing (47%), which includes aerospace (63%); in PST services (20.3%), which includes scientific R&D services and architectural, engineering, and related services; and in computer and electronic products manufacturing (9.9%) (figure 4-13).

Apart from direct funding for R&D in the form of contracts and grants to businesses, the U.S. government offers indirect R&D support via fiscal incentives such as tax credits (see sidebar, "Federal R&E Tax Credit").

Figure 4-12
**Percentage change in U.S. domestic business R&D performance: 2008–09 and 2010–11**




PST = professional, scientific, and technical.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics and U.S. Census Bureau, Business R&D and Innovation Survey (annual series).

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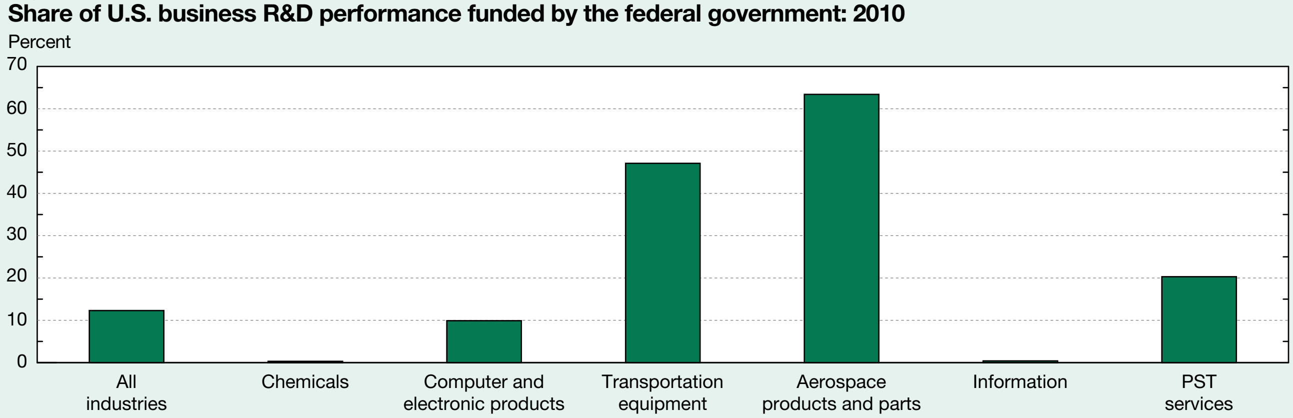
Figure 4-13
**Share of U.S. business R&D performance funded by the federal government: 2010**




PST = professional, scientific, and technical.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics and U.S. Census Bureau, Business R&D and Innovation Survey (2010).

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## Domestic and International Funding Sources, by Type of Source

Funding for domestic business R&D may be classified by the geographic location of funding sources, by ownership, and by a combination of these categories according to new details available from BRDIS. Most domestic R&D is funded from domestic sources (regardless of ownership) and by company-owned units (regardless of their location). In 2011, $238.8 billion (81.2% of $294.1 billion of domestic R&D performance) was funded internally (company-owned units regardless of location), including $3.3 billion by subsidiaries located abroad (table 4-7; see also appendix tables 4-15–4-19).

More generally, the $294.1 billion in 2011 U.S. business R&D performance can be partitioned in four major funding and location sources (table 4-7). The largest of these four components, $235.4 billion (80% percent), was funded by U.S.-located, within-company sources. Domestic external sources funded another $43.1 billion (15%). The bottom left row in figure 4-14 shows the distribution of these external domestic sources, the largest of which is the federal government. Overall, $278.6 billion (95%) of domestic business R&D performance was funded by U.S.-located sources in 2011, as summarized in the left panels of figure 4-14.

The remainder, $15.5 billion (5%), was funded by sources from abroad as shown in the right panels of figure 4-14. These sources may be classified by ownership or affiliation, namely, subsidiaries abroad owned by U.S.-located companies, foreign parents of U.S.-located companies, or independent foreign sources (primarily companies).

Table 4-8 provides further detail on 2011 funding from abroad for selected industries by affiliation and type of organization (for-profit companies, foreign governments, and others, including foreign universities). Virtually all of the $15.5 billion in funding from abroad for domestic business R&D performance came from other companies. About half (48%) came from foreign parent companies, 29% came from foreign independent companies, and 22% came from company-owned units abroad (see also appendix tables 4-17 and 4-19).

The top five industries received $12.4 billion, or 80%, of total funding from abroad in 2011, about the same share of these industries in total domestic performance (81%). However, chemicals (including its pharmaceuticals and

### Federal R&E Tax Credit

The United States and other OECD countries offer fiscal incentives for business R&D at the national and subnational levels (Thomson 2012). For businesses, tax credits reduce after-tax costs of R&D activities. For governments, tax credits are forgone revenue, known as tax expenditures. Public incentives for R&D are generally justified by the inability of private performers to fully capture benefits from these activities, given the intangible nature of knowledge and information.

The U.S. research and experimentation (R&E) tax credit was originally established by the Economic Recovery Tax Act of 1981 on a temporary basis. It has been extended and modified several times and was last renewed through 31 December 2013 by the American Taxpayer Relief Act of 2012.* The credit is designed to apply to incremental amounts beyond recent research activity by a business. In particular, the regular research tax credit applies to 20% of qualified research expenses beyond a base.† The efficiency of the credit, how much a dollar worth of credit generates research activities beyond what otherwise would occur, depends on the effective credit (after limitations in overall business credits and other adjustments to the statutory credit are taken into account for a given taxpayer) and how sensitive R&D is to business costs. For an overview and methodologies to estimate the effectiveness of the R&E credit, see Guenther (2013) and Hall (1995).

Research tax credit claims fell 6.4% to $7.8 billion in 2009 from $8.3 billion in 2008, whereas corporate tax returns claiming the credit dropped 3% to 12,359 filers (appendix tables 4-21 and 4-22), based on estimates from Statistics of Income/Internal Revenue Service (IRS). The reported reduction in credit activity is consistent with the 3.3% decline in company-funded domestic R&D over the same period (appendix table 4-15). R&E credit claims relative to company-funded domestic R&D have fluctuated rather narrowly between 3.0% and 3.5% since 2001 (3.5% in 2009).

* See Internal Revenue Code (IRC) Section 41(a)(1). P.L. 112-240, Section 301. The 2012 Act retroactively extended the research tax credit from 1 January 2012 through 31 December 2013.

† For the regular credit, the base amount is a multiyear average of research intensity (research relative to gross receipts) up to a maximum of 50% of current research spending. Variations include the alternative simplified credit and the alternative incremental R&E tax credit (AIRC; IRC Section 41(c)(4)), in place for 1996–2008 tax years (Guenther 2013). See also IRS form 6765 at http://www.irs.gov/pub/irs-pdf/f6765.pdf.

Table 4-7
**Funding sources for domestic business R&D performed: 2011**
(Millions of U.S. dollars)

| Geographic source | Within company | Outside company | All sources |
|---|---|---|---|
| All locations | 238,768 | 55,324 | 294,093 |
| United States | 235,427 | 43,123 | 278,550 |
| Outside United States | 3,342 | 12,199 | 15,543 |

NOTE: Detail may not add to total due to rounding.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics and U.S. Census Bureau, Business R&D and Innovation Survey (2011).

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medicines component) and PST services (including its scientific R&D services component) accounted for a larger share in funding from abroad compared with their share in total domestic R&D performance.

At the same time, sources of funding from abroad differ considerably for pharmaceuticals and scientific R&D services. Over half ($1.0 billion or 55%) of funding from abroad for scientific R&D services companies came from foreign independent companies, with the balance coming almost exclusively from foreign parents ($809 million or 43%) (table 4-8). For pharmaceuticals, affiliated sources dominated funding from abroad (26% from subsidiaries located abroad and 39% from foreign parents), based on BRDIS statistics, consistent with the high level of outward and inward foreign direct investment (FDI) in R&D in this industry discussed later in this chapter. Foreign independent companies accounted for a third (34%) of funding from abroad for this industry.

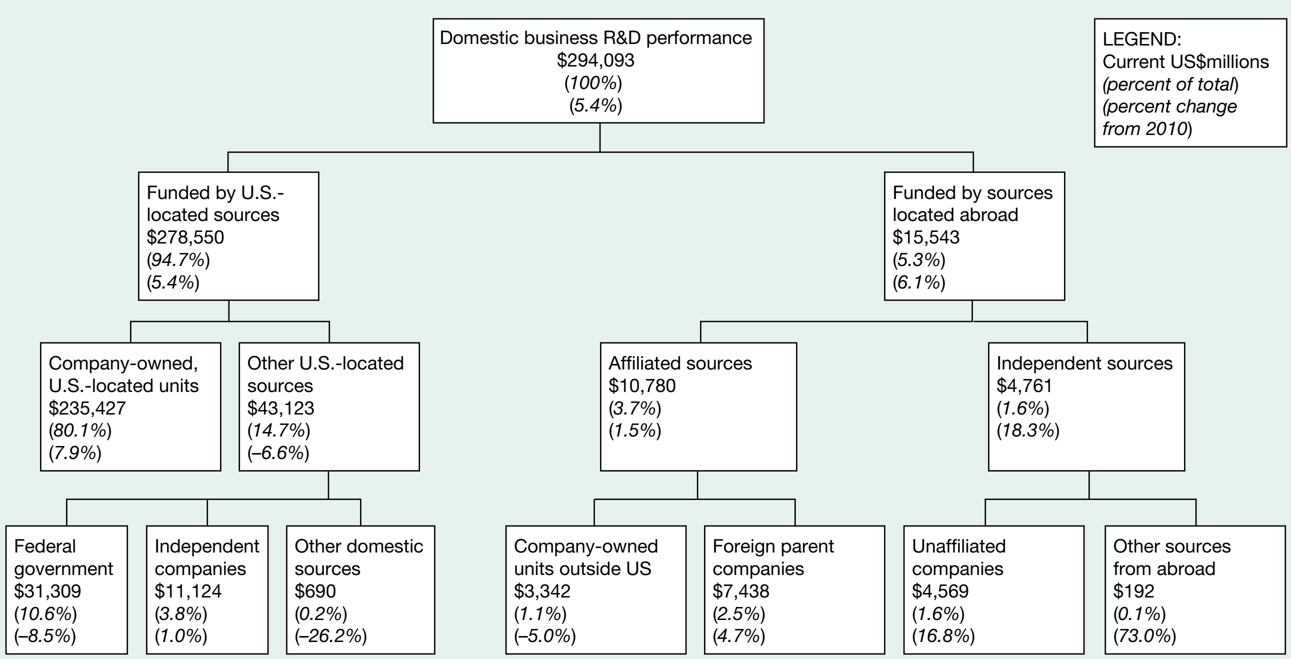
### Business Activities for Domestic R&D

Data at the industry level presented above are obtained by classifying a company's total R&D into a single industry, even if R&D activities occur in multiple lines of business. For example, if a company has $100 million in R&D expenses—$80 million in pharmaceuticals and $20 million in medical devices—the total R&D expense of $100 million will be assigned to the pharmaceuticals industry because this is the largest component of its R&D expense (Shackelford 2012). In addition to collecting data by the main industry classification, BRDIS collects data by lines of business most closely related to R&D expense. Codes for line of business are collected at a rather fine level of detail, as indicated in appendix table 4-20. However, most companies performed R&D in only one business activity area. In 2010, 86% of companies reported domestic R&D performed by and paid for by the company related to only one business activity. See Shackelford (2012) for an in-depth analysis of the relationship between business codes and industry codes.

## R&D by Multinational Companies

The spread of R&D by MNCs reflects a number of trends in international production and innovation. Among these are the need to strengthen or complement internal technological capabilities, increased complexity of global supply-chains in R&D-intensive sectors, and improved scientific and technological resources across the globe (Moncada-Paternò-Castello, Vivarelli, and Voigt 2011; OECD 2008). R&D associated with FDI, the ownership or control of a business (affiliate) in another country, represents another dimension of the international character of knowledge creation and exploitation. Direct investment is defined as ownership or control of 10% or more of the voting securities of a business

Figure 4-14
**Domestic and international funding sources for U.S. business R&D performance, by type of source: 2011**




NOTE: Detail may not add to total due to rounding.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics and U.S. Census Bureau, Business R&D Innovation Survey (2010 and 2011).

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(affiliate) in another country. This section covers statistics collected by BEA on R&D performed by majority-owned affiliates (those owned more than 50% by their parent companies) of foreign MNCs located in the United States and on R&D performed by U.S. MNCs and their majority-owned foreign affiliates.[13]

Between 2000 and 2010, U.S. R&D performed by members of MNCs grew faster than R&D in the U.S. business sector as a whole. Over this period, R&D performed by all U.S.-located businesses grew at an average annual rate of 1.1% in constant dollars. R&D performed in the United States by affiliates of foreign MNCs grew at an average annual rate of 2.3% in constant dollars. R&D performed in the United States by parents of U.S. MNCs also grew at an average annual rate of 2.3% in constant dollars over the same 2000–10 period.[14]

In 2010, parent companies performed $212.5 billion ($191.5 billion in constant dollars) or 76% of U.S. business R&D—higher than their 68% share in 2000. U.S. affiliates of foreign MNCs performed about 15% of U.S. business R&D in 2010, compared with 11% in 2000.[15] The rest of this section looks at changes in recent years (in current dollars) See appendix tables 4-23–4-30.

## U.S. Affiliates of Foreign Companies

Affiliates of foreign MNCs located in the United States (U.S. affiliates) performed $41.3 billion of R&D in 2010, up 2.1% after little change in 2009 and 2008 (appendix table 4-23). R&D by these companies has accounted for 14%–15% of U.S. business R&D performance since 2007, according to BEA and NSF statistics. Year-to-year movements in U.S. affiliates' R&D activity reflect a combination of changes in foreign ownership of existing U.S.-located firms, the establishment of new R&D-performing companies by foreign investors, and variations in R&D strategies and resources by firms that are foreign owned in consecutive years.

In 2010, three-fourths of R&D by U.S. affiliates of foreign MNCs was performed by firms owned by parent companies based in five countries: Switzerland (22.0%), the United Kingdom (14.5%), Germany (13.8%), France (12.7%), and Japan (12.4%) (table 4-9; appendix table 4-23).

