Chapter 4
Research and Development: National Trends and International Comparisons

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Highlights

Trends in National R&D Performance

Growth in total U.S. R&D performance slowed noticeably in 2009, compared to the last several years, but the broader trend remains that R&D spending growth continues to significantly outpace growth of the U.S. economy as a whole.

- Overall R&D performed in the United States in 2009 totaled an estimated $400 billion (current dollars)—somewhat below the $403 billion level in 2008, but well above the $377 billion in 2007. Adjusted for inflation, the 2009 estimate represents a $6 billion or 1.7% decline from 2008.
- The 2009 slowdown primarily reflects a drop in business R&D in the face of the 2008–09 financial crisis and the economic recession. At the same time, R&D spending in other performing sectors continued to rise, notably for federal and academic R&D, in part because of the one-time federal R&D funding increase appropriated in the American Recovery and Reinvestment Act of 2009.
- U.S. R&D performance has increased largely uninterrupted since 1953. Over the last 5 years (2004–09), annual growth in U.S. R&D spending averaged 5.8%, compared to annual average growth of 3.3% for U.S. gross domestic product (GDP). Indeed, over the last several decades, average annual growth in R&D spending has substantially outpaced that of GDP.

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

- The business sector performed an estimated $282 billion of R&D in 2009, or 71% of the U.S. total, drawing on business, federal sources, and other sources of R&D support. The business sector itself provided an estimated $247 billion of funding for R&D in 2009, or 62% of the U.S. total; almost all of which supported R&D performed by business.
- The levels of business R&D performance and funding were both higher in 2008 than in 2009 ($291 billion and $259 billion, respectively). Even with the decline in 2009, expanded business spending has accounted for most of the nation's R&D growth over the last 5 years.
- The academic sector is the second-largest performer of U.S. R&D, accounting for an estimated $54 billion in 2009, or about 14% of the national total.
- The federal government is the second-largest funder of U.S. R&D, providing an estimated $124 billion, or 31% of the U.S. total in 2009.

U.S. R&D is dominated by development activities, largely performed by the business sector. The business sector also performs the majority of applied research, but most basic research is conducted at universities and colleges and funded by the federal government.

- In 2009, basic research was about 19% ($76 billion) of total U.S. R&D performance, applied research was about 18% ($71 billion), and development was about 63% ($253 billion).
- Universities and colleges historically have been the main performers of U.S. basic research—and accounted for about 53% of all U.S. basic research in 2009. The federal government remains the primary source of basic research funding, accounting for about 53% of all such funding in 2009.
- The business sector is the predominant performer of applied research, accounting for 58% of all U.S. applied research in 2009. Business is also the largest source of funding for applied research, providing 48% in 2009.
- Development is by far the largest component of U.S. R&D. Funding for development comes primarily from the business sector, 78% in 2009; nearly all of the rest comes from the federal government.

R&D and GDP Growth

Treating R&D as an investment, rather than as an expense, affects estimates of GDP growth.

- When R&D is treated as an investment, estimates of average annual GDP growth between 1959 and 2007 are 0.07 points higher than when R&D is treated as an expense.
- The difference in estimated average annual growth is higher in recent periods: 0.17 percentage points for 1995 to 2001 and 0.12 percentage points from 2002 to 2007.

U.S. Business R&D

Domestic R&D performed by the business sector reached $291 billion in 2008.

- More than three-quarters of U.S. business R&D is performed in six industry groups—four in manufacturing (chemicals, computer and electronic products, aerospace and defense, and automotive) and two in services (software and computer-related products, and R&D services).

R&D by Multinational Companies

The majority of R&D by U.S. multinational companies (MNCs) continues to be performed in the United States. Outside the United States, R&D by U.S.-owned foreign affiliates is performed mostly in Western Europe, Canada, and Japan, followed more recently by other locations in the Asia-Pacific region.

- In 2008, U.S. MNC parent companies and their majority-owned foreign affiliates performed $236.1 billion in R&D worldwide, according to the Bureau of Economic Analysis. This included $199.1 billion performed by the parent companies in the United States and $37.0 billion by their majority-owned foreign affiliates.
- The share of R&D performed by Asia-located affiliates (other than in Japan) increased from 5.3% to 14.4% from 1997 to 2008. In particular, the share of U.S.-owned affiliates R&D performed in China, South Korea, Singapore, and India rose from a half percentage point or less in 1997 to 4% for China, just under 3% for South Korea, and just under 2% each for Singapore and India in 2008.
- Majority-owned affiliates of foreign MNCs located in the United States (U.S. affiliates) performed $40.5 billion of R&D in 2008 virtually unchanged from the $41.0 billion they performed in 2007. Since 1999, the share of these companies in total business R&D has fluctuated narrowly between 13% and 15%.

Exports and Imports of R&D-Related Services

Trends in cross-border transactions in research, development, and testing (RDT) services are another indicator of global linkages.

- In 2009, U.S. RDT exports and imports stood at $18.2 billion and $15.8 billion, respectively, for a balance of $2.5 billion.
- In 2008, the proportion of RDT exports ($17.4 billion) to domestic U.S. business R&D performance ($290.7 billion) was 5.6%. This proportion was about 3.8% in 2001.
- Most transactions in RDT services—around 85% of total annual RDT exports—occur within multinational companies.

Federal R&D

Federal spending on R&D has continued to grow, although at a slower pace, when adjusted for inflation, in the last several years. Defense continues to account for more than half of annual federal R&D spending. Health-related R&D accounts for the majority of federal nondefense R&D.

- Eight federal agencies accounted for 97% of federal R&D spending in FY 2009: the departments of Commerce, Defense, Energy, Health and Human Services, and Homeland Security, and the National Science Foundation and National Air and Space Administration. Federal obligations for R&D have increased annually since the late 1990s. When adjusted for inflation, growth has been flatter after FY 2005.
- In FY 2009, federal obligations for R&D reached $133.3 billion and an additional $3.6 billion for R&D plant. The American Recovery and Reinvestment Act of 2009 obligated an additional $8.7 billion for R&D and $1.4 billion for R&D plant for the same fiscal year.
- In the last 10 years, federal funding for basic and applied research has grown faster in the life sciences, mathematics/computer sciences, and psychology than in other fields. In the environmental sciences, growth has not kept pace with inflation.
- Over the last two decades, the greatest change in federal R&D priorities has been the rise in health-related R&D, which currently accounts for just over half of nondefense R&D spending.