Table 4-8
**Domestic business R&D performance and funding from abroad for selected industries: 2011**
(Millions of U.S. dollars)

| Industry | Domestic business R&D performance | | Funding from abroad | | | | | | | Funding from abroad as share of domestic business R&D (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| | Total | Percent | Total | Percent | Subsidiaries[a] | Foreign parent companies | Unaffiliated companies | Foreign governments | All other funding from abroad | |
| All industries | 294,093 | 100.0 | 15,543 | 100.0 | 3,342 | 7,438 | 4,569 | 63 | 129 | 5.3 |
| Manufacturing industries | 201,361 | 68.5 | 11,497 | 74.0 | 2,527 | 5,871 | 2,999 | 46 | 54 | 5.7 |
| Chemicals | 55,324 | 18.8 | 5,229 | 33.6 | 1,354 | 2,209 | 1,658 | 0 | 8 | 9.5 |
| Pharmaceuticals and medicines | 45,949 | 15.6 | 4,717 | 30.3 | 1,235 | 1,848 | 1,626 | 0 | 8 | 10.3 |
| Computer and electronic products | 62,704 | 21.3 | 3,291 | 21.2 | 521 | 1,735 | 991 | D | D | 5.2 |
| Transportation equipment | 40,880 | 13.9 | 857 | 5.5 | D | D | D | D | 7 | 2.1 |
| Nonmanufacturing industries | 92,731 | 31.5 | 4,046 | 26.0 | 815 | 1,568 | 1,570 | 17 | 76 | 4.4 |
| Information | 41,865 | 14.2 | 565 | 3.6 | D | D | D | D | * | 1.3 |
| PST services | 38,219 | 13.0 | 2,489 | 16.0 | 201 | 1,038 | 1,175 | 17 | 58 | 6.5 |
| Scientific R&D services | 15,301 | 5.2 | 1,862 | 12.0 | 0 | 809 | 1,024 | 2 | 27 | 12.2 |

* = less than $500,000; D = data withheld to avoid disclosing operations of individual companies.

PST = professional, scientific, and technical.

[a] In the table, subsidiaries are company-owned units located outside the United States. Although all estimates include an adjustment to the weight to account for unit nonresponse, the estimates for domestic R&D paid by subsidiaries abroad do not include item imputation. Caution should be used when comparing the subsidiaries' estimates to other estimates presented in the table.

NOTES: Detail may not add to total due to rounding. Industry classification is based on the dominant business code for domestic R&D performance, where available. For companies that did not report business codes, the classification used for sampling was assigned. Statistics pertain to companies located in the United States that performed or funded R&D.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics and U.S. Census Bureau, Business R&D and Innovation Survey (2011).

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Manufacturing U.S. affiliates performed 70% or more of U.S. affiliates R&D since 2006 (appendix tables 4-24 and 4-25). The R&D intensity (R&D divided by value added) of manufacturing U.S. affiliates was 6.4% in 2010—little changed since 2007.[16] R&D by affiliates classified in pharmaceuticals increased by 4% to $15.1 billion in 2010. This industry has accounted for at least a third of U.S. affiliates R&D since 2006 and has the highest R&D intensity (32.2% in 2010) among the largest R&D-performing industries within U.S. affiliates. Other manufacturing industries posting increases in R&D performance include computers and electronic products (8.7%) and electrical equipment, appliances, and components (8.9%). On the other hand, transportation equipment R&D was flat in 2010 after double-digit declines in 2009 and 2008, in part associated with changes in foreign ownership within the industry. Within nonmanufacturing industries, affiliates in information services increased R&D performance by 11.2% in 2010, whereas PST services R&D declined by 6.8%.

## U.S. MNCs' Parent Companies and Their Foreign Affiliates

Parent companies of U.S. MNCs performed $212.5 billion of R&D in the United States, based on preliminary 2010 data from BEA (appendix table 4-30).[17] Their majority-owned foreign affiliates (MOFAs) performed $39.5 billion (appendix table 4-26). (The latter was essentially flat after declining 6.0% in 2009, the first such decline since 2001). Thus, U.S. MNCs (U.S. parent companies and their MOFAs) performed $252.0 billion in R&D globally in 2010. From 2000 to 2010, global R&D by U.S. MNCs grew at an average annual rate of 2.6% in constant dollars. R&D performed overseas by MOFAs grew at a 4.4% annual rate in constant dollars, compared with a 2.3% annual rate by U.S. parents on the same basis. However, parent companies still perform over 80% of U.S. MNCs R&D in the United States (84% in 2010 compared with 88% in 2000). The rest of this section focuses on recent trends in geographic and industrial focus of MOFA R&D in current dollars (see appendix tables 4-26–4-28).

European host countries accounted for 62% of U.S. MOFA R&D in 2010, down from 66% in 2007 (table 4-10; appendix table 4-26). At the same time, Germany and the United Kingdom remain by far the largest hosts of U.S.-owned R&D with at least $6 billion each. Another 5 of the 13 countries with at least $1 billion in U.S. MOFA R&D in 2010 are in Europe (table 4-11). The shares of R&D performed by U.S. MOFAs in Canada and Japan—traditional locations for U.S. FDI and R&D along with Europe—have declined from 7.9% to 7.0% and from 5.6% to 4.8%, respectively, from 2007 to 2010.

On the other hand, the shares of R&D activities by affiliates in other regions are increasing. The region of Asia-Pacific, excluding Japan, accounted for a record 16.3% of U.S. MOFA R&D in 2010. The Middle East and Latin America each accounted for about 5% in 2010, up from 3.0% and 3.4%, respectively, in 2007. Within these emerging regions for U.S.-owned R&D, China, India, Brazil, and Israel accounted for the largest shares.

U.S. MOFA R&D performance in China more than doubled in current dollars from 2005 to 2008, with year-to-year double-digit increases to a record $1.7 billion in 2008.

Table 4-9
**R&D performed by majority-owned affiliates of foreign companies in the United States, by selected industry of affiliate and investor country: 2010**
(Millions of current U.S. dollars)

| | | Manufacturing | | | | | | Nonmanufacturing | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Country | All industries | Total | Chemicals | Machinery | Computer, electronic products | Electrical equipment, appliances, components | Transportation equipment | Wholesale trade | Information | Professional, scientific, technical services |
| All countries | 41,272 | 29,894 | 16,638 | 2,509 | 4,731 | 621 | 2,306 | 6,035 | 1,870 | 2,843 |
| Canada | 575 | 314 | 1 | 9 | D | 1 | 211 | 106 | 49 | 84 |
| France | 5,248 | 4,064 | 1,360 | D | 1,891 | 225 | 71 | 145 | D | 74 |
| Germany | 5,679 | 4,731 | 2,099 | D | 106 | 18 | 907 | 338 | D | 79 |
| Japan | 5,112 | 1,842 | 713 | 117 | 479 | 47 | 287 | 2,302 | 194 | 669 |
| Netherlands | 1,910 | 1,592 | 169 | D | D | 5 | D | D | 3 | 26 |
| Switzerland | 9,086 | 7,676 | 7,103 | 40 | D | D | 6 | D | 2 | 1,019 |
| United Kingdom | 5,975 | 5,621 | 4,046 | 45 | 282 | D | 425 | 102 | 111 | 137 |
| Other | 7,687 | 4,054 | 1,146 | 633 | 957 | 193 | D | 2,546 | 134 | 755 |

D = suppressed to avoid disclosure of confidential information.

NOTES: Preliminary 2010 estimates are for majority-owned (> 50%) affiliates of foreign companies by country of ultimate beneficial owner and industry of affiliate. Includes R&D conducted by foreign affiliates, whether for themselves or others under contract; excludes R&D conducted by others for affiliates.

SOURCE: Bureau of Economic Analysis, Survey of Foreign Direct Investment in the United States (annual series), http://www.bea.gov/international, accessed January 2013.

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Table 4-10
**R&D performed abroad by majority-owned foreign affiliates of U.S. parent companies, by selected industry of affiliate and host region/country/economy: 2010**
(Millions of current U.S. dollars)

| Region/country/ economy | All industries | Total | Chemicals | Machinery | Computer, electronic products | Electrical equipment, appliances, components | Transportation equipment | Wholesale trade | Information | Professional, scientific, technical services |
|---|---|---|---|---|---|---|---|---|---|---|
| All countries | 39,470 | 27,571 | 8,532 | 1,448 | 6,030 | 703 | 7,584 | 1,975 | 2,018 | 7,759 |
| Canada | 2,749 | 1,449 | 434 | 26 | 286 | D | 535 | 174 | 311 | 806 |
| Europe | 24,406 | 18,208 | 6,351 | 963 | 2,997 | 376 | 5,047 | 1,379 | 865 | 3,855 |
| Austria | 277 | D | 21 | 111 | 8 | 23 | 4 | 6 | 0 | D |
| Belgium | 2,116 | D | D | 15 | 9 | D | D | D | * | 321 |
| Czech Republic | 68 | D | 9 | 6 | D | 0 | 9 | D | 0 | 2 |
| Denmark | 196 | D | D | 8 | 63 | * | 0 | D | 3 | 2 |
| Finland | 221 | D | 12 | D | D | 4 | 2 | 2 | 0 | D |
| France | 1,984 | 1,783 | 410 | 96 | 575 | D | 347 | 83 | 41 | 73 |
| Germany | 6,713 | 5,505 | 341 | 275 | 1,017 | 190 | 3,162 | 568 | 48 | 552 |
| Greece | 27 | 26 | 22 | 0 | * | 0 | 0 | 1 | 0 | * |
| Hungary | 65 | 30 | 5 | 2 | * | 2 | D | 3 | 0 | 31 |
| Ireland | 1,431 | 1,045 | 585 | * | 283 | 0 | 2 | 3 | 297 | D |
| Italy | 589 | 401 | 187 | 76 | 29 | 4 | 52 | 8 | 2 | 176 |
| Luxembourg | D | D | D | 0 | 0 | 0 | 0 | 1 | * | D |
| Netherlands | 1,290 | 1,074 | 701 | 28 | 41 | D | D | 10 | 52 | 151 |
| Norway | 137 | D | 3 | D | 38 | 0 | 0 | * | D | 2 |
| Poland | 136 | 62 | 7 | 1 | 1 | * | 45 | 1 | 2 | 71 |
| Portugal | 56 | D | 29 | 1 | 1 | 1 | D | 1 | D | * |
| Russia | 65 | D | 5 | 0 | 1 | 0 | 2 | 6 | * | D |
| Spain | 607 | 545 | 146 | 3 | D | 10 | 92 | D | 0 | D |
| Sweden | 520 | 334 | 52 | 49 | D | 4 | D | 4 | D | D |
| Switzerland | 1,558 | 935 | 460 | 56 | 185 | 17 | D | 259 | D | D |
| Turkey | 53 | 50 | 31 | * | 0 | 0 | 14 | 1 | 1 | 1 |
| United Kingdom | 5,905 | 3,736 | 1,695 | 191 | 323 | 28 | 984 | D | 183 | 1,778 |
| Other | D | D | D | 2 | 1 | 1 | 14 | 2 | 0 | 28 |
| Latin America and OWH | 1,949 | 1,725 | 356 | D | 96 | D | 1,030 | D | D | 142 |
| Argentina | 115 | 73 | 47 | D | D | 0 | 9 | 1 | 0 | D |
| Brazil | 1,372 | 1,281 | 215 | 51 | 77 | 1 | D | 22 | D | 33 |
| Mexico | 338 | 305 | D | 4 | D | D | D | 2 | * | 31 |
| Africa | 88 | D | 23 | 1 | * | 0 | 9 | 4 | 0 | D |
| South Africa | 74 | D | 23 | * | 0 | 0 | 6 | 3 | 0 | D |
| Middle East | 1,965 | D | 50 | D | 640 | 0 | 0 | D | D | D |
| Israel | 1,948 | D | 47 | D | 640 | 0 | 0 | D | D | 950 |
| Asia and Pacific | 8,313 | 5,290 | 1,319 | 275 | 2,011 | 275 | 962 | 289 | 765 | 1,955 |
| Australia | 767 | 560 | 162 | 12 | D | D | D | 28 | 4 | 170 |
| China | 1,452 | D | 101 | 41 | 348 | 109 | 55 | 9 | D | 443 |
| Hong Kong | 153 | 104 | 12 | 0 | 86 | 5 | 0 | 6 | 6 | 37 |
| India | 1,644 | 446 | 83 | D | 231 | 6 | 73 | D | D | 778 |
| Indonesia | 28 | D | 2 | 0 | 0 | 0 | * | * | 0 | D |
| Japan | 1,885 | 1,576 | 808 | 152 | 300 | D | 74 | 57 | D | D |
| Malaysia | 376 | 337 | 2 | * | 320 | * | 0 | 2 | 0 | 37 |
| New Zealand | 21 | 18 | 2 | 1 | * | 5 | 0 | 1 | 0 | 2 |
| Philippines | 55 | D | 4 | 0 | 18 | * | 1 | * | 0 | D |
| Singapore | 753 | 514 | 67 | D | 424 | 8 | 12 | 12 | 18 | 206 |
| South Korea | 835 | 780 | 49 | 19 | 166 | 0 | D | D | D | 27 |
| Taiwan | 235 | 127 | 21 | D | 82 | D | D | 14 | D | D |
| Thailand | 106 | D | 6 | 4 | D | 0 | 8 | 3 | 0 | D |
| Other | 2 | 2 | * | 0 | 2 | 0 | 0 | 0 | 0 | 0 |

* = ≤ $500,000; D = suppressed to avoid disclosure of confidential information.

OWH = other Western Hemisphere.

NOTES: Preliminary 2010 estimates are for majority-owned (> 50%) affiliates of U.S. parent companies by host country and industry of affiliate. Includes R&D conducted by foreign affiliates, whether for themselves or others under contract; excludes R&D conducted by others for affiliates.

SOURCE: Bureau of Economic Analysis, Survey of U.S. Direct Investment Abroad (annual series), http://www.bea.gov/international, accessed January 2013.