Federal R&E Tax Credit

To counteract potential business underinvestment in R&D, the federal government makes available tax credits for companies that expand their R&D activities.

- Business research and experimentation (R&E) tax credit claims were about $8.3 billion both in 2007 and in 2008.
- Five industries accounted for 75% of R&E credit claims in 2008: computer and electronic products; chemicals, including pharmaceuticals and medicines; transportation equipment, including motor vehicles and aerospace; information, including software; and professional, scientific, and technical services, including computer and R&D services.

International R&D Comparisons

The top three R&D-performing countries: United States, China—now the second largest R&D performer—and Japan represented just over half of the estimated $1.28 trillion in global R&D in 2009.

- The United States, the largest single R&D-performing country, accounted for about 31% of the 2009 global total, down from 38% in 1999.
- Asian countries—including China, India, Japan, Malaysia, Singapore, South Korea, Taiwan, and Thailand—represented 24% of the global R&D total in 1999 but accounted for 32% in 2009, including China (12%) and Japan (11%).

- The pace of real growth over the past 10 years in China's overall R&D remains exceptionally high at about 20% annually.
- The European Union accounted for 23% total global R&D in 2009, down from 27% in 1999.

Wealthy economies generally devote larger shares of their GDP to R&D than do less developed economies.

- The U.S. R&D/GDP ratio (or R&D intensity) was about 2.9% in 2009 and has fluctuated between 2.6% and 2.8% during the past 10 years, largely reflecting changes in business R&D spending.
- In 2009, the United States ranked eighth in R&D intensity—surpassed by Israel, Sweden, Finland, Japan, South Korea, Switzerland, and Taiwan—all of which perform far less R&D annually than the United States.
- Among the top European R&D-performing countries, Germany reported a 2.8% R&D/GDP ratio in 2008; France, 2.2%; and the United Kingdom, 1.9%.
- The Japanese and South Korean R&D/GDP ratios were among the highest in the world in 2008, each at about 3.3%. China's ratio remains relatively low, at 1.7%, but has more than doubled from 0.8% in 1999.

Introduction

Research and development activities are an important input to commercial innovation and the objectives of government agencies. R&D is part of a class of intangible inputs that also include software, higher education, and worker training. Intangibles are at least as important sources of long-term economic growth as are physical investments in machinery, equipment, and other infrastructure (Corrado et al. 2006; Jorgenson 2007; Van Ark and Hulten 2007). Indeed, the America COMPETES Act[1] specifically recognizes the role of innovation, STEM education, entrepreneurship, and technology transfer based on federally performed or funded R&D in strengthening U.S. competitiveness.

This chapter focuses on R&D, presenting data on public and private funding and performance in the United States. It also examines related international investments or transactions involving R&D financing or performance.

Chapter Organization

This chapter is organized into eight main sections. A section on trends in national R&D performance is followed by four sections on the business sector. Business R&D, the second section, covers domestic R&D in detail. The third section covers foreign operations of U.S.-owned companies. The fourth section examines R&D by U.S. multinational companies (MNCs) and foreign-owned MNCs with U.S. activities, and the fifth describes international transactions in R&D services.

The sixth section presents patterns of federal government R&D, including mission areas such as defense, energy, and health, and concludes with federal tax incentives for business R&D. This is followed by a section on selected federal programs to aid small businesses and activities in technology transfer and commercialization.

The eighth and last section discusses international comparisons of R&D, including national R&D expenditures by performer and source (including universities), national R&D intensities, and government R&D priorities across member countries of the Organisation for Economic Cooperation and Development (OECD). The chapter also includes two appendix tables (appendix tables 4-1 and 4-2) that contain information on how R&D comparisons across time and among different countries can be made.

Trends in National R&D Performance

The U.S. R&D system consists of a variety of performers and sources of funding, including businesses, the federal government, universities and colleges, other (nonfederal) government, and nonprofit organizations. Organizations that perform R&D often receive significant levels of outside funding; those that fund R&D may also be significant performers. (See sidebar, "Measured and Unmeasured R&D.") The discussion throughout this section examines current levels and key trends in U.S. R&D performance and funding (see Glossary for definitions).[2] Supporting this section is a series of appendix tables (appendix tables 4-3 through 4-10) that report core data on U.S. national patterns of R&D funding and performance.

Trends in U.S. R&D Performance and R&D Intensity

Overall spending on R&D conducted in the United States in calendar year 2009 is estimated to have totaled $400.5 billion, somewhat below the 2008 level of $403.0 billion, but well above the $377.0 billion in 2007 (current dollars) (table 4-1). Adjusted for inflation, the 2009 level is a $6 billion or 1.7% decline from 2008.[3]

The 2009 spending slowdown primarily reflects a drop in business R&D in both current and constant dollars in the face of the 2008–09 financial crisis and economic recession. However, R&D spending in other sectors continued to rise, in both current and constant dollar terms. Some of this was the effect—notably for federal and academic R&D and R&D infrastructure—of the one-time $18.3 billion funding increase appropriated in the American Recovery and Reinvestment Act of 2009 (ARRA, Public Law 111-5, enacted in February 2009).

The 2009 slowdown in spending growth notwithstanding, increases in national R&D spending have occurred largely uninterrupted since 1953 in both current and real dollars (figure 4-1). U.S. R&D spending crossed the $100 billion (current dollars) threshold in 1984, passed $200 billion in 1997, exceeded $300 billion in 2004, and was at or above $400 billion in both 2008 and 2009.

The year-over-year rate of R&D funding growth outpaced that of gross domestic product in each of the last 3 years—even during the economic downturn (table 4-2). Over the last 5 years (2004–09), annual growth in the total of R&D spending averaged 5.8%, compared to GDP at 3.3%. And, similarly, growth in total R&D spending outpaces that of GDP when the averaging period is either 10 or 20 years. The same relative findings prevail when the dollars are adjusted for inflation (table 4-2).

R&D intensity—a country's national R&D expenditures expressed as a percentage of its GDP—provides another gauge of overall national R&D performance and is a widely used target-setting tool internationally.

In 2009, the U.S. R&D/GDP ratio was nearly 2.9%, rising from around 2.8% in 2008 and 2.7% in 2007 (figure 4-2). The ratio has ranged from 1.4% in 1953 to a high of nearly 2.9% in 1964 and has fluctuated in the range of 2.1% to 2.8% in the subsequent years.

Most of this continuity in the U.S. R&D/GDP ratio reflects the growth in nonfederal R&D spending, which rose from about 0.6% of GDP in 1953 to just below 2.0% in the last several years. The increase reflects the growing role of business R&D in the national R&D system and, more broadly, the growing prominence of R&D-derived goods and services in the national and global economies.

The peaks and valleys in the U.S. R&D/GDP ratio also reflect changing federal R&D priorities. The ratio's drop from its peak in 1964 resulted largely from federal cutbacks in defense and space R&D programs. From 1975 to 1979, gains in energy R&D activities worked to keep the ratio stable. Beginning in the late 1980s, cuts in defense-related R&D lowered the federal R&D/GDP ratio, which was counterbalanced by a steady or rising nonfederal ratio. Since 2000, increased federal spending for, notably, defense and biomedical research have helped to push upward the federal ratio.

Performers of R&D

The National Science Foundation (NSF) tracks the R&D spending patterns of all the major performers in the overall U.S. R&D system: businesses, intramural R&D activities of federal agencies, federally funded R&D centers (FFRDCs), universities and colleges, and other nonprofit organizations. For state-level detail see sidebar, “Location of R&D Performance by State” and chapter 8.

Measured and Unmeasured R&D

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

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

National Patterns integrates the R&D spending and funding data from these separate surveys into U.S. R&D totals, which are calculated on a calendar-year basis, disaggregated for the main performing sectors and funding sources. Due to practical constraints, some elements of R&D performance are omitted from the U.S. totals. In evaluating R&D performance trends over time and in international comparisons, it is important to be aware of these omissions.

To reduce cost and respondent burden, the U.S. business R&D estimates are derived from a survey of R&D-performing companies with five or more employees. Accordingly, no estimates of R&D performance currently are available for companies with fewer than five employees. (NSF is currently working on the design and implementation of a Microbusiness Innovation and Science and Technology (MIST) Survey, which will collect data from companies with fewer than five employees.)

Social science R&D had, until 2008, been excluded from the U.S. business R&D statistics. R&D in the humanities and other non-S&E fields (such as law) has been excluded from the U.S. academic R&D statistics. (Other countries include both in their national statistics, making their national R&D expenditures relatively larger when compared with those of the United States.) Changes are now underway in both these respects in the U.S. surveys. NSF’s new U.S. Business R&D and Innovation Survey (see BRDIS sidebar later in this chapter), fielded for the first time in 2009 (to collect 2008 data), now includes social science R&D ($1.2 billion in 2008) and will also better capture the full range of business R&D funded by others. NSF is also now fielding a redesigned Higher Education R&D Survey (starting with the 2010 academic fiscal year), which will include non-S&E R&D expenditures in the reported totals.

The statistics for academic R&D track research expenditures that are separately budgeted and accounted (notably, sponsored research). But U.S. universities generally do not maintain records for the “departmental research” performed by faculty, which then cannot be included in the academic R&D totals. This can be a significant limitation in international R&D comparisons, as department research estimates are often included in the national statistics of other countries. (For a further discussion, see sidebar “Government Funding Mechanisms for Academic Research” later in this chapter.)

Likewise, the activity of individuals performing R&D on their own time and not under the auspices of a corporation, university, or other organization is omitted from official U.S. R&D statistics.

Statistics on R&D performance by state governments had only been sporadically collected until 2006 and 2007, when NSF and the U.S. Census Bureau first fielded a survey on this topic (now being conducted every 2 years; state government R&D performance totals only several hundred million dollars annually). Finally, NSF has not fielded a full survey on R&D performance by nonprofit organizations since 1998—the National Patterns performance figures for this sector in the national R&D totals are estimated.

The National Center for Science and Engineering Statistics has commissioned the National Research Council’s Committee on National Statistics (CNSTAT) to form a panel to review the methodologies used in developing the National Patterns dataset. The panel began work in mid-2011.

Business Sector

The business sector is by far the largest performer of U.S. R&D. R&D performed by businesses in the United States totaled an estimated $282.4 billion in 2009 (table 4-1), about 71% of total U.S. R&D (figure 4-3). This predominance of the business sector has long been the case (figure 4-4), with shares of national R&D performance ranging from 69% to 75% over the course of the last 20 years. The business sector is also the nation's largest R&D funder, accounting for about 62% of the U.S. total.

Table 4-1
U.S. R&D expenditures, by performing sector and source of funding: 2004–09

Sector	2004	2005	2006	2007	2008	2009
	Current $millions					
All performing sectors	302,503	324,993	350,162	376,960	403,040	400,458
Business	208,301	226,159	247,669	269,267	290,681	282,393
Federal government	37,685	39,568	41,611	43,906	44,674	46,151
Federal intramural[a]	24,898	26,322	28,240	29,859	29,839	30,901
FFRDCs	12,788	13,246	13,371	14,047	14,835	15,250
Industry administered[b]	2,485	2,601	3,122	5,165	6,346	6,446
U&C administered[b]	7,659	7,817	7,306	5,567	4,766	4,968
Nonprofit administered	2,644	2,828	2,943	3,316	3,724	3,835
Universities and colleges	43,122	45,190	46,955	49,010	51,650	54,382
Other nonprofit organizations	13,394	14,077	13,928	14,777	16,035	17,531
All funding sectors	302,503	324,993	350,162	376,960	403,040	400,458
Business	191,266	207,680	227,057	246,679	258,626	247,357
Federal government	91,656	96,276	100,768	105,822	117,611	124,432
Universities and colleges	7,936	8,578	9,285	9,959	10,707	11,436
Nonfederal government	2,883	2,922	3,021	3,265	3,518	3,675
Other nonprofit organizations	8,761	9,538	10,031	11,235	12,578	13,559
	Constant 2005 $millions					
All performing sectors	312,548	324,993	339,202	354,864	371,184	364,951
Business	215,218	226,159	239,917	253,484	267,706	257,355
Federal government	38,937	39,568	40,308	41,332	41,143	42,059
Federal intramural[a]	25,724	26,322	27,356	28,109	27,480	28,161
FFRDCs	13,212	13,246	12,953	13,224	13,663	13,897
Industry administered[b]	2,568	2,601	3,024	4,862	5,844	5,875
U&C administered[b]	7,913	7,817	7,078	5,241	4,389	4,528
Nonprofit administered	2,732	2,828	2,851	3,121	3,429	3,495
Universities and colleges	44,554	45,190	45,485	46,137	47,568	49,561
Other nonprofit organizations	13,839	14,077	13,492	13,911	14,767	15,977
All funding sectors	312,548	324,993	339,202	354,864	371,184	364,951
Business	197,617	207,680	219,950	232,220	238,184	225,425
Federal government	94,700	96,276	97,614	99,619	108,315	113,399
Universities and colleges	8,200	8,578	8,995	9,375	9,861	10,422
Nonfederal government	2,979	2,922	2,926	3,074	3,240	3,349
Other nonprofit organizations	9,052	9,538	9,717	10,576	11,584	12,356