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Table 4-11
**R&D performed abroad, shares, and R&D intensity of majority-owned foreign affiliates of U.S. parent companies, by selected host country: 2007 and 2010**

| Country | R&D performed (US$millions) | | R&D performed shares (%) | | R&D/value added ratio (%) | |
|---|---|---|---|---|---|---|
| | 2007 | 2010 | 2007 | 2010 | 2007 | 2010 |
| Total | 34,446 | 39,470 | 100.0 | 100.0 | 3.1 | 3.2 |
| Germany | 6,403 | 6,713 | 18.6 | 17.0 | 7.2 | 8.0 |
| United Kingdom | 6,000 | 5,905 | 17.4 | 15.0 | 3.6 | 3.9 |
| Canada | 2,712 | 2,749 | 7.9 | 7.0 | 2.3 | 2.1 |
| Belgium | 1,191 | 2,116 | 3.5 | 5.4 | 5.1 | 8.6 |
| France | 1,557 | 1,984 | 4.5 | 5.0 | 2.8 | 4.0 |
| Israel | 1,025 | 1,948 | 3.0 | 4.9 | 22.9 | 28.0 |
| Japan | 1,919 | 1,885 | 5.6 | 4.8 | 4.8 | 3.9 |
| India | 382 | 1,644 | 1.1 | 4.2 | 5.2 | 9.9 |
| Switzerland | 1,162 | 1,558 | 3.4 | 3.9 | 4.4 | 4.7 |
| China | 1,173 | 1,452 | 3.4 | 3.7 | 5.5 | 3.9 |
| Ireland | 1,510 | 1,431 | 4.4 | 3.6 | 2.7 | 2.3 |
| Brazil | 607 | 1,372 | 1.8 | 3.5 | 1.9 | 3.0 |
| Netherlands | 752 | 1,290 | 2.2 | 3.3 | 2.7 | 5.4 |

NOTES: Sorted by 2010 R&D performed. Data are for majority-owned (> 50%) foreign affiliates of U.S. parent companies. Data include R&D expenditures performed by affiliates, whether for themselves or for others under contract. Data exclude R&D expenditures 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 14 January 2013.

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This is consistent with increases in total R&D performed in China in recent years and its emergence as the second-largest R&D-performing country (see section, "International Comparisons of R&D Performance"). Single-digit declines in 2009 and 2010 put R&D performed by U.S. MOFAs in China at $1.5 billion in 2010 (appendix table 4-26).

Reported R&D activity by U.S. MOFAs tripled in India and more than doubled in Brazil from 2007 to 2010 in current dollars, growing much faster than U.S. MOFA production activity in those countries measured as value added (thus increasing their R&D intensity measured as the ratio to value added). U.S. MOFA R&D expenditures in Brazil and India are now on par with affiliates in China. Among countries with at least $1 billion in R&D performed by U.S. MOFAs in 2010, U.S. MOFAs located in Israel have the largest R&D intensity (table 4-11).

Three manufacturing industries, chemicals (which includes pharmaceuticals), transportation equipment, and computer and electronic products accounted for 56% of U.S. MOFA R&D in 2010. Overall, affiliates classified in manufacturing accounted for 70%. The largest R&D-performing nonmanufacturing industries were information services and PST services (table 4-10; appendix table 4-28).

In spite of the relative decline in the share of traditional locations such as Europe as a whole and Japan, they remain the top R&D hosts for U.S. MNCs in major industries, reflecting both strengths of host countries in certain technologies and the large R&D stocks by U.S. MNCs in these locations.

Germany is by far the largest location of U.S. MOFA R&D in transportation equipment ($3.2 billion of $7.6 billion in this industry by U.S. MOFAs globally) and in computers and electronic products manufacturing ($1.0 billion out of $6.0 billion by U.S. MOFAs globally). The United Kingdom is the top location in chemicals manufacturing R&D and in PST services R&D by U.S. MOFAs. Japan is the second-largest host for R&D performed by U.S. MOFAs classified in chemicals manufacturing.

On the other hand, among MOFAs classified in PST services, India has emerged as the second-largest host country for U.S.-owned R&D performance after the United Kingdom ($0.8 billion compared with the United Kingdom's $1.8 billion), based on available preliminary 2010 country-industry details from BEA (table 4-10).

## Cross-National Comparisons of Business R&D

This section compares business R&D across OECD countries across two dimensions: the distribution of business R&D across industries and the role of affiliates of foreign MNCs.

Companies classified in manufacturing perform most business R&D in the top seven R&D-performing countries, with shares ranging from 89% in Germany to 69% in the United States, based on OECD's Analytical Business Enterprise R&D (ANBERD) database (see table 4-12).[18] These countries, however, differ in terms of the focus of their business R&D.

Pharmaceuticals manufacturing is the largest business R&D sector in the United Kingdom (28% of United Kingdom business enterprise R&D) and in the United States (16% of U.S. business enterprise R&D). Motor vehicles R&D has the largest share in Germany (33%). R&D in radio, television, and communication equipment manufacturing,

Table 4-12
**Share of manufacturing and nonmanufacturing in business R&D, by selected country: 2010 or most recent year**
(Percent)

| Country | Manufacturing | Nonmanufacturing |
|---|---|---|
| Germany (2008) | 89.0 | 11.0 |
| South Korea (2010) | 87.7 | 12.3 |
| Japan (2010) | 87.1 | 12.9 |
| China (2009) | 84.0 | 16.0 |
| France (2007) | 83.6 | 16.4 |
| United Kingdom (2009) | 73.9 | 26.1 |
| United States (2009) | 69.3 | 30.7 |

NOTES: Industry classifications for France and South Korea are based on product field. For all other countries, data are based on main activity.

SOURCE: Organisation for Economic Co-operation and Development, Analytical Business Enterprise R&D (ANBERD) Statistical Analysis Database (STAN), R&D Expenditures in Industry, http://stats.oecd.org/Index.aspx?DataSetCode=ANBERD2011_REV3, accessed 7 February 2013.

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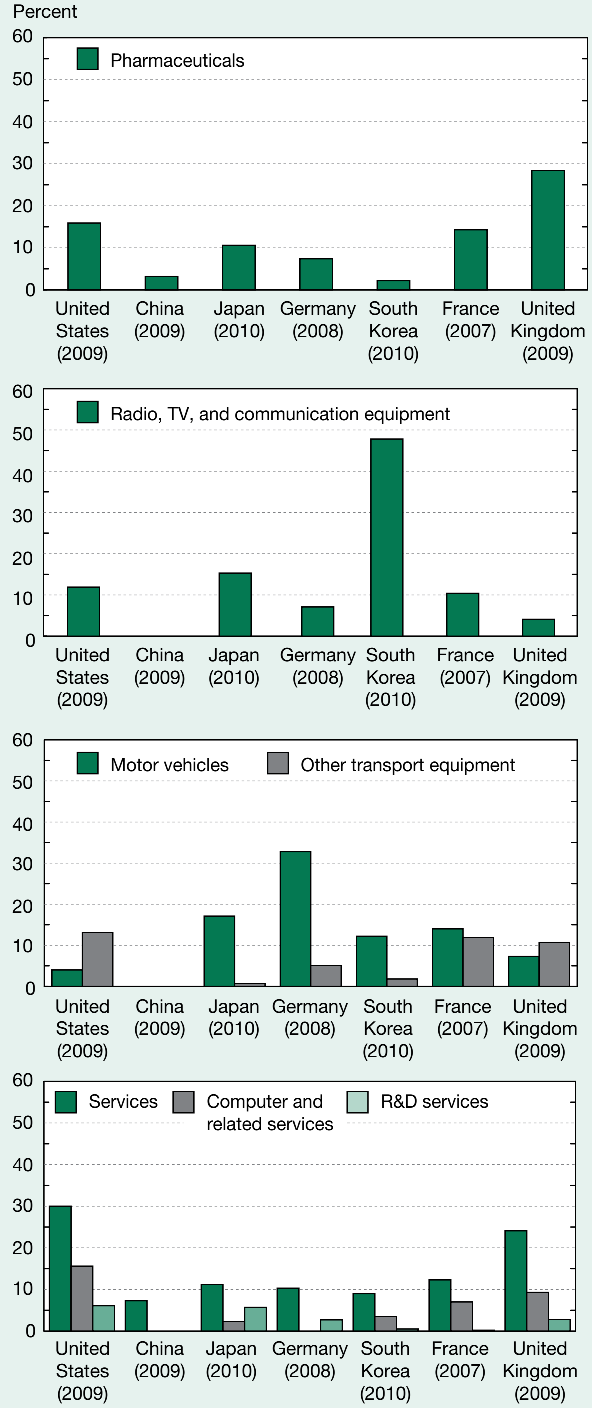
which includes semiconductor devices, accounts for close to half (48%) of South Korea's business enterprise R&D (figure 4-15).

Business R&D in other transportation equipment (appendix table 4-31), which includes commercial and defense-related aerospace and spacecraft, has the highest shares in the United States (13%), France (12%), and the United Kingdom (11%).[19] These three countries also report the largest proportion of defense R&D within government budget appropriations or outlays for R&D (GBAORD) (table 4-15) discussed elsewhere in this chapter. In addition, France and the United Kingdom host 17 of the top 25 EU R&D-performing companies classified in the related category of aerospace and defense, according to the 2012 EU Scoreboard (EC 2012).

R&D in services industries (the main R&D performing component in nonmanufacturing) had the largest share in the United States (30%) and the lowest share in China (7%), based on the most recent comparable industry-level ANBERD data. Within services, computer and related services accounted for the largest share in the United States and the United Kingdom (figure 4-15; appendix table 4-31).

R&D performed within a country by affiliates of foreign MNCs represented more than half of business enterprise R&D in smaller OECD countries such as Belgium, Ireland, Israel, and several Eastern and Central European countries in 2009 (figure 4-16). Japan, the second-largest business R&D performer among countries reporting foreign-affiliate R&D, had the lowest share (6%), compared with about 14% for the United States.

Figure 4-15
**Industry share of business R&D in selected countries: 2010 or most recent year**




NOTES: Data for China are not available for all industries. Data are classified according to International Standard Industrial Classification, Revision 3.1, by Organisation for Economic Co-operation and Development source. Data for France and South Korea are based on product field. For all other countries, data are based on main activity.

SOURCE: Organisation for Economic Co-operation and Development, Analytical Business Enterprise R&D (ANBERD) Statistical Analysis Database (STAN), R&D Expenditures in Industry, http://stats.oecd.org/Index.aspx?DataSetCode=ANBERD2011_REV3, accessed 7 February 2013.

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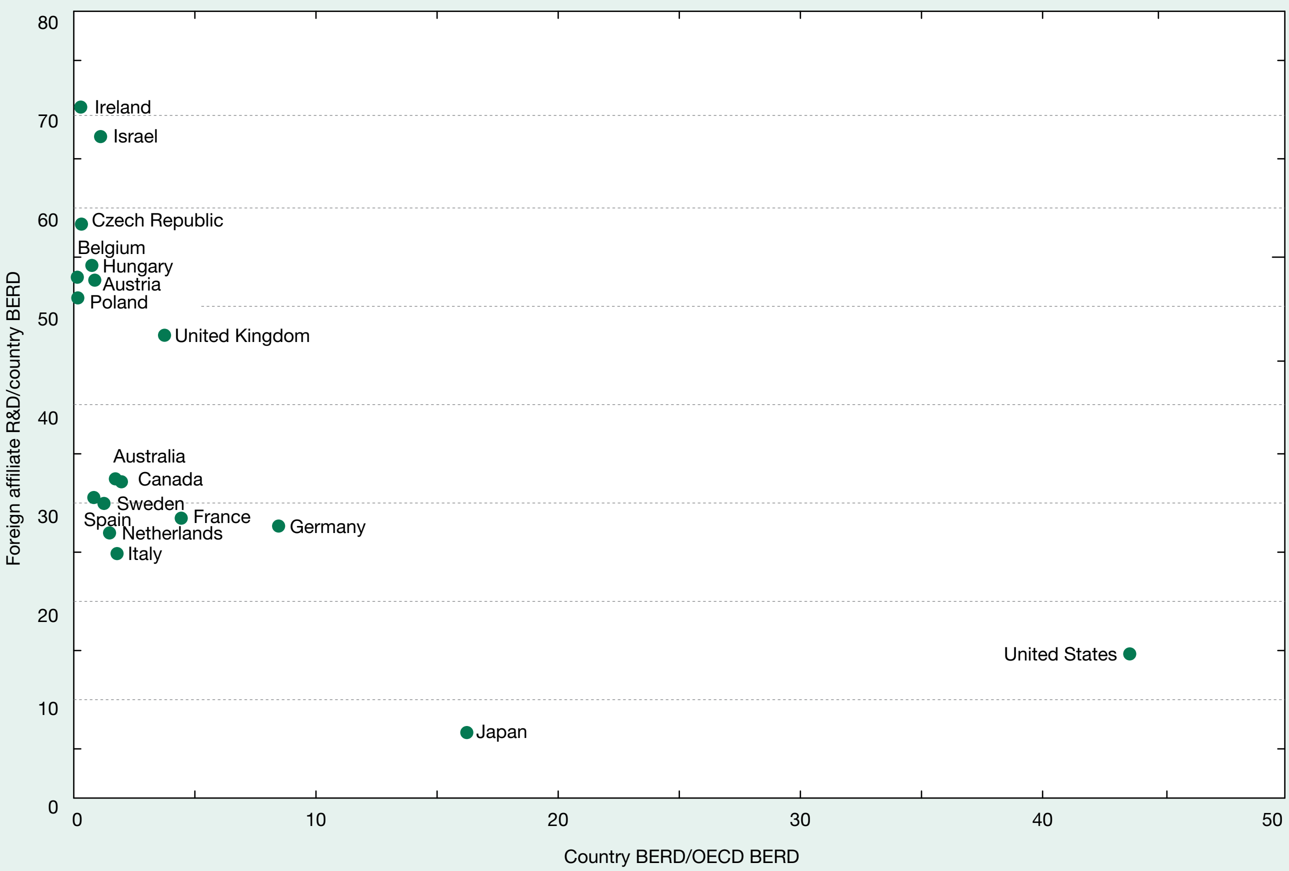
Figure 4-16
**Business enterprise R&D and R&D by foreign affiliates, by selected shares: 2009**




BERD = Business Enterprise R&D; OECD = Organisation for Economic Co-operation and Development.

SOURCE: OECD, *Main Science and Technology Indicators* (2012/2).

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## Federal R&D Performance and Funding

The U.S. government supports and facilitates the nation's R&D system through various policy avenues. The most direct of these are the R&D activities conducted by federal organizations (whether agency intramural laboratories and facilities or FFRDCs) and the funding for R&D provided to other performers (such as businesses and academic institutions).[20] This section provides statistical detail on these federally performed and funded R&D activities—in particular, how the funding has been allocated among differing national objectives, how current federal spending on R&D differs across the agencies, and how the current spending is allocated among differing research fields. The next section compares federal R&D spending priorities with those of national governments in the other major R&D-performing countries. (For definitions of key federal budget terms used in this section, see the sidebar, "Federal Budgetary Concepts and Related Terms.")

### Federal R&D Budget, by National Objectives

Federal support for the nation's R&D spans a range of objectives: national defense, health, space, energy, natural resources and environment, general science, and various other categories. The Office of Management and Budget (OMB) classifies agency funding requests into 20 broad categories termed *budget functions* (OMB 2012a). Federal agency R&D activities appear in 15 of these 20 functional categories.[21] While the authority for spending granted to the agencies (termed *budget authority* or *appropriations*) through the federal budget legislation enacted annually by the Congress is not yet actual spending, a look at how this budget authority divides among the various functional categories provides a useful picture of the present priorities and trends in federal support for U.S. R&D.

Budget authority for all spending on R&D by the federal agencies totaled \$144.4 billion (current dollars) in FY 2011 (figure 4-17; appendix tables 4-32 and 4-33). In FY 2010, the total was \$149.0 billion. It was \$164.3 billion in FY 2009—noticeably higher because of the one-time \$18.7

billion increase from ARRA.[22] The totals in FYs 2006 and 2001 were $136.0 billion and $91.5 billion, respectively.

### Defense-Related R&D

R&D directed at national defense objectives is supported primarily by the Department 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). National defense represented about 58% ($83.2 billion) of the total budget authority for R&D in FY 2011 (appendix table 4-32). It also accounted for 58% in FY 2006 and 51% in FY 2001.

This predominance of national defense R&D goes back many years. In FY 1980, there was rough equivalence between national defense and nondefense R&D. By FY 1985, national defense had become more than twice as large as nondefense, but from 1986 to 2001, nondefense R&D surged, with the national defense share shrinking back to just over half. Following September 11, 2001, however, national defense R&D again increased as a share, accounting for 59% of federal R&D budget authority in FY 2008. The drop to 52% in FY 2009 reflects chiefly an effect of the one-time increase in R&D budget authority from ARRA, primarily targeted at health, energy, and general science research.

## 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.

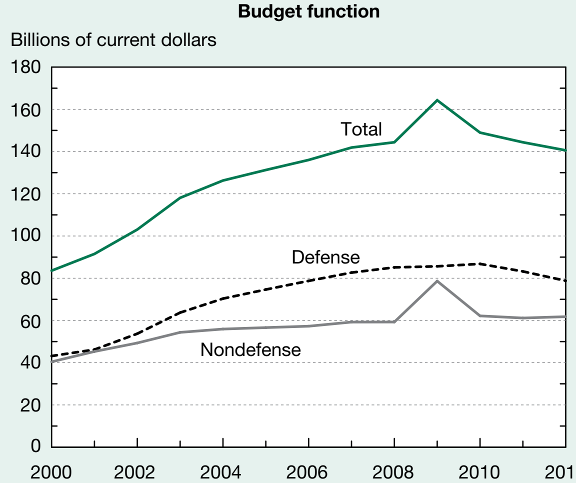
**Outlays.** Federal outlays represent the dollar amounts for checks issued and cash payments made during a given period, regardless of when funds were appropriated or obligated.

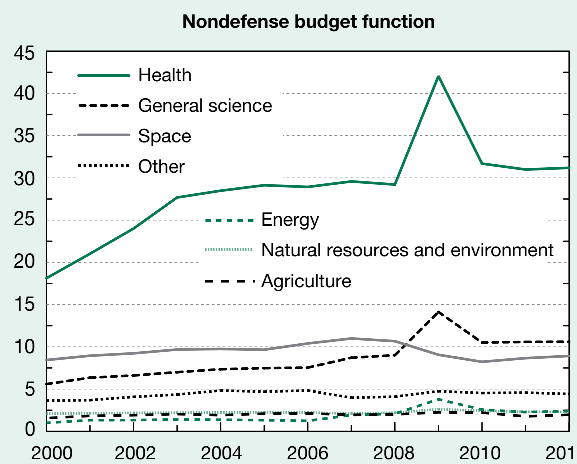
**R&D plant.** In general, R&D plant refers to the acquisition of, construction of, major repairs to, or alterations in structures, works, equipment, facilities, or land for use in R&D activities. Data included in this section refer to obligated federal dollars for R&D plant.

### Nondefense R&D

Nondefense R&D spans the other 14 budget function categories, which include activities in the areas of health, space research and technology, energy, general science, natural resources and environment, transportation, agriculture, education, international affairs, veterans benefits, and a number of other small categories related to economic and governance matters. Budget authority for nondefense R&D accounted for 42% ($61.2 billion) in FY 2011 (appendix table 4-32). It was also 42% in FY 2006, but it was just under 50% in FY 2001.

Figure 4-17
**Federal budget authority for R&D and R&D plant, by budget function: FYs 2000–12**




NOTES: Data for FY 2012 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: international affairs, commerce and housing credit, transportation, community and regional development, education and training, Medicare, income security, veterans benefits, and administration of justice.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Federal R&D Funding by Budget Function (FYs 2010–12). See appendix table 4-32.

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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 just over half of all nondefense R&D (figure 4-17). Health R&D was 12% of total federal R&D budget authority in FY 1980 but rose to 22% in FY 2011. This rise in share jumped after FY 1998, when national policymakers set the National Institutes of Health (NIH) budget on course to double by FY 2003. Health research was also particularly favored by the ARRA increment, rising to 26% of the total R&D budget authority in FY 2009 (appendix table 4-32).

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 budget authority throughout the 1990s. The loss of the Space Shuttle *Columbia* and its crew in February 2003 prompted curtailment of manned space missions. In FY 2006, the space R&D share was down to about 8%; it was 6% in FY 2011.

Nondefense federal R&D classified as general science had about a 4% share of total federal R&D in the mid-1990s, growing to 7% in FY 2011. However, much of this change reflected an important reclassification: starting in FY 1998, several DOE programs were shifted from the energy category to general science.

## Federal Spending on R&D, by Agency

Fifteen federal departments and a dozen other agencies engage in and/or fund R&D in the United States. Nine of these departments/agencies reported R&D spending in excess of $1 billion annually in FY 2011, and these nine accounted for 97% of the total (table 4-13; appendix table 4-35). Another six of the departments/agencies reported spending above $100 million annually.

(The budget figures reported in this section are in *obligations*. For the distribution of federal R&D across the agencies, data on spending in *obligations* terms provide the most comprehensive and consistent account. *Budget authority*, as discussed earlier, lays out the themes of the broad federal spending plan. Spending *obligations* reflect federal dollars as they are spent, that is, the implementation of the plan by federal agencies. Because planning and actual spending are different steps, the reported statistics on R&D in obligations

Table 4-13
**Federal obligations for R&D and R&D plant, by agency and performer: FY 2011**
(Millions of dollars)

| | | | | Total by performers | | | |
|---|---|---|---|---|---|---|---|
| Agency | Total | R&D | R&D plant | Intramural and FFRDCs | Percent of total | Extramural performers | Percent of total |
| All agencies | 136,418.1 | 132,140.6 | 4,277.4 | 44,196.3 | 32.4 | 92,221.7 | 67.6 |
| Department of Defense | 71,842.3 | 71,684.2 | 158.1 | 22,268.8 | 31.0 | 49,573.5 | 69.0 |
| Department of Health and Human Services | 31,766.3 | 31,573.7 | 192.6 | 6,200.1 | 19.5 | 25,566.2 | 80.5 |
| Department of Energy | 9,923.2 | 9,136.2 | 786.9 | 7,516.7 | 75.7 | 2,406.5 | 24.3 |
| National Aeronautics and Space Administration | 8,429.0 | 6,570.5 | 1,858.5 | 2,070.2 | 24.6 | 6,358.7 | 75.4 |
| National Science Foundation | 5,373.3 | 4,924.4 | 448.9 | 350.6 | 6.5 | 5,022.6 | 93.5 |
| Department of Agriculture | 2,634.6 | 2,591.3 | 43.3 | 1,657.2 | 62.9 | 977.4 | 37.1 |
| Department of Commerce | 1,419.7 | 1,135.5 | 284.2 | 1,011.3 | 71.2 | 408.3 | 28.8 |
| Department of Homeland Security | 1,051.1 | 634.7 | 416.4 | 667.5 | 63.5 | 383.6 | 36.5 |
| Department of Transportation | 1,021.2 | 997.0 | 24.2 | 349.2 | 34.2 | 671.9 | 65.8 |
| Department of the Interior | 694.8 | 688.6 | 6.3 | 571.5 | 82.2 | 123.4 | 17.8 |
| Department of Veterans Affairs | 579.0 | 579.0 | 0.0 | 579.0 | 100.0 | 0.0 | 0.0 |
| Environmental Protection Agency | 577.0 | 577.0 | 0.0 | 464.9 | 80.6 | 112.1 | 19.4 |
| Department of Education | 346.3 | 346.3 | 0.0 | 19.1 | 5.5 | 327.3 | 94.5 |
| Smithsonian Institution | 227.0 | 169.0 | 58.0 | 227.0 | 100.0 | 0.0 | 0.0 |
| Department of Justice | 101.0 | 101.0 | 0.0 | 27.9 | 27.6 | 73.1 | 72.4 |
| All other agencies | 432.3 | 432.3 | 0.0 | 215.3 | 49.8 | 217.0 | 50.2 |

FFRDC = federally funded R&D center.

NOTES: The table lists all agencies with R&D obligations greater than $100 million in FY 2011. R&D is basic research, applied research, and development and 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 businesses, 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 Labor, Department of State, Department of Treasury, Agency for International Development, Appalachian Regional Commission, Federal Communications Commission, Federal Trade Commission, Library of Congress, National Archives and Records Administration, Nuclear Regulatory Commission, and Social Security Administration.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, *Federal Funds for Research and Development* (FYs 2010–12). See appendix table 4-35.

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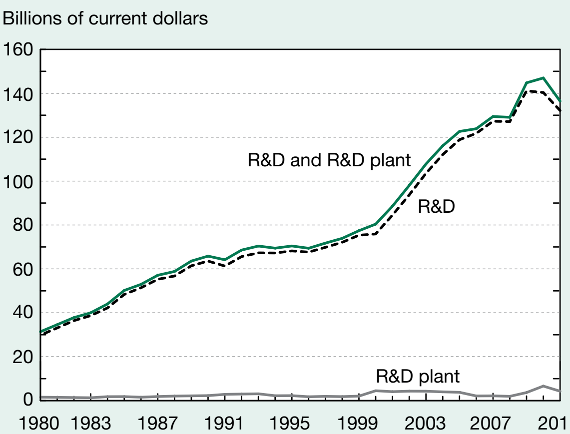
typically differ from the corresponding items in budget authority terms.)

In FY 2011, federal obligations for R&D and R&D plant together totaled $136.4 billion: $132.1 billion for R&D and an additional $4.3 billion for R&D plant (table 4-13). The corresponding figures for FY 2010 were $147.0 billion in total, $140.4 billion for R&D, and $6.6 billion for R&D plant; for FY 2009, they were $144.8 billion in total, $141.1 billion for R&D, and $3.7 billion for R&D plant (appendix table 4-34). Federal obligations for R&D increased annually on both a current and constant dollar basis from the late 1990s through FY 2010 (figure 4-18; appendix table 4-34). The FY 2011 drop in funding was a noticeable departure from this trend.

(The corresponding figures for federal funding of U.S. R&D cited in table 4-1 earlier in this chapter are lower. The table 4-1 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. For a discussion, see the sidebar, "Tracking R&D: The Gap between Performer- and Source-Reported Expenditures.")

The nine departments/agencies that account presently for almost all federal R&D differ widely in the balance of R&D performed and/or funded among intramural laboratories, FFRDCs, and various extramural performers (including private businesses, universities and colleges, other nonprofit organizations, state and local governments, and foreign organizations). There are also significant differences in the

Figure 4-18
**Federal obligations for R&D and R&D plant: FYs 1980–2011**




NOTE: Data for FYs 2009 and 2010 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 (annual series). See appendix table 4-34.

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character-of-work profiles, that is, the balances among the basic research, applied research, and development conducted.

### Department of Defense

In FY 2010, DOD obligated a total of $71.8 billion for R&D and R&D plant (table 4-13), which represented a little over half (53%) of all federal spending on R&D and R&D plant that year. Nearly the entire DOD total was R&D spending ($71.7 billion), with the remainder spent on R&D plant.

Thirty-one percent ($22.3 billion) of the total was spending by the department's intramural labs, related agency R&D program activities, and FFRDCs (table 4-13). Extramural performers accounted for 69% ($49.6 billion) of the obligations, with the bulk going to business firms ($46.6 billion; appendix table 4-35).

Considering just the R&D component, relatively small amounts were spent on basic research ($1.9 billion, 3%) and applied research ($4.7 billion, 7%) in FY 2011 (table 4-14). The vast majority of obligations, $65.1 billion (91%), went to development. Furthermore, the bulk of this DOD development ($59.0 billion) was allocated for major systems development, which includes the main activities in developing, testing, and evaluating combat systems (figure 4-19). The remaining DOD development ($6.1 billion) was allocated for advanced technology development, which is more similar to other agencies' development obligations.

### Department of Health and Human Services

The Department of Health and Human Services (HHS) is the main federal source of spending for health-related R&D. In FY 2011, the department obligated $31.8 billion for R&D and R&D plant, or 23% of the total of federal obligations that year (appendix table 4-35). Nearly all of this was for R&D ($31.6 billion). Furthermore, much of the total, $29.9 billion, represented the R&D activities of NIH.

For the department as a whole, R&D and R&D plant obligations for agency intramural activities and FFRDCs accounted for 20% ($6.2 billion) of the total. Extramural performers accounted for 81% ($25.6 billion). Universities and colleges ($18.3 billion) and other nonprofit organizations ($4.9 billion) conducted the most sizable of these extramural activities (appendix table 4-35).

Nearly all of HHS R&D funding is allocated to research: 51% for basic research and 49% for applied research (table 4-14).

### Department of Energy

DOE obligated $9.9 billion for R&D and R&D plant in FY 2011, about 8% of the total of federal obligations that year. Of this amount, $9.1 billion was for R&D and $0.8 billion was for R&D plant.

The department's intramural laboratories and FFRDCs accounted for 76% of the total obligations. Many of DOE's

## Tracking R&D: The Gap between Performer- and Source-Reported Expenditures

In the United States—and in some other Organisation for Economic Co-operation and Development (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 between the data provided by funders and that provided by performers can arise for numerous reasons, such as the different calendars for reporting government obligations (fiscal years) and performance expenditures (calendar years). In the United States, there has been a sizable gap between performer and funder data for federal R&D over the past two decades.