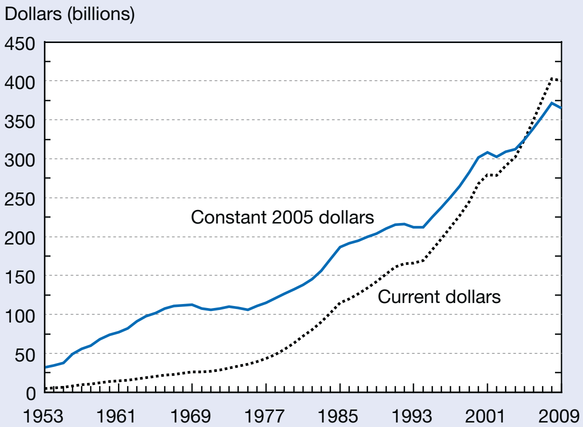
FFRDC = federally funded research and development center; U&C = universities and colleges

[a] Includes expenditures of federal intramural R&D and costs associated with administering extramural R&D.
[b] Los Alamos National Laboratory (approximately $2 billion in annual R&D expenditures in recent years) became industry administered in June 2006; previously, it was U&C administered. Lawrence Livermore National Laboratory (more than $1 billion in annual R&D expenditures in recent years) became industry administered in October 2007; previously, it was U&C administered. These shifts in administration category are a main reason for the changes apparent in the R&D performer figures across 2006, 2007, and 2008.

NOTES: Data are based on annual reports by performers except for the nonprofit sector. Expenditure levels for academic and federal government performers are calendar-year approximations based on fiscal year data. For federal government expenditures, the approximation is equal to 75% of the amount reported in the same fiscal year plus 25% of the amount reported in the subsequent fiscal year. For academic expenditures, the respective percentages are 50 and 50, because those fiscal years generally begin on July 1 instead of October 1. Some of the figures for other nonprofit organizations are estimated and may later be revised.

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

Figure 4-1
U.S. total R&D expenditures: 1953–2009



NOTE: Some figures involve estimates and may later be revised.

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

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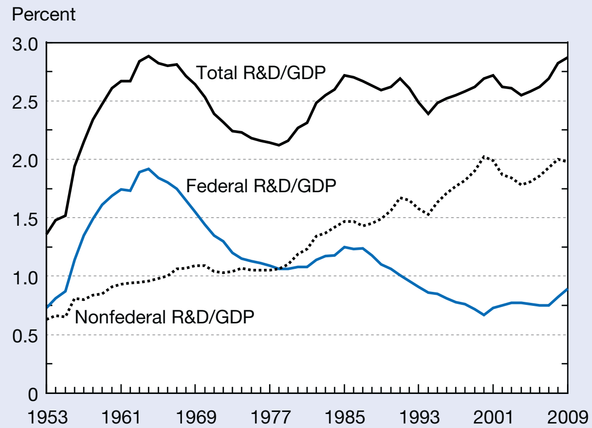
Figure 4-2
Ratio of U.S. R&D to gross domestic product, roles of federal and nonfederal funding for R&D: 1953–2009



GDP = gross domestic product

NOTES: Some figures involve estimates and may later be revised. Federal R&D/GDP ratios represent the federal government as a funder of R&D by all performers; the nonfederal ratios reflect all other sources of R&D funding.

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

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Table 4-2
Annual rates of growth in U.S. R&D expenditures, total and by performing sectors: 1989–2009
(Percent)

Expenditures and gross domestic product	Longer term trend			Most recent years		
	1989–2009	1999–2009	2004–09	2006–07	2007–08	2008–09
	Current dollars					
Total R&D, all performers	5.3	5.0	5.8	7.7	6.9	-0.6
Business	5.3	4.5	6.3	8.7	8.0	-2.9
Federal government	3.6	5.7	4.1	5.5	1.8	3.3
Federal intramural[a]	3.6	5.6	4.4	5.7	-0.1	3.6
FFRDCs	3.6	5.8	3.6	5.1	5.6	2.8
Universities and colleges	6.4	6.8	4.7	4.4	5.4	5.3
Other nonprofit organizations	8.1	7.9	5.5	6.1	8.5	9.3
Gross domestic product	4.8	4.1	3.3	4.9	1.9	-2.5
	Constant 2005 dollars					
Total R&D, all performers	2.9	2.6	3.1	4.6	4.6	–1.7
Business	3.0	2.1	3.6	5.7	5.6	–3.9
Federal government	1.3	3.2	1.6	2.5	–0.5	2.2
Federal intramural[a]	1.3	3.2	1.8	2.8	–2.2	2.5
FFRDCs	1.3	3.3	1.0	2.1	3.3	1.7
Universities and colleges	4.0	4.3	2.2	1.4	3.1	4.2
Other nonprofit organizations	5.7	5.4	2.9	3.1	6.2	8.2
Gross domestic product	2.4	1.7	0.7	1.9	–0.3	–3.5

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

NOTE: Longer term trend rates are calculated as compound annual growth rates.

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

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A decline of business R&D performance from $290.7 billion in 2008 to $282.4 billion in 2009 was the first such year-to-year decline since 2002. Nevertheless, business R&D performance rose on average (table 4-2) at 6.3% annually from 2004 to 2009, outpacing the growth rates of both total U.S. R&D (5.8%) and gross domestic product (3.3%). After adjusting for inflation, business R&D grew at a 3.6% annual rate, total R&D at 3.1%, and U.S. GDP at 0.7%).

Universities and Colleges

Universities and colleges performed $54.4 billion of R&D in 2009 (table 4-1). This was almost 14% of total U.S. R&D spending that year, making academia the second-largest performer of U.S. R&D (figure 4-3).

Academic R&D spending increased in each of the last 5 years (in both current dollars and constant dollars). The academic share in total U.S. R&D has ranged between 11% and 14% over the past 20 years.

Universities and colleges have a special niche in the nation's R&D system: they performed more than half (53%) of the nation's basic research in 2009. Academic institutions also rely much more extensively than the business sector on external sources of funding, particularly the federal government, at about 60%, to support the R&D they perform. (See chapter 5 for an extensive analysis of academic R&D.)

Location of R&D Performance by State

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

In 2008, the 10 states with the largest R&D expenditure levels accounted for about 62% of U.S. R&D expenditures that can be allocated to the states: California, New Jersey, Texas, Massachusetts, Washington, New York, Maryland, Michigan, Pennsylvania, and Illinois (table 4-A).* California alone accounted for 22% of the U.S. total, exceeding the next-highest state, Massachusetts, by almost 4 times. The top 20 states accounted for 84% of the R&D total; the 20 lowest-ranking states, around 5% (see appendix tables 4-11 and 4-12).

The states with the biggest R&D expenditures are not necessarily those with the greatest relative concentration of R&D. Among those with the highest R&D/GDP ratios in 2008 were New Mexico, the District of Columbia, Maryland, and Massachusetts (table 4-A). New Mexico is the location of a number of major government research facilities. The District of Columbia is home to major federal science and technology agencies with intramural research labs and R&D management activities. Maryland is also the site of many government research facilities and growing research universities. Massachusetts benefits from both leading research universities and thriving high-technology industries. California has relatively high R&D intensity, but nonetheless is ninth from the top. (Chapter 8 provides additional information on R&D related activities in the states.)

U.S. R&D performance by sector and state

The proportion of R&D performed by each of the main R&D-performing sectors (business, universities and colleges, federal intramural and FFRDCs) varies across the states, but the states that lead in total R&D also tend to be well represented in each of these sectors (table 4-A).

In 2008, R&D performed by the business sector accounted for about 73% of the U.S. R&D total that could be allocated to specific states. Of the top 10 states in total R&D performance, 9 are also in the top 10 in industry R&D. Connecticut, 8th in business-sector R&D and home to substantial pharmaceutical R&D activity, surpasses Maryland in the business R&D ranking.

University-performed R&D accounts for 14% of the allocable U.S. total and mirrors the distribution of overall R&D performance. Only New Jersey and Washington fall out of the top 10 total R&D states, replaced by North Carolina and Ohio.

Federal R&D performance (including both intramural and FFRDCs)—about 12% of the U.S. total—is more concentrated geographically than that in other sectors. Only 5 states—Maryland, California, New Mexico, the District of Columbia, and Virginia—account for 65% of all federal R&D performance.** This figure rises to 80% when the other 5 of the top 10 states—Massachusetts, Tennessee, Washington, Illinois, and Alabama—are included.

Federal R&D accounts for the bulk of total R&D in several states, including New Mexico, which is home to the nation's two largest FFRDCs (Los Alamos and Sandia National Laboratories) and Tennessee (36%) home to Oak Ridge National Laboratory. The high figures for Maryland (55%), the District of Columbia (80%), and Virginia (37%) reflect the concentration of federal facilities and federal R&D administrative offices in the national capital area.

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* The latest data available on the distribution of U.S. R&D performance by state are for 2008. Total U.S. R&D expenditures that year are estimated at $403.0 billion. Of this total, $372.7 billion could be attributed to one of the 50 states or the District of Columbia. This state-attributed total differs from the U.S. total for a number of reasons: some business R&D expenditures cannot be allocated to any of the 50 states or the District of Columbia because respondents did not answer the question related to location; nonfederal sources of nonprofit R&D expenditures (an estimated $8.4 billion in 2008) could not be allocated by state; state-level university R&D data have not been adjusted for double-counting of R&D passed from one academic institution to another; and state-level university and federal R&D performance data are not converted from fiscal to calendar years.

** Federal intramural R&D includes costs associated with the administration of intramural and extramural programs by federal personnel, as well as actual intramural R&D performance. This is a main reason for the large amount of federal intramural R&D in the District of Columbia.

Location of R&D Performance by State—continued

Table 4-A

Top 10 U.S. states in R&D performance, by sector and intensity: 2008

	All R&D[a]		Sector ranking			R&D intensity (R&D/GDP ratio)		
Rank	State	Amount (current $millions)	Business	U&C	Federal intramural and FFRDC[b]	State	R&D/GDP (%)	GDP (current $billions)
1	California	81,323	California	California	Maryland	New Mexico	7.58	78.0
2	New Jersey	20,713	New Jersey	New York	California	District of Columbia	6.15	96.8
3	Texas	20,316	Texas	Texas	New Mexico	Maryland	5.92	280.5
4	Massachusetts	20,090	Massachusetts	Maryland	District of Columbia	Massachusetts	5.53	363.1
5	Washington	16,696	Washington	Pennsylvania	Virginia	Connecticut	5.10	222.2
6	Maryland	16,605	Michigan	Massachusetts	Massachusetts	Washington	4.96	336.3
7	New York	16,486	New York	North Carolina	Tennessee	New Jersey	4.28	484.3
8	Michigan	15,507	Connecticut	Illinois	Washington	New Hampshire	4.24	58.8
9	Pennsylvania	13,068	Pennsylvania	Ohio	Illinois	California	4.22	1,925.5
10	Illinois	11,961	Illinois	Michigan	Alabama	Michigan	4.12	376.2

FFRDC = federally funded research and development center; GDP = gross domestic product; U&C = universities and colleges

[a]Includes in-state total R&D performance of business sector, universities and colleges, federal agencies, FFRDCs, and federally financed nonprofit R&D.
[b]Includes costs associated with administration of intramural and extramural programs by federal personnel and actual intramural R&D performance.