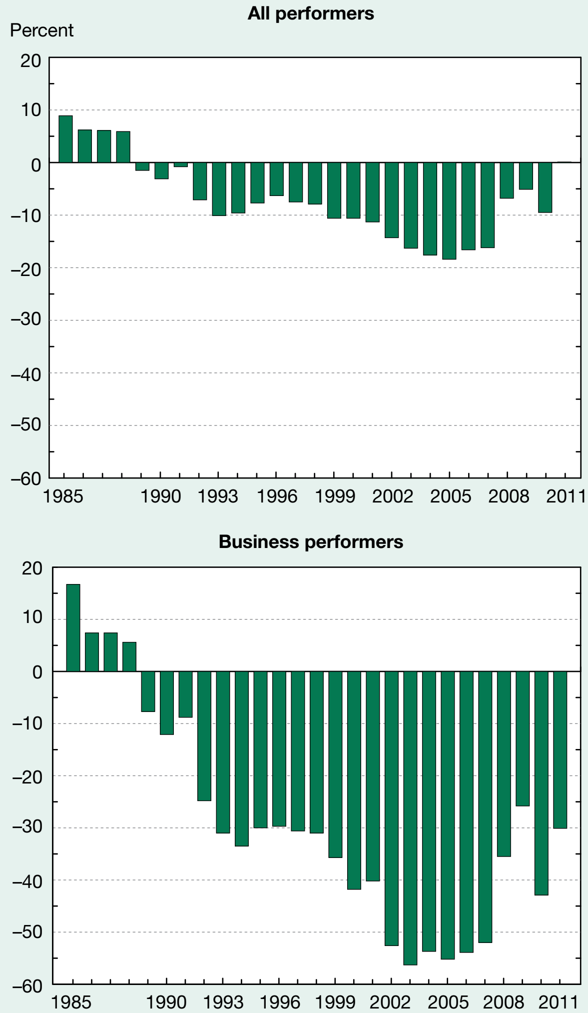
In the mid-1980s, performer-reported federal R&D in the United States exceeded federal reports of funding by $3 billion to $4 billion annually (5%–10% of the government total). This pattern reversed itself, however, at the end of the decade: in 1989, the government-reported R&D total exceeded performer reports by almost $1 billion. The government-reported excess increased noticeably from then 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 $107 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% less than the federally reported R&D support to industry in FY 2007 (figure 4-A; appendix table 4-36). These differences in federal R&D totals were seen primarily in DOD funding of development activities by industry. The figures for 2008–11 suggest a narrowing of the federal agency reporting excess, but they 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. A General Accounting Office investigation made the following assessment:

> 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. (GAO 2001:2)

Echoing this assessment, the National Research Council (NRC 2005) noted that comparing federal outlays for R&D (as opposed to obligations) with performer expenditures results in a smaller discrepancy. (In FY 2007, federal agencies reported total R&D outlays of $109 billion, compared with the performer-related total of $107 billion. In FY 2011, federal agencies reported R&D outlays of $131 billion, compared with the performer-reported total of $134 billion.)

Figure 4-A
**Differences in federal R&D support, as reported by performers and federal agencies: 1985–2011**




NOTE: Difference is defined as the percentage 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 (FYs 2010–12). See appendix table 4-36.

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Table 4-14
**Federal obligations for R&D, by agency and character of work: FY 2011**
(Millions of current dollars)

| | | | | | Percent of total R&D | | |
|---|---|---|---|---|---|---|---|
| Agency | Total R&D | Basic research | Applied research | Development | Basic research | Applied research | Development |
| All agencies | 132,140.6 | 29,060.8 | 29,105.9 | 73,973.9 | 22.0 | 22.0 | 56.0 |
| Department of Defense | 71,684.2 | 1,903.9 | 4,674.3 | 65,106.1 | 2.7 | 6.5 | 90.8 |
| Department of Health and Human Services | 31,573.7 | 16,123.7 | 15,316.7 | 133.3 | 51.1 | 48.5 | 0.4 |
| Department of Energy | 9,136.2 | 3,717.2 | 3,054.2 | 2,364.8 | 40.7 | 33.4 | 25.9 |
| National Aeronautics and Space Administration | 6,570.5 | 856.8 | 717.8 | 4,995.8 | 13.0 | 10.9 | 76.0 |
| National Science Foundation | 4,924.4 | 4,581.2 | 343.2 | 0.0 | 93.0 | 7.0 | 0.0 |
| Department of Agriculture | 2,591.3 | 1,078.8 | 1,293.4 | 219.1 | 41.6 | 49.9 | 8.5 |
| Department of Commerce | 1,135.5 | 149.8 | 839.3 | 146.4 | 13.2 | 73.9 | 12.9 |
| Department of Transportation | 997.0 | 8.1 | 704.6 | 284.2 | 0.8 | 70.7 | 28.5 |
| Department of the Interior | 688.6 | 48.9 | 564.6 | 75.1 | 7.1 | 82.0 | 10.9 |
| Department of Homeland Security | 634.7 | 91.2 | 208.2 | 335.2 | 14.4 | 32.8 | 52.8 |
| Department of Veterans Affairs | 579.0 | 218.0 | 314.0 | 47.0 | 37.7 | 54.2 | 8.1 |
| Environmental Protection Agency | 577.0 | 88.0 | 403.4 | 85.6 | 15.3 | 69.9 | 14.8 |
| Department of Education | 346.3 | 7.5 | 205.6 | 133.2 | 2.2 | 59.4 | 38.5 |
| Smithsonian Institution | 169.0 | 169.0 | 0.0 | 0.0 | 100.0 | 0.0 | 0.0 |
| Department of Justice | 101.0 | 17.5 | 65.8 | 17.7 | 17.3 | 65.1 | 17.5 |
| All other agencies | 432.2 | 1.2 | 400.8 | 30.4 | 0.3 | 92.7 | 7.0 |

NOTES: The table lists all agencies with R&D obligations greater than $100 million in FY 2011. Detail may not add to total due to rounding. All other agencies includes Department of Housing and Urban Development, Department of Labor, Department of State, Department of the Treasury, Agency for International Development, Appalachian Regional Commission, Federal Communications Commission, Federal Trade Commission, Library of Congress, National Archives and Records Administration, Nuclear Regulatory Commission, and Social Security Administration.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Federal Funds for Research and Development (FYs 2010–12). See appendix table 4-35.

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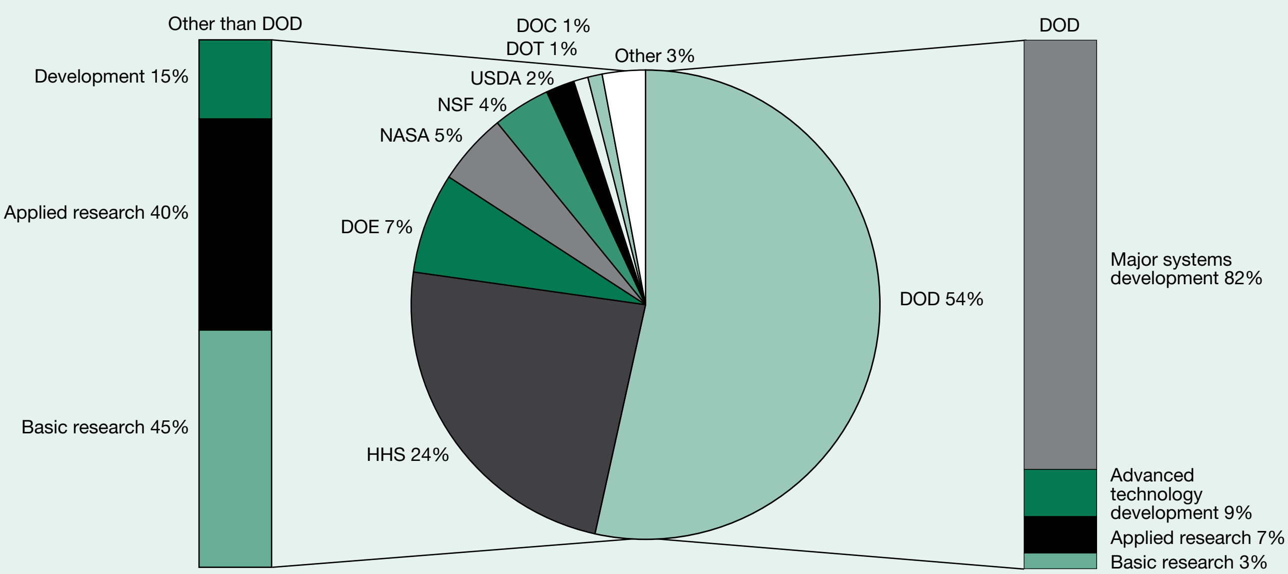
Figure 4-19
**Federal obligations for R&D, by agency and character of work: FY 2011**




DOC = Department of Commerce; DOD = Department of Defense; DOE = Department of Energy; DOT= Department of Transportation; HHS = Department of Health and Human Services; NASA = National Aeronautics and Space Administration; NSF = National Science Foundation; USDA = U.S. Department of Agriculture.

NOTE: Detail may not add to total due to rounding.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Federal Funds for Research and Development (FYs 2010–12). See appendix table 4-35.

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research activities require specialized equipment and facilities available only at its intramural laboratories and FFRDCs, which are used by scientists and engineers from other agencies and sectors as well as by DOE researchers. Accordingly, DOE invests more resources in its intramural laboratories and FFRDCs than other federal agencies. The 24% of obligations to extramural performers went chiefly to businesses and universities and colleges.

For the $9.1 billion obligated to R&D, basic research accounted for 41%, applied research accounted for 33%, and development accounted for 26%. DOE R&D activities are distributed among domestic energy systems, defense (much of it funded by the department's National Nuclear Security Administration), and general science (much of which is funded by the department's Office of Science).

### National Aeronautics and Space Administration

The National Aeronautics and Space Administration (NASA) obligated $8.4 billion to R&D in FY 2011, 6% of the federal total. Seventy-five percent of these obligations were for extramural R&D, given chiefly to business sector performers. Agency intramural R&D and that by FFRDCs represented 25% of the NASA obligations total. By character of work, 76% of the NASA R&D obligations funded development activities, 13% funded basic research, and 11% funded applied research.

### National Science Foundation

NSF obligated $5.4 billion for R&D and R&D plant in FY 2011, or 4% of the federal total. Extramural performers, chiefly universities and colleges ($5.0 billion), represented 94% of this total. Basic research accounted for about 93% 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.

### Department of Agriculture

The Department of Agriculture (USDA) obligated $2.6 billion for R&D in FY 2011, 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 2011, about 63% ($1.7 billion) funded R&D by agency intramural performers, chiefly the Agricultural Research Service. Basic research accounts for about 42%, applied research accounts for 50%, and development accounts for 9%.

### Department of Commerce

The Department of Commerce (DOC) obligated $1.4 billion for R&D in FY 2011, most of which represented the R&D and R&D plant spending of the National Oceanic and Atmospheric Administration and the National Institute of Standards and Technology. Seventy-one percent of this total was for agency intramural R&D; 29% went to extramural performers, primarily businesses and universities and colleges. For the R&D component, 13% was basic research, 74% was applied research, and 13% was development.

### Department of Homeland Security

The Department of Homeland Security (DHS) obligated $1.1 billion for R&D and R&D plant in FY 2011, nearly all of which was for activities by the department's Science and Technology Directorate. Sixty-four percent of this total was for agency intramural and FFRDC activities. Just under 37% was conducted by extramural performers—mainly businesses—but also universities and colleges and other nonprofit organizations. Of the obligations for R&D, 14% was basic research, 33% was applied research, and 53% was development.

### Department of Transportation

The Department of Transportation (DOT) obligated $1.0 billion for R&D and R&D plant in FY 2011, most of which was for activities by the department's Federal Aviation Administration and Federal Highway Administration. Thirty-four percent of this obligations total was for agency intramural and FFRDC activities. Sixty-six percent was conducted by extramural performers—mainly businesses—but also state and local governments, universities and colleges, and other nonprofit organizations. Of the obligations for R&D, barely 1% was basic research, 71% was applied research, and 29% was development.

### Other Agencies

The six other departments/agencies obligating more than $100 million annually for R&D in FY 2011 were the Departments of Education (ED), the Interior (DOI), Justice, and Veterans Affairs; the Environmental Protection Agency (EPA); and the Smithsonian Institution (tables 4-13 and 4-14). These agencies varied with respect to the character of research and the roles of intramural, FFRDC, and extramural performers.

## Federal Spending on Research, by Field

The research conducted and/or funded by the federal government spans the full range of S&E fields. These fields vary widely with respect to their current funding levels and the history of support (appendix tables 4-37 and 4-38).

Funding for basic and applied research combined accounted for $58.2 billion (about 44%) of the $132.1 billion total of federal obligations for R&D in FY 2011 (table 4-14). Of this amount, $30.2 billion (52% of $58.2 billion) supported research in the life sciences (figure 4-20; appendix table 4-37). The fields with the next-largest amounts were engineering ($10.1 billion, 17%) and the physical sciences ($5.5 billion, 10%), followed by mathematics and computer sciences ($3.3 billion, 6%) and environmental sciences ($3.1 billion, 5%). The balance of federal obligations for research in FY 2011 supported psychology, the social sciences, and all other sciences ($5.9 billion overall, or 10% of the total for research).