NOTES: Small differences in parameters for state rankings may not be significant. Rankings do not account for the margin of error of the estimates from sample surveys.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources (annual series). State GDP data are from the U.S. Bureau of Economic Analysis. See appendix tables 4-11 and 4-12.

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Federal Agencies and FFRDCs

R&D performed by the federal government includes the activities of agency intramural research laboratories and federally funded research and development centers (FFRDCs). The figures for intramural R&D also include expenditures for agency planning and administration of both intramural and extramural R&D projects. Federal agencies' intramural R&D performance is funded entirely by the federal government. FFRDCs are R&D-performing organizations that are exclusively or substantially financed by the federal government. An FFRDC is operated to provide R&D capability to serve agency mission objectives or, in some cases, to provide major facilities at universities for research and associated training purposes. Each FFRDC is administered by an industrial firm, a university, a nonprofit institution, or a consortium.

R&D spending by federal intramural labs and FFRDCs was $46.2 billion in 2009, about 12% of all U.S. R&D (table 4-1). Of this amount, $30.9 billion (8% of all U.S. R&D) was intramural and $15.3 billion (4%) was R&D by FFRDCs.

Spending on this federal R&D performance grew rapidly from 2001 to 2003, primarily reflecting increased defense spending following the terrorist attacks in the United States on September 11, 2001. A slower pace of growth has prevailed, however, since then.

The volume of the federal government's R&D performance is small compared with that of the U.S. business sector. Nonetheless, the $46.2 billion performance total in 2009 exceeds domestic R&D expenditures of every country except Japan, China, and Germany. And this figure does not include government investments in R&D infrastructure and equipment, which support the maintenance and operation of unique research facilities and the conduct of research activities that would be too costly or risky for a single company or university to undertake.

Other Nonprofit Organizations

R&D performed in the United States by nonprofit organizations other than universities and certain FFRDCs is estimated at $17.5 billion in 2009. This amount represents just over 4% of all U.S. R&D in that year, a share that has been fairly stable since 2000.

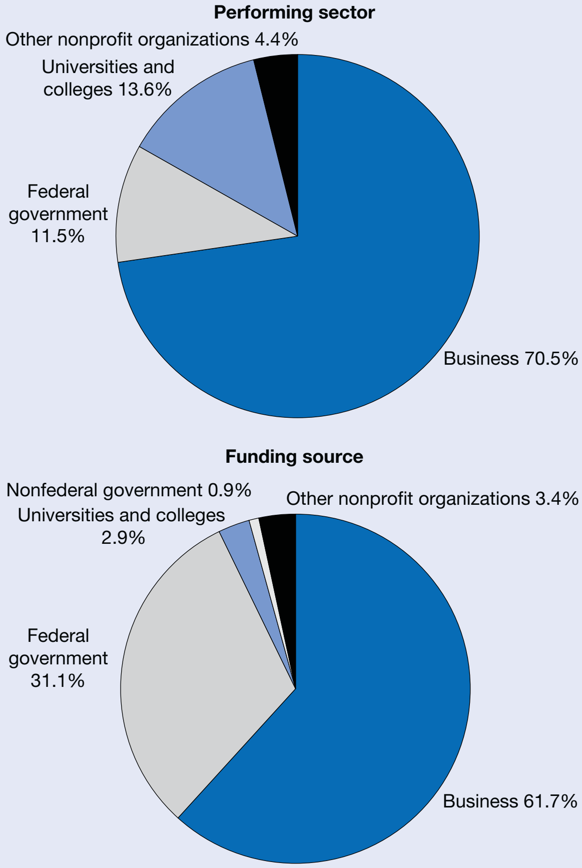
Sources of R&D Funding

Funds that support the conduct of R&D in the United States come from a variety of sources, including businesses, federal and other governments, academic institutions, and other nonprofit organizations. The mix of funding sources varies by performer.

R&D Funding by Business

The business sector, the largest performer of U.S. R&D, is also its largest funder, at about $247.4 billion in 2009 or about 62% of the U.S. total (table 4-1, figure 4-3), virtually all in support of business R&D.[4] The business sector's predominant role in funding R&D began in the early 1980s, when its support began to exceed 50% of all U.S. R&D funding (figure 4-5)—a share that has continually increased over the last 30 years. Just about all business funding for

Figure 4-3
Shares of U.S. total R&D expenditures, by performing sector and funding source: 2009



NOTES: Some figures involve estimates and may later be revised. National R&D expenditures are estimated to be $400.5 billion in 2009. Federal performing sector includes federal agencies and federally funded research and development centers. State and local government support to business is included in business support for business performance.

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

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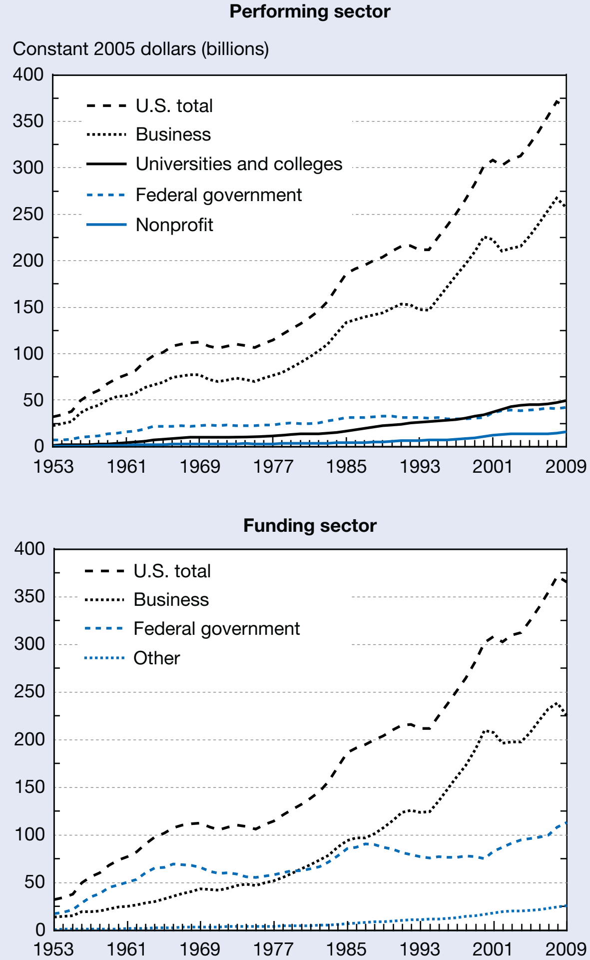
Figure 4-4
U.S. R&D, by performing and funding sectors: 1953–2009



NOTES: Some figures involve estimates and may later be revised. Current dollar figures are converted to constant dollars based on the implicit gross domestic product price deflator. Federal performers of R&D include federal agencies and federally funded research and development centers. Other funding includes support from universities and colleges, nonfederal government, and nonprofit organizations. State and local government funding to businesses is included in business support for business R&D performance.

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

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R&D (98%) is directed toward business R&D performance (table 4-3). The small remainder has gone to academic and other nonprofit performers. (For a fuller discussion, see the “U.S. Business R&D” section later in this chapter.)

R&D Funding by the Federal Government

The federal government was once the predominant sponsor of the nation’s R&D, funding some 67% of all U.S. R&D in 1964 (figure 4-5). But the federal share decreased in subsequent years to less than half in 1979 and to a low of 25% in 2000. Changing business conditions and expanded federal funding of health, defense, and counterterrorism R&D pushed it back up above 30% in 2009.

The federal government remains a major source of funds for all U.S. performer sectors except private business, where its role (while not negligible) is substantially overshadowed by business’s own funds.

In 2009, according to the reports of R&D performers,[5] the federal government provided an estimated $124.4 billion (current dollars) of R&D funds, about 31% of all U.S. spending on R&D that year (table 4-1).

In 2009, the largest recipient of federal R&D funding, $46.2 billion, was federal agencies and their FFRDCs (table 4-3). FFRDCs also received about $400 million from nonfederal sources, less than 1% of their total support.

Table 4-3
U.S. R&D expenditures, by performing sector, source of funds, and character of work: 2009

Performing sector and character of work	Source of funds ($millions)					Total expenditures (% distribution)
	Total	Business	Federal government	Universities and colleges	Other nonprofit organizations	
R&D	400,458	247,357	124,431	15,111	13,559	100.0
Business	282,393	242,820	39,573	**	**	70.5
Federal government	46,150	**	46,150	**	**	11.5
Federal intramural	30,901	**	30,901	**	**	7.7
FFRDCs	15,249	**	15,249	**	**	3.8
Industry administered	6,446	**	6,446	**	**	1.6
U&C administered	4,968	**	4,968	**	**	1.2
Nonprofit administered	3,835	**	3,835	**	**	1.0
Universities and colleges	54,383	3,279	31,575	15,111	4,418	13.6
Other nonprofit organizations	17,532	1,258	7,133	**	9,141	4.4
Percent distribution by source	100.0	61.8	31.1	3.8	3.4	–
Basic research	75,970	16,486	40,451	10,800	8,233	100.1
Business	14,784	13,444	1,340	**	**	19.5
Federal government	11,373	**	11,373	**	**	15.0
Federal intramural	5,507	**	5,507	**	**	7.2
FFRDCs	5,866	**	5,866	**	**	7.7
Industry administered	2,550	**	2,550	**	**	3.4
U&C administered	1,808	**	1,808	**	**	2.4
Nonprofit administered	1,508	**	1,508	**	**	2.0
Universities and colleges	40,544	2,344	24,242	10,800	3,158	53.4
Other nonprofit organizations	9,269	698	3,496	**	5,075	12.2
Percent distribution by source	100.0	21.7	53.2	14.2	10.8	–
Applied research	71,330	34,344	30,101	3,535	3,350	100.1
Business	41,055	33,258	7,797	**	**	57.6
Federal government	12,665	**	12,665	**	**	17.8
Federal intramural	8,006	**	8,006	**	**	11.2
FFRDCs	4,659	**	4,659	**	**	6.5
Industry administered	1,930	**	1,930	**	**	2.7
U&C administered	1,289	**	1,289	**	**	1.8
Nonprofit administered	1,440	**	1,440	**	**	2.0
Universities and colleges	11,912	767	6,577	3,535	1,033	16.7
Other nonprofit organizations	5,698	319	3,062	**	2,317	8.0
Percent distribution by source	100.0	48.1	42.2	5.0	4.7	–
Development	253,161	196,527	53,882	776	1,976	100.0
Business	226,554	196,118	30,436	**	**	89.5
Federal government	22,115	**	22,115	**	**	8.7
Federal intramural	17,389	**	17,389	**	**	6.9
FFRDCs	4,726	**	4,726	**	**	1.9
Industry administered	1,967	**	1,967	**	**	0.8
U&C administered	1,872	**	1,872	**	**	0.7
Nonprofit administered	887	**	887	**	**	0.4
Universities and colleges	1,927	168	756	776	227	0.8
Other nonprofit organizations	2,565	241	575	**	1,749	1.0
Percent distribution by source	100.0	77.6	21.3	0.3	0.8	–

** = small to negligible amount, included in other funding sectors

FFRDC = federally funded research and development center; U&C = universities and colleges

NOTES: Funding for FFRDC performance is chiefly federal, but any nonfederal support is included in the federal figures. State and local government support to business is included in business support for business performance. State and local government support to U&C ($3,675 million) is included in U&C support for U&C performance. Some figures for other nonprofit organizations are estimates and may later be revised.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources (annual series). See appendix tables 4-3–4-10.

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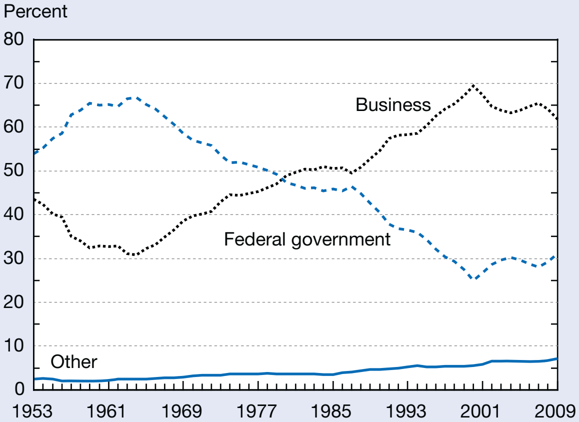
Figure 4-5
U.S. total R&D expenditures, by source of funding: 1953–2009



NOTES: Some figures involve estimates and may later be revised. Other includes universities and colleges, state and local government, and other nonprofit organizations.