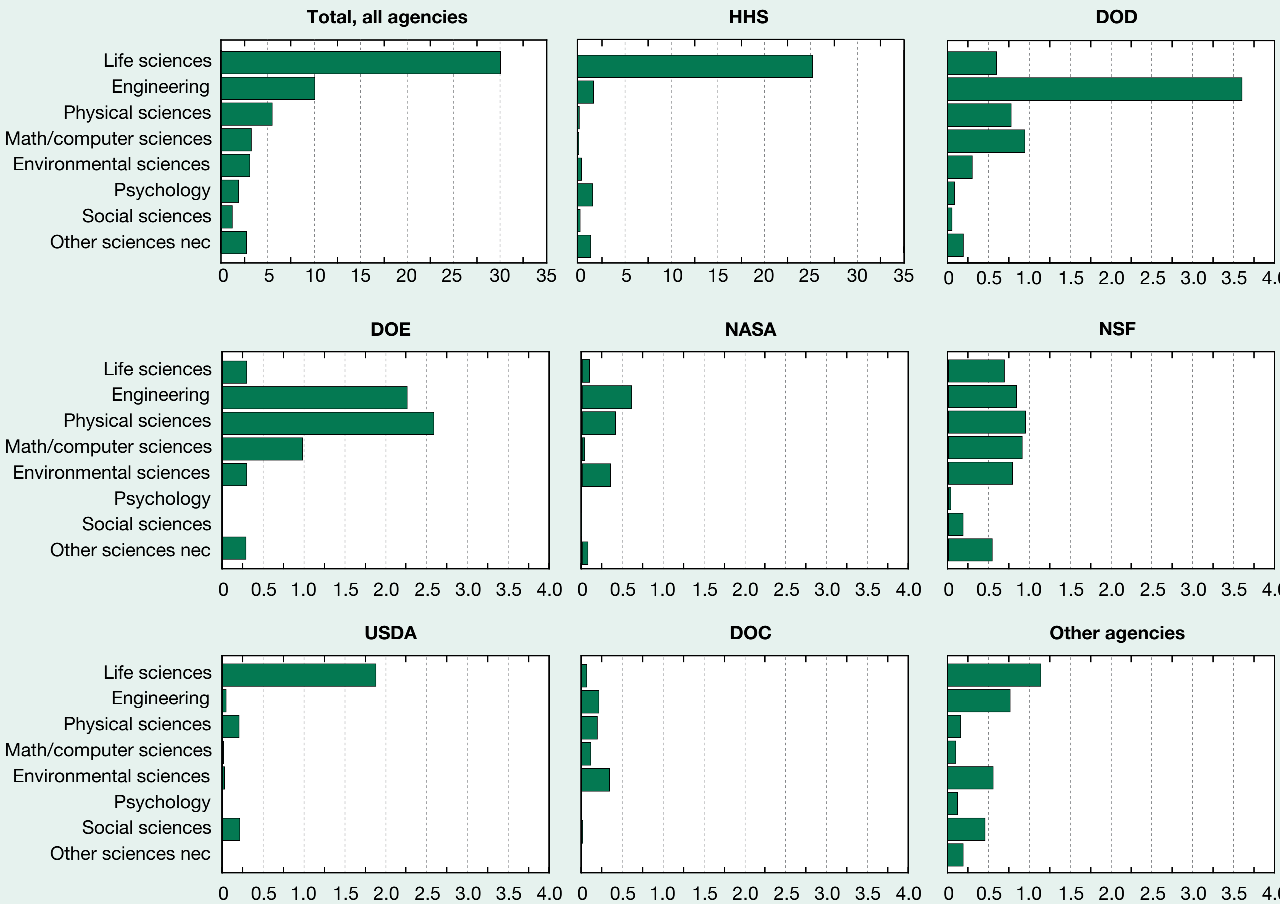
With differing missions, the federal agencies vary significantly in the types of S&E fields emphasized. HHS accounted for the largest share (54%) of federal obligations for research in FY 2011 (appendix table 4-37). Most of this amount funded research in medical and related life sciences, primarily through NIH. The five next-largest federal agencies for research funding that year were DOE (12%), DOD (11%), NSF (8%), USDA (4%), and NASA (3%).

DOE's $6.8 billion in research obligations provided funding for research in the physical sciences ($2.6 billion) and engineering ($2.3 billion), along with mathematics and computer sciences ($1.0 billion). DOD's $6.6 billion of research funding emphasized engineering ($3.6 billion) but also included mathematics and computer sciences ($1.0 billion), physical sciences ($0.8 billion), and life sciences ($0.6 billion). NSF—not a mission agency in the traditional sense—is charged with "promoting the health of science." Consequently, it had a comparatively diverse $4.9 billion research portfolio that allocated about $0.7 billion to $0.9 billion in each of the following fields: environmental, life, mathematics and computer, and physical sciences and engineering. Lesser amounts were allocated to psychology and the social and other sciences. USDA's $2.4 billion was directed primarily at the life (agricultural) sciences ($1.9 billion). NASA's $1.6 billion for research emphasized engineering ($0.6 billion), followed by the physical sciences ($0.4 billion) and environmental sciences ($0.4 billion).

Growth in federal research obligations has slowed in recent years. Federal obligations for research in all S&E fields expanded on average at 1.7% annually (in current dollars) over the 2006–11 period but at a much higher 2.7% over the 2001–11 period (appendix table 4-38).

Looking just at the recent period of FY 2006–11, the level of federal research obligations in the life sciences, psychology, and the social sciences experienced average annual growth at or just below the pace of expansion for all S&E (1.7%), meaning these fields essentially maintained their

Figure 4-20
**Federal obligations for research, by agency and major S&E field: FY 2011**
Billions of current dollars




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 = U.S. Department of Agriculture.

NOTES: The scales for Total, all agencies, and HHS differ from those of other agencies listed. Research includes basic and applied research.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Federal Funds for Research and Development (FYs 2010–12). See appendix table 4-37.

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shares of the total (appendix table 4-38). Obligations for the fields of mathematics/computer sciences and engineering, however, expanded at average paces well above that for all S&E, meaning these fields' shares of the total were increasing. Obligations for the physical sciences grew at less than half the rate of all S&E, a greater level of obligations in FY 2011 than in FY 2006, but a declining share of the whole. The field of environmental sciences experienced both a declining share and a lower absolute level in FY 2011 compared with that in FY 2006.

## Cross-National Comparisons of Government R&D Priorities

Government R&D funding statistics compiled annually by the OECD provide insights into how national government priorities for R&D differ across countries. Known technically as government budget appropriations or outlays for R&D (GBAORD), this indicator provides data on how a country's overall government funding for R&D splits among a set of socioeconomic categories (e.g., defense, health, space, general research).[23] These GBAORD statistics for the United States and other top R&D-performing countries appear in table 4-15 (with added detail in appendix table 4-39).[24]

Defense is an objective for government funding of R&D for the top seven R&D-performing countries, but the share varies widely (table 4-15). Defense accounted for 57% of U.S. federal R&D support in 2011, but it was markedly lower elsewhere: a smaller but still sizable 16% in South Korea and 15% in the United Kingdom, and below 7% in France, Germany, and Japan. (GBAORD statistics have not yet been available for China.)

Defense has received more than 50% of the federal R&D budget in the United States for much of the past 20 years. It was 63% in 1990 as the long Cold War period drew to a close, but it dropped in subsequent years. The defense share of government R&D funding for the other countries over the past 20 years has generally declined or remained at a stable, low level.

The health and environment objective accounted for some 57% of nondefense federal R&D budget support in the United States in FY 2011 and 33% in the United Kingdom. For both countries, the share has expanded markedly over the share prevailing several decades ago. The health and environment share is currently 14% in South Korea and 10% or less in France, Germany, and Japan. The funding under this objective is predominantly health (in contrast to the environment) in the United States and mainly health in the United Kingdom (appendix table 4-39). However, 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. In the United States, government R&D funding in this category was 20% of all nondefense federal support for R&D in 1990, dropping to 11% in 2011 (table 4-15).[25] In the United Kingdom, it was 32% in 1990 but declined to 8% in 2011. France was 33% in 1990 but dropped to 17% in 2011. Japan was 34% in 1990 but dropped to only 27% in 2011 (with particular emphasis on energy and industrial production and technology). Germany was 26% in 1990 and 24% in 2011 (with an industrial production and technology emphasis). South Korea (50%) exhibits the largest share by far in this category in 2011 (with a strong emphasis on industrial production and technology).

The civil space objective now accounts for 14% of nondefense federal R&D funding in the United States (table 4-15). The share has generally been declining over the last 20 years: 21% in 2000 and 24% in 1990. The share in France is currently about 14% 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 nonoriented research fund and general university fund (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: Japan (59%), Germany (58%), and the United Kingdom (52%). France (42%) and South Korea (31%) were below half but still sizable. The corresponding 2011 share for the United States (16%) was substantially smaller. Nevertheless, cross-national comparisons of these particular indicators can be difficult because some countries (notably the United States) do not use the GUF mechanism to fund R&D for general advancement of knowledge, 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 (see the sidebar, "Government Funding Mechanisms for Academic Research").

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 (5%), and the United Kingdom (4%) than in Japan (1%). The United States (3%) and South Korea (3%) are in between.

## Federal Programs to Promote Technology Transfer and the Commercialization of Federal R&D

Starting in the late 1970s, concerns by domestic policymakers about the strength of U.S. industries and their ability to succeed in the increasingly competitive global economy took on greater intensity. The issues raised included whether the new knowledge and technologies arising from federally funded R&D were being fully and effectively exploited for the benefit of the national economy, whether there were undue barriers in the private marketplace that worked to slow

Table 4-15
**Government R&D support by major socioeconomic objectives, for selected countries and years: 1990–2011**

| | | | | Percent of nondefense | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Region/country and year | GBAORD (current US$ millions, PPP) | Percent of GBAORD: Defense | Percent of GBAORD: Nondefense | Economic development programs | Health and environment | Education and society | Civil space | Non-oriented research | General university funds |
| United States | | | | | | | | | |
| 1990 | 63,781.0 | 62.6 | 37.4 | 20.1 | 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 |
| 2005 | 131,259.0 | 56.9 | 43.1 | 11.2 | 55.8 | 2.8 | 17.1 | 13.2 | na |
| 2011 | 144,379.0 | 56.8 | 43.2 | 10.5 | 56.8 | 2.9 | 13.9 | 16.0 | na |
| EU | | | | | | | | | |
| 1990 | na | na | na | na | na | na | na | na | na |
| 2000 | 76,388.3 | 12.9 | 87.1 | 22.4 | 11.5 | 3.4 | 6.0 | 15.4 | 34.7 |
| 2005 | 90,797.3 | 10.4 | 89.6 | 19.8 | 13.3 | 4.1 | 5.4 | 20.0 | 36.4 |
| 2011 | 111,574.9 | 4.6 | 95.4 | 21.0 | 13.7 | 4.7 | 5.9 | 17.6 | 34.1 |
| France | | | | | | | | | |
| 1990 | 13,650.6 | 40.0 | 60.0 | 32.8 | 9.3 | 0.8 | 13.0 | 24.6 | 18.9 |
| 2000 | 14,740.2 | 21.4 | 78.6 | 17.7 | 9.7 | 1.1 | 13.2 | 27.4 | 28.5 |
| 2005 | 18,084.5 | 20.8 | 79.2 | 16.4 | 11.8 | 0.4 | 10.9 | 28.3 | 29.4 |
| 2011 | 19,422.2 | 6.8 | 93.2 | 17.3 | 9.8 | 5.4 | 13.9 | 17.9 | 24.4 |
| Germany | | | | | | | | | |
| 1990 | 13,328.4 | 13.5 | 86.5 | 25.9 | 10.8 | 2.9 | 6.8 | 15.2 | 37.6 |
| 2000 | 16,808.7 | 7.8 | 92.2 | 21.6 | 9.4 | 3.9 | 5.1 | 17.5 | 42.4 |
| 2005 | 19,865.0 | 5.8 | 94.2 | 20.3 | 10.1 | 4.1 | 5.2 | 18.0 | 43.1 |
| 2011 | 29,234.2 | 4.0 | 96.0 | 24.4 | 9.5 | 3.9 | 4.9 | 17.0 | 41.0 |
| United Kingdom | | | | | | | | | |
| 1990 | 8,102.3 | 43.5 | 56.5 | 31.9 | 18.1 | 4.0 | 5.5 | 10.3 | 29.8 |
| 2000 | 10,359.1 | 36.2 | 63.8 | 12.1 | 28.3 | 6.4 | 3.5 | 18.8 | 30.4 |
| 2005 | 13,228.0 | 23.9 | 76.1 | 7.1 | 25.8 | 7.4 | 3.0 | 25.9 | 30.2 |
| 2011 | 13,280.0 | 14.6 | 85.4 | 7.9 | 32.5 | 4.4 | 3.4 | 22.5 | 29.3 |
| China | | | | | | | | | |
| 1990 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 2000 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 2005 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 2011 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Japan | | | | | | | | | |
| 1990 | 10,133.6 | 5.4 | 94.6 | 34.1 | 4.5 | 1.1 | 6.9 | 8.4 | 45.1 |
| 2000 | 21,173.8 | 4.1 | 95.9 | 33.4 | 6.6 | 1.0 | 5.8 | 14.6 | 37.0 |
| 2005 | 27,617.8 | 4.0 | 96.0 | 33.2 | 6.8 | 0.8 | 7.0 | 16.9 | 35.3 |
| 2011 | 34,172.2 | 2.7 | 97.3 | 26.6 | 7.0 | 0.7 | 6.7 | 21.5 | 37.9 |
| South Korea | | | | | | | | | |
| 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 | ** |
| 2005 | 8,539.3 | 14.6 | 85.4 | 51.9 | 18.8 | 5.1 | 4.2 | 20.1 | ** |
| 2011 | 15,897.8 | 16.3 | 83.7 | 49.9 | 14.1 | 2.7 | 2.4 | 30.9 | ** |

** = 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 are converted to dollars through PPPs. 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. The figures are as reported by the Organisation for Economic Co-operation and Development.

SOURCE: Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators* (2012/2). See appendix table 4-39.

*Science and Engineering Indicators 2014*

businesses in the creation and commercialization of innovations and new technologies, and whether better public-private partnerships for R&D and business innovation had the potential to significantly aid the nation's economy in responding to these emerging challenges (Tassey 2007). As the reality of the global economic changes deepened throughout the 1980s and 1990s (and into the present), it became apparent that the United States' global science and technology leadership needed to have a match in a dynamic economic system able to quickly absorb and capitalize on R&D advances in ways beneficial to the economic fortunes of U.S. consumers and businesses.

Numerous national policies and related initiatives have been directed at these challenges over the last 30 years, including how to better transfer and economically exploit the results of federally funded R&D. One major national policy thrust has been to enhance formal mechanisms for transferring knowledge arising from federally funded and performed R&D (Crow and Bozeman 1998; NRC 2003). Other policies have taken on strengthening the prospects for the development and flow of early-stage technologies into the commercial marketplace, accelerating the commercial exploitation of academic R&D, and facilitating the conduct of R&D on ideas and technologies with commercial potential by entrepreneurial small and/or minority-owned businesses. (For an overview of major federal policy initiatives in this realm since the early 1980s, see the sidebar, "Major Federal Policies Promoting Technology Transfer and Commercialization of R&D.")

The sections immediately below focus on this theme of the transfer and commercial exploitation of federally funded R&D and review the status indicators for several major federal policies and programs directed at these objectives. (Chapter 5 contains related information about the knowledge diffusion and patents arising from academic research.)

## 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 for). 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 for, 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.

### Federal Technology Transfer

*Technology transfer* is "the process by which technology or knowledge developed in one place or for one purpose is applied and used in another place for the same or different purpose" (FLC 2011:3). As applied in the federal setting, 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. It can also involve linking R&D capabilities and the resources of federal laboratories with outside public or private organizations for mutual benefit, including flowing know-how and technologies developed on the outside into federal research facilities to better meet mission objectives and enhance internal capabilities.

The Stevenson-Wydler Act of 1980 (P.L. 96-480) directed federal agencies with laboratory operations to become active in the technology transfer process. It also required these agencies to establish technology transfer offices (termed an Office of Research and Technology Applications [ORTA]) to assist in identifying transfer opportunities and establishing appropriate arrangements for transfer relationships with nonfederal parties. Follow-on legislation in the 1980s through 2000 amending Stevenson-Wydler have worked to extend and refine the authorities available to the agencies and their federal labs to identify and manage intellectual assets created by their R&D and to participate in collaborative R&D relationships with nonfederal parties, including private businesses, universities, and nonprofit organizations (FLC 2011).

## Major Federal Policies Promoting Technology Transfer and Commercialization of R&D

*Technology Innovation Act of 1980 (Stevenson-Wydler Act) (P.L. 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) (P.L. 96-517)*—Permitted small businesses, universities, and nonprofits to obtain titles to inventions developed with federal funds. Also allowed government-owned and government-operated laboratories to grant exclusive patent rights to commercial organizations.

*Small Business Innovation Development Act of 1982 (P.L. 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 (P.L. 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 (P.L. 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 (P.L. 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 (April 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 (P.L. 100-418)*—Directed attention to public-private cooperation on R&D, technology transfer, and commercialization (in addition to measures on trade and intellectual property protection). Also established the Manufacturing Extension Partnership (MEP) program at the National Institute of Standards and Technology.

*National Competitiveness Technology Transfer Act of 1989 (P.L. 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 (P.L. 102-564)*—Reauthorized the existing SBIR program, increasing both the percentage of an agency's budget to be devoted to SBIR and the maximum level of awards. Also established the Small Business Technology Transfer (STTR) program to enhance 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 (P.L. 103-42)*—Relaxed restrictions on cooperative production activities, enabling research joint venture participants to work together on jointly acquired technologies.

*National Technology Transfer and Advancement Act of 1995 (P.L. 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 (P.L. 106-404)*—Broadened CRADA licensing authority to make such agreements more attractive to private industry and increase the transfer of federal technology. Established technology transfer performance reporting requirements for agencies with federal laboratories.

*America COMPETES Act of 2007 (America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Sciences [COMPETES] Act) (P.L. 110-69)*—Authorized increased investment in R&D; strengthened educational opportunities in science, technology, engineering, and mathematics from elementary through graduate school; and further promoted the nation's innovation infrastructure. Among various provisions, the act created the Advanced Research Project Agency–Energy (ARPA-E) to promote and fund R&D on advanced energy technologies; it also called for a President's Council on Innovation and Competitiveness.

*America COMPETES Reauthorization Act of 2010 (P.L. 111–358)*—Updated the America COMPETES Act of 2007 and authorized additional funding to science, technology, and education programs over the succeeding 3 years. Numerous provisions were intended to broadly strengthen the foundation of the U.S. economy, create new jobs, and increase U.S. competitiveness abroad.

*Presidential Memorandum, Accelerating Technology Transfer and Commercialization of Federal Research in Support of High-Growth Businesses (October 2011)*—Issued by President Obama, this memorandum directed a variety of actions by federal departments and agencies to establish goals and measure performance, streamline administrative processes, and facilitate local and regional partnerships to accelerate technology transfer and support private sector commercialization.

The metrics on federal technology transfer continue to primarily track the number of activities, that is, invention disclosures, patent applications and awards, licenses to outside parties of patents and other intellectual property, and agreements to conduct collaborative research with outside parties (IDA STPI 2011). Systematic documentation of the downstream outcomes and impacts of transfer remains a challenge. Also notably missing for most agencies and their labs is an accounting of the technical articles published in professional journals, conference papers, and other kinds of scientific communications. Most federal laboratory scientists, engineers, and managers continue to view these traditional forms of new knowledge dissemination as an essential technology transfer mechanism. (For further discussion of the current mechanisms and main metrics for federal technology transfer, see the 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 2006 and 2010, spanning the activity areas of invention disclosures and patenting, intellectual property licensing, and collaborative relationships for R&D, appear in table 4-16. (Similar statistics for a larger set of agencies, going back to FY 2001, appear in appendix table 4-40.)

As is apparent in the distribution of the statistics across the activity types in table 4-16, 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 DOD, USDA, and DOC). Some agencies have unique transfer authorities that can confer practical advantages. NASA, for example, can establish collaborative R&D relationships through special authorities it has under the NASA Space Act of 1958; USDA has a number of special authorities for establishing R&D collaborations other than through Cooperative Research and Development Agreements (CRADAs); DOE has contractor-operated national labs, with nonfederal staff, that are not constrained by the normal federal limitation on copyright by federal employees and can 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, the technologies principally targeted for development, the intellectual property protection tools and policies available, and the types of external parties through which transfer and collaboration are chiefly pursued.

## Small Business Innovation-Related Programs

The Small Business Innovation Research (SBIR) program and Small Business Technology Transfer (STTR) program are longstanding federal programs that provide competitively awarded funding to small businesses for various purposes. These include stimulating technological innovation,

## Federal Technology Transfer: Activities and Metrics

Federal technology transfer can take a variety of forms (FLC 2011), including the following:

*Commercial transfer.* Movement of knowledge or technology developed by a federal laboratory to private organizations into 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 laboratory 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 laboratory to enhance the existing internal capabilities.

*Dual use.* Development of technologies, products, or families of products with both commercial and federal applications.

Federal technology transfer metrics to date have typically covered activities in 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 laboratory'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).

Data on technology transfer metrics such as these are now increasingly available. Nonetheless, it has been long and well recognized by the federal technology transfer community that counts of patent applications and awards, intellectual property licenses, CRADAs, and the like cannot, normally, by themselves provide a reasonable gauge of the downstream outcomes and impacts that result from the transfers—many of which involve considerable time and numerous subsequent developments to reach full fruition. There is a growing literature on federal technology transfer success stories, facilitated in part by the annual agency technology transfer performance reporting mandated by the Technology Transfer Commercialization Act of 2000 and through regularly updated reports by technology transfer professional organizations such as the Federal Laboratory Consortium. Even so, the documentation of these downstream outcomes and impacts is well short of complete.

addressing federal R&D needs, increasing private sector commercialization of innovations flowing from federal R&D, and fostering technology transfer through cooperative R&D between small businesses and research institutions. The U.S. Small Business Administration provides overall coordination for both programs, with implementation by the federal agencies that participate (SBA 2013). The attention devoted to smaller and/or startup R&D-based companies by these programs exemplifies the promotion of innovation-based entrepreneurship via public-private partnerships that enable not only financing but also R&D collaboration and commercialization opportunities (Gilbert, Audretsch, and McDougall 2004; Link and Scott 2010).

The SBIR program was established by the Small Business Innovation Development Act of 1982 (P.L. 97-219) for the purpose of stimulating technological innovation by increasing the participation of small companies in federal R&D projects, increasing private sector commercialization of innovation derived from federal R&D, and fostering participation by minority and disadvantaged persons in technological innovation. The program was reauthorized by the Small Business Reauthorization Act of 2000 (P.L. 106-544), extending the program through the end of September 2008. Subsequently, the program has received several extensions from the Congress, which now carries the program through 2017. Eleven federal agencies currently participate in the SBIR program: USDA, DOC, DOD, ED, DOE, HHS, DHS, DOT, EPA, NASA, and NSF.

The STTR program was established by the Small Business Technology Transfer Act of 1992 (P.L. 102-564, Title II) for the purpose of facilitating cooperative R&D by small businesses, universities, and nonprofit research organizations and encouraging the transfer of technology developed through such research by entrepreneurial small businesses.

Table 4-16
**Federal laboratory technology transfer activity indicators, total and selected U.S. agencies: FYs 2006 and 2010**
(Number)

| Technology transfer activity | All federal laboratories | DOD | HHS | DOE | NASA | USDA | DOC |
|---|---|---|---|---|---|---|---|
| | FY 2006 | | | | | | |
| Invention disclosures and patenting | | | | | | | |
| Inventions disclosed | 5,193 | 1,056 | 442 | 1,694 | 1,749 | 105 | 14 |
| Patent applications | 1,912 | 691 | 166 | 726 | 142 | 83 | 5 |
| Patents issued | 1,284 | 472 | 164 | 438 | 85 | 39 | 7 |
| Licensing | | | | | | | |
| All licenses, total active in the FY | 10,186 | 444 | 1,535 | 5,916 | 2,856 | 332 | 111 |
| Invention licenses | 4,163 | 438 | 1,213 | 1,420 | 308 | 332 | 111 |
| Other intellectual property licenses | 6,023 | 6 | 322 | 4,496 | 2,548 | 0 | 0 |
| Collaborative relationships for R&D | | | | | | | |
| CRADAs, total active in the FY | 7,268 | 2,999 | 164 | 631 | 1 | 195 | 3,008 |
| Traditional CRADAs | 3,666 | 2,424 | 92 | 631 | 1 | 163 | 149 |
| Other collaborative R&D relationships | 9,738 | 0 | 0 | 0 | 4,275 | 3,477 | 2,114 |
| | FY 2010 | | | | | | |
| Invention disclosures and patenting | | | | | | | |
| Inventions disclosed | 4,783 | 698 | 363 | 1,616 | 1,722 | 164 | 34 |
| Patent applications | 1,830 | 436 | 113 | 965 | 144 | 112 | 19 |
| Patents issued | 1,143 | 304 | 153 | 480 | 129 | 44 | 11 |
| Licensing | | | | | | | |
| All licenses, total active in the FY | 13,542 | 397 | 1,941 | 6,224 | 3,901 | 343 | 41 |
| Invention licenses | 4,004 | 341 | 1,240 | 1,453 | 354 | 343 | 41 |
| Other intellectual property licenses | 9,121 | 56 | 683 | 4,771 | 3,547 | 0 | 0 |
| Collaborative relationships for R&D | | | | | | | |
| CRADAs, total active in the FY | 8,525 | 3,248 | 447 | 697 | 1 | 287 | 2,399 |
| Traditional CRADAs | 4,768 | 2,516 | 300 | 697 | 1 | 233 | 101 |
| Other collaborative R&D relationships | 18,667 | 287 | 0 | 0 | 4,246 | 11,214 | 2,897 |

CRADA = Cooperative Research and Development Agreement; DOC = Department of Commerce; DOD = Department of Defense; DOE = Department of Energy; NASA = National Aeronautics and Space Administration; HHS = Department of Health and Human Services; USDA = U.S. Department of Agriculture.

NOTES: Other federal agencies not listed but included in the All federal laboratories 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 licenses refers to intellectual property 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 laboratory and one or more nonfederal organizations. Federal agencies have varying authorities for other kinds of collaborative R&D relationships. Detail may not add to total due to categories in the source data that are not displayed or other distinctions in the source data.

SOURCE: National Institute of Standards and Technology, *Federal Laboratory Technology Transfer, Fiscal Year 2010 Summary Report to the President and the Congress*, August 2012, http://www.nist.gov/tpo/publications/index.cfm. See appendix table 4-40.

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The program was reauthorized through the end of September 2009 by the Small Business Technology Transfer Program Reauthorization Act of 2001 (P.L. 107-50). Congress has likewise provided a number of extensions since then, with the program now continuing through 2017. Five federal agencies currently participate in the STTR program: DOD, DOE, HHS, NASA, and NSF.

For SBIR, federal agencies with extramural R&D budgets exceeding $100 million annually must set aside 2.5% (since FY 1997) for SBIR awards to U.S.-located small businesses (defined as those with fewer than 500 employees, including any affiliates). Three phases of activities are recognized. Phase I: A small company can apply for a Phase I funding award (normally not exceeding $150,000) for up to 6 months to assess the scientific and technical feasibility of an idea with commercial potential. Phase II: Based on the scientific/technical achievements in Phase I and continued expectation of commercial potential, the company can apply for Phase II funding (normally, not exceeding $1,000,000) for 2 years of further development. Phase III: Where the Phase I and II results warrant, the company pursues a course toward commercialization. The SBIR program itself does not provide funding for Phase III, but depending on the agency Phase III may involve non-SBIR-funded R&D or production contracts for products, processes, or services intended for use by the federal government. Several agencies offer bridge funding to Phase III and other commercialization support for startups (NRC 2008:208–16).

The initial round of SBIR awards was for FY 1983. This amounted to 789 Phase I awards, across all the participating agencies, for a total of $38.1 million of funding (table 4-17; appendix table 4-41). By FY 2011, the program had expanded considerably: 5,396 awards (3,626 Phase I; 1,770 Phase II), with total funding of $1.946 billion ($502 million Phase I; $1.444 billion Phase II). In FY 2011, the majority of the funding reflected awards by DOD (43%) and HHS (32%) (appendix table 4-42). NASA (9%), DOE (7%), and NSF (5%) accounted for smaller shares. The other six participating agencies were 1% or less of the total.

For the STTR program, federal agencies with extramural R&D budgets that exceed $1 billion annually must reserve 0.3% for STTR awards to small businesses. STTR operates within the same three-phase framework as SBIR. Phase I provides awards for company efforts to establish the technical merit, feasibility, and commercial potential of proposed projects; the funding in this phase normally does not exceed $100,000 over 1 year. Phase II is for continued R&D efforts, but award is conditional on success in Phase I and continued expectation of commercial potential. Phase II funding normally does not exceed $750,000 over 2 years. Phase III is for the small business to pursue commercialization objectives, based on the Phase I and II results. The STTR program does

Table 4-17
**SBIR and STTR awards, number and funding, by type of award: Selected years, FYs 1983–2011**

| | Number of awards | | | Funding ($millions) | | |
|---|---|---|---|---|---|---|
| Fiscal year | Total | Phase I | Phase II | Total | Phase I | Phase II |
| SBIR | | | | | | |
| 1983 | 789 | 789 | 0 | 38.1 | 38.1 | 0.0 |
| 1985 | 1,839 | 1,483 | 356 | 195.5 | 74.5 | 121.0 |
| 1990 | 3,225 | 2,379 | 846 | 453.7 | 121.2 | 332.4 |
| 1995 | 4,366 | 3,092 | 1,274 | 960.8 | 236.5 | 724.3 |
| 2000 | 5,307 | 3,959 | 1,348 | 1,062.2 | 295.0 | 767.2 |
| 2005 | 6,083 | 4,216 | 1,867 | 1,857.6 | 452.5 | 1,405.1 |
| 2009 | 5,796 | 4,016 | 1,780 | 1,926.2 | 503.4 | 1,422.8 |
| 2010 | 6,184 | 4,271 | 1,913 | 2,115.2 | 548.0 | 1,567.3 |
| 2011 | 5,396 | 3,626 | 1,770 | 1,946.0 | 502.1 | 1,443.9 |
| STTR | | | | | | |
| 1983 | na | na | na | na | na | na |
| 1985 | na | na | na | na | na | na |
| 1990 | na | na | na | na | na | na |
| 1995 | 1 | 1 | 0 | 0.1 | 0.1 | 0.0 |
| 2000 | 410 | 315 | 95 | 64.0 | 23.7 | 40.3 |
| 2005 | 802 | 579 | 223 | 227.7 | 66.1 | 161.6 |
| 2009 | 831 | 593 | 238 | 236.8 | 72.2 | 164.6 |
| 2010 | 905 | 625 | 280 | 289.2 | 77.5 | 211.6 |
| 2011 | 708 | 468 | 240 | 234.6 | 64.2 | 170.4 |

na = not applicable.

SBIR = Small Business Innovation Research program; STTR = Small Business Technology Transfer program.

NOTES: The first SBIR program awards were made in FY 1983. The first STTR program award was made in FY 1995.

SOURCE: Small Business Administration, SBIR/STTR official website, http://www.sbir.gov/past-awards, accessed 25 February 2013. See appendix tables 4-41–4-43.

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not provide funding for Phase III activities. Furthermore, to pursue Phase III, companies must secure non-STTR R&D funding and/or production contracts for products, processes, or services for use by the federal government.

The STTR program started with a single Phase I award for $100,000 in FY 1995 (table 4-17). In FY 2011, there were 708 awards (468 Phase I; 240 Phase II), with funding totaling $235 million ($64 million Phase I; $170 million Phase II). Fewer federal agencies participate in STTR, but those dominant in SBIR are also dominant in STTR. STTR awards from DOD accounted for 44% of the $235 million award total in FY 2011 (appendix table 4-43). HHS accounted for 36% of the STTR awards, and the remainder was from NASA (9%), DOE (8%), and NSF (4%).

### Other Programs

The federal policies, authorities, and incentives established by the Stevenson-Wydler Act (and the subsequent amending legislation) and the SBIR and STTR programs are far from the whole of federal efforts to promote the transfer and commercialization of federal R&D. Numerous programs for these purposes exist in the federal agencies. Given the specifics of agency missions, they have a narrower scope and smaller pools of resources. Several examples are described below.

The Hollings Manufacturing Extension Partnership (MEP) is a nationwide network of manufacturing extension centers located in all 50 U.S. states and Puerto Rico. MEP was created by the Omnibus Trade and Competitiveness Act of 1988 (P.L. 100-418) and is headed by the Department of Commerce's National Institute of Standards and Technology (NIST 2013a). The MEP centers (nonprofit) exist as a partnership among the federal government, state and local governments, and the private sector. MEP provides technical expertise and other services to small and medium-sized U.S. manufacturers to improve their ability to develop new customers, expand into new markets, and create new products. The centers work directly with manufacturers to engage specific issues, including technology acceleration, process improvements, innovation strategies, workforce training, supply-chain development, and exporting. They also serve to connect manufacturers with universities and research laboratories, trade associations, and other relevant public and private resources. A recent MEP annual report (FY 2012) describes the program as operating with $300 million of annual resources: $100 million from the federal government, and $200 million from state and local governments and the private sector (NIST 2013b). The MEP report indicates that technical expertise and other services were provided during FY 2012 to 31,373 U.S. manufacturing companies and attributes impacts of $6.6 billion in increased or retained sales, 61,139 increased or retained jobs, and $900 million in cost savings for these businesses.

The Department of Energy's Advanced Research Projects Agency—Energy (ARPA-E) provides funding, technical assistance, and market development to advance high-potential, high-impact energy technologies that are too early stage for private sector investment (DOE 2013). The main interest is energy technology projects with the potential to radically improve U.S. economic security, national security, and environmental quality—in particular, short-term research that can have transformational impacts, not basic or incremental research. ARPA-E was authorized by the America COMPETES Act of 2007 (P.L. 110-69), and it received $400 million of initial funding through the American Recovery and Investment Act of 2009 (P.L. 111-5). Federal funding (appropriations) for ARPA-E was $180 million in FY 2011 and $275 million in FY 2012. The program is currently authorized through FY 2013, although the FY 2013 funding level remains unresolved at this time (DOE 2013). ARPA-E reports 190 funded projects active as of November 2012, with a total of 275 projects funded since 2009. The program currently identifies 14 project areas, with topics including advanced batteries, energy storage technologies, improved building energy efficiencies, biofuels, and solar energy.

The National Science Foundation's Industry/University Cooperative Research Centers (I/UCRC) Program supports university/industry partnerships for the conduct of industrially relevant fundamental research, collaborative education, and the transfer of university-developed ideas, research results, and technology to industry (NSF 2013). NSF provides support to I/UCRC through partnership mechanisms where, according to NSF, funding is typically leveraged from 10 to 15 times by business and other nonfederal funding. The I/UCRC Program reports there are currently 60 such centers across the United States, with over 1,000 nonacademic members: 85% are industrial firms, with the remainder comprised of state governments, national laboratories, and other federal agencies. NSF funding to I/UCRC was about $15 million in FY 2011. Research is prioritized and executed in cooperation with each center's membership organizations.

## Conclusion

Worldwide R&D performance (measured as expenditures) totaled an estimated $1,435 billion (current PPP dollars) in 2011 (latest global total available). The comparable figure for 2001 was $753 billion, which reflected a brisk, 6.7% average annual growth over this 10-year period.

U.S. R&D increased to $407 billion in 2010 and to $424 billion in 2011 (table 4-1). At just under 30% of the global total in 2011, the United States remains, by far, the world's largest R&D performer. Nonetheless, with other countries also expanding their investments in R&D, the U.S. share has declined since 2001, when it was 37%. From 2001 to 2011, the share of total global R&D accounted for by East/Southeast Asia and South Asia—including China, India, Japan, Singapore, South Korea, and Taiwan—increased from 25% to 34% in 2011. By contrast, the EU countries accounted for 22% of total global R&D in 2011, down from 26% in 2001.

China continues to exhibit the most dramatic R&D growth pattern. At $208 billion of R&D expenditures in 2011, China is the world's second-largest R&D performer. While this is less than half the U.S. level, the growth in China's R&D spending has averaged an exceptionally high 20.7% annually in 2001–11 (18.1% adjusted for inflation). By comparison, the annual growth rate for U.S. R&D averaged 4.3% over this same period. Corresponding average annual growth rates for the largest R&D countries of the EU (Germany, France, United Kingdom) are in the 3%–6% range.

The growth in total of U.S. R&D expenditures in 2010 and 2011 followed a shallow decline in 2009 ($1.9 billion or 0.5%), mainly the result of a drop in business R&D in the face of the national and international financial crisis and economic downturn that started in late 2008. But while small, this was only the second such (current dollar) decline in U.S. R&D since the early 1950s. R&D's year-over-year expansion from 2009 to 2010 was 0.5%; for 2010 to 2011, it was 4.4%. R&D growth in 2010 was well behind that of GDP (4.2%) that year, but in 2011 R&D returned to the more normal circumstance of outpacing that year's GDP growth (3.9%). The ratio of R&D to GDP dropped from 2.90% in 2009 to 2.81% in 2010 and rose slightly to 2.81% in 2011. The statistics for 2012 and beyond, when they are available, will be important in determining if the historic pattern whereby R&D growth matches or exceeds GDP growth has resumed.

## Notes

1. In this chapter constant or inflation-adjusted dollars are based on the GDP implicit price deflator (in 2005 dollars) as published by BEA (NIPA Table 1.1.9. Implicit Price Deflators for Gross Domestic Product) as of May 2012. See appendix table 4-1. GDP deflators are calculated on an economy-wide rather than an R&D-specific basis.

2. In this chapter, GDP data are from BEA, Survey of Current Business, 31 May 2012.

3. The data for academic R&D described in this chapter adjust the academic fiscal year basis of the survey data to calendar year and net out double-counting from pass-throughs of research funds from one academic institution to another. Accordingly, the data may differ from what is cited in chapter 5.

4. Furthermore, this figure does not include federal 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 academic institution to undertake.

5. 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.

6. It is straightforward arithmetic, based on the data in appendix tables 4-2–4-5, to calculate similar character-of-work shares for years earlier than 2011. Nonetheless, care must be applied in describing character-of-work shares over time. The survey methods for collecting data on character-of-work shares have on occasion been revised, most notably for the academic, business, and FFRDC R&D expenditure surveys. Some differences observed in the shares directly calculated from the appendix table time series data more nearly reflect the result of these improvements in the character-of-work questions.

7. The OECD notes that in measuring R&D, the greatest source of error is typically the difficulty of locating the dividing line between experimental development and related activities needed 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 manufactured goods, 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. The figures cited here for total global R&D in 2001, 2006, and 2011 are NSF estimates. R&D expenditures for all countries are denominated in U.S. dollars, based on purchasing power parities. These estimates are based on data from the OECD, *Main Science and Technology Indicators* (Volume 2013/1) and from R&D statistics for additional countries assembled by UNESCO, Institute for Statistics (as of early August 2013). At present, there is no database on R&D spending that is comprehensive and consistent for all nations performing R&D. The OECD and UNESCO databases together provide R&D performance statistics for 214 countries, although the data are not current or complete for all. NSF's estimate of total global R&D reflects 91 countries, with reported annual R&D expenditures of $50 million or more, which accounts for most all of current global R&D.

9. The figures cited for the EU in 2001 are adjusted to include all of the current 28 member countries.

10. The last recession was officially dated December 2007 to June 2009. For details, see http://www.nber.org/cycles.html.

11. See Archibugi, Filippetti, and Frenz (2013) and references therein for studies on the relationship of R&D, innovation, and business cycles.

12. BRDIS does not collect data for companies with fewer than five employees. See sidebar, "Measured and Unmeasured R&D," for more details including a new survey under development to cover these companies.

13. For forthcoming releases from a project linking and comparing BEA's MNC and BRDIS foreign statistics, see http://www.nsf.gov/statistics/rdlink/.

14. BEA releases MNC statistics in current dollars. Figures in the text were deflated by the authors using the GDP implicit price deflator (2005 = 1.00000) published separately by BEA (see endnote 1; appendix table 4-1).

15. Some companies are both parents of U.S. MNCs and subsidiaries of foreign MNCs, so the latter shares overlap.

16. For value-added and other MNCs operations data, see http://www.bea.gov/iTable/index_MNC.cfm.

17. See additional MNC R&D parent data by industry in appendix table 4-29.

18. U.S. business R&D data in ANBERD are for 2009. U.S. (BRDIS) 2010 statistics were used elsewhere in this chapter. ANBERD industry-level data presented here are based on International Standard Industrial Classification (ISIC) Revision 3.1. For ANBERD methodology, see OECD (2012). For additional cross-country indicators such as value added and trade in high-technology industries, see chapter 6.

19. Note that 2007 data for France in this section are arguably less comparable than more recent data from the other countries given the economic and financial crisis that started in 2008.

20. The analysis in this section focuses primarily on developments in federal R&D priorities and funding support over the course of the last decade. But there is a particularly interesting story to tell in how the comparatively minor federal role in the nation's science and research system up until World War II was reconsidered, redirected, and greatly enlarged, starting shortly after the end of the war and up through the subsequent decades to the present. For a review of the essential elements of this evolving postwar federal role, see Jankowski (2013).

21. The 15 budget function categories in which federally performed and/or funded R&D activities typically appear are national defense (050); international affairs (150); general science, space, and technology (250); energy (270); natural resources and environment (300); agriculture (350); commerce and housing credit (370); transportation (400); community and regional development (450); education, training, and social services (500); health (550); Medicare (570); income security (600); veterans benefits and services (700); and administration of justice (750). The other five categories in which R&D typically does not occur are social security (650), general government (800), net interest (900), allowances (920), and undistributed offsetting receipts (950). Furthermore, to clarify analysis, NCSES statistics on federal R&D funding by budget function normally separate the (250) function into subfunctions: general science and basic research (251) and space flight, research, and supporting activities (252).

22. For more on the effect of ARRA in R&D performance, see chapter 5.

23. GBAORD parses total government funding on R&D into the 14 socioeconomic categories specified by the EU's 2007 edition of the Nomenclature for the Analysis and Comparison of Scientific Programs and Budgets (NABS). These categories are exploration and exploitation of the earth; environment; exploration and exploitation of space; transport, telecommunications, and other infrastructures; energy; industrial production and technology; health; agriculture; education; culture, recreation, religion, and mass media; political and social systems, structures, and processes; general advancement of knowledge: R&D financed from general university funds; general advancement of knowledge: R&D financed from sources other than general university funds; and defense. GBAORD statistics published by the OECD in the *Main Science and Technology Indicators* series report on clusters of these 14 NABS categories.

24. GBAORD statistics reported for the United States are budget authority figures.

25. 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.

## 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.

**European Union (EU):** As of June 2013, the EU comprised 27 member nations: 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. Croatia joined the EU in July 2013. Unless otherwise noted, Organisation for Economic Co-operation and Development data on the EU include all 28 members; data on the EU from other sources are limited to the 27 nations that were members as of June 2013.

**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.

**Gross domestic product (GDP):** The market value of goods and services produced within a country. It is one of the main measures in the national income and product accounts.

**G20:** Group of Twenty brings together finance ministers and central bank governors from Argentina, Australia, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan, the Republic of Korea, Mexico, Russia, Saudi Arabia, South Africa, Turkey, the United Kingdom, the United States, and the EU.

**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 (NIPA):** 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, South Korea, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States. Among its many activities, the OECD compiles social, economic, and science and technology statistics for all member and selected nonmember countries.

**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 and R&D value-added ratio.

**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.

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