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

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The second largest recipient was the business sector, for which, in 2009, the federal government provided $39.6 billion of the $282.4 billion that funded business R&D. Through the early 1960s, more than half of the nation's business R&D had been funded by the federal government. This share fell below 10% by 2000 and had rebounded to 143% by 2009 (appendix table 4-3).

Federal funds to academia provided $31.6 billion (58%) of the $54.4 billion spent on academic R&D in 2009. Of the $17.5 billion spent on R&D by other nonprofit organizations, $7.1 billion (about 41%) was supported by federal funds.

R&D Funding from Other Sources

The balance of R&D funding from other sources is small: $28.6 billion in 2009, or about 7% of all funding. This includes academia's own institutional funds (which support academic institution's own R&D), other nonprofits (the majority of which fund their own R&D, but also contribute to academic research), and state and local governments (primarily for academic research).

Nonetheless, this segment of funding has been growing fairly rapidly for some time. From 1999 to 2009, growth in funding from these sectors averaged 5.4% per year in real-dollar terms—ahead of the pace of funding growth in both the federal and business sectors. Most R&D funded by these nonfederal sources is performed by the academic sector, which also provided about one-fifth of its own total spending on R&D.

R&D by Character of Work

R&D encompasses a range of activities: from fundamental research in the physical, life, and social sciences; to research addressing such critical societal issues as global climate change, energy efficiency, and health care; to the development of platform or general-purpose technologies and new goods and services. Because the activities are so diverse, it helps to classify them in separate categories when analyzing R&D expenditures. The most widely used classifications distinguish among basic research, applied research, and (experimental) development (see definitions in Glossary).[6] Nevertheless, these categories are not always mutually exclusive and any particular R&D activity may have aspects of more than one category.

Basic Research

In 2009, spending on basic research activities amounted to about $76.0 billion (19%) of the $400.5 billion of total U.S. R&D (table 4-4, figure 4-6). The basic research share has gradually moved upward, from about 14% in 1979 to 19% in 2009 (table 4-4).

Universities and colleges continue to occupy a unique position in U.S. basic research. They are the primary performer of U.S. basic research (53% in 2009), while also training the next generation of researchers (table 4-4). The business sector performs nearly 20%; the federal government (agency intramural labs and FFRDC s), 15%; and other nonprofit organizations, 12%.

The federal government remains by far the prime source of funding for basic research, accounting for about 53% of all such funding in 2009 (table 4-3). Universities and colleges themselves provide about 14% of the funding. Other nonprofit organizations provide 11%.

Business's $16.5 billion devoted to basic research is small by comparison to its $247.4 billion of funding for total R&D in 2009, but it still accounted for about 22% of the overall funding for basic research.

Business views about performing basic research involve considerations about the appropriability of results, commercialization risks, and uncertain investment returns. However, involvement in basic research can help boost human capital, attract and retain talent, absorb external knowledge, and strengthen innovation capacity. Businesses that invest most heavily in basic research are those whose new products are most directly tied to ongoing science and technological advances, such as the pharmaceuticals and scientific R&D service sectors.

Applied Research

Applied research activities accounted for about 18% ($71.3 billion) of total U.S. R&D in 2009, modestly under the amount spent on basic research that year (table 4-4). Looking back over two decades, the share of applied research is somewhat lower at present than in the past: 23% 5 years ago, 21% 10 years ago, and 23% 20 years ago.

Table 4-4
U.S. R&D expenditures, by character of work and performing sectors: 1979–2009

Character of work and sector	1979	1989	1999	2004	2009
			$billions		
All R&D	55.4	141.9	245.0	302.5	400.5
Basic	7.8	21.9	38.9	56.1	76.0
Applied	12.1	32.3	52.0	69.2	71.3
Development	35.4	87.7	154.4	177.2	253.2
			Percent distribution		
All R&D	100.0	100.0	100.0	100.0	100.0
Basic	14.1	15.4	15.9	18.5	19.0
Applied	21.8	22.8	21.2	22.9	17.8
Development	63.9	61.8	63.0	58.6	63.2
Basic research	100.0	100.0	100.0	100.0	100.0
Business	13.5	22.0	17.1	14.0	19.5
Federal intramural	14.2	10.5	8.6	8.4	7.2
FFRDCs	14.7	12.9	9.6	8.9	7.7
Universities and colleges	48.9	46.7	54.0	57.0	53.4
Other nonprofit organizations	8.8	7.9	10.8	11.8	12.2
Applied research	100.0	100.0	100.0	100.0	100.0
Business	57.7	69.1	70.4	65.7	57.6
Federal intramural	20.0	11.0	10.6	10.8	11.2
FFRDCs	5.0	3.2	3.2	4.5	6.5
Universities and colleges	11.7	13.0	11.1	13.0	16.7
Other nonprofit organizations	5.6	3.6	4.7	6.1	8.0
Development	100.0	100.0	100.0	100.0	100.0
Business	81.9	82.9	89.9	87.5	89.5
Federal intramural	11.1	10.7	6.0	7.2	6.9
FFRDCs	4.0	4.1	2.1	2.6	1.9
Universities and colleges	1.3	1.4	0.9	1.2	0.8
Other nonprofit organizations	1.7	0.9	1.0	1.5	1.0

FFRDC = federally funded research and development center

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

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The business sector performed 58% of all applied research in 2009; the federal government (federal agency intramural labs and FFRDCs), 18%; universities and colleges, another 17%; nonprofit organizations, 8% (table 4-4).

Business provided the bulk of funding for applied research in 2009, 48%. The federal government provided 42%, and academia and other nonprofit organizations each contributed around 5%.

Business sectors that perform relatively large amounts of applied research include chemicals and aerospace. The federal funding is spread broadly across all the performers, with the largest amounts (in 2009) going to federal intramural labs, the business sector, and universities and colleges.

Development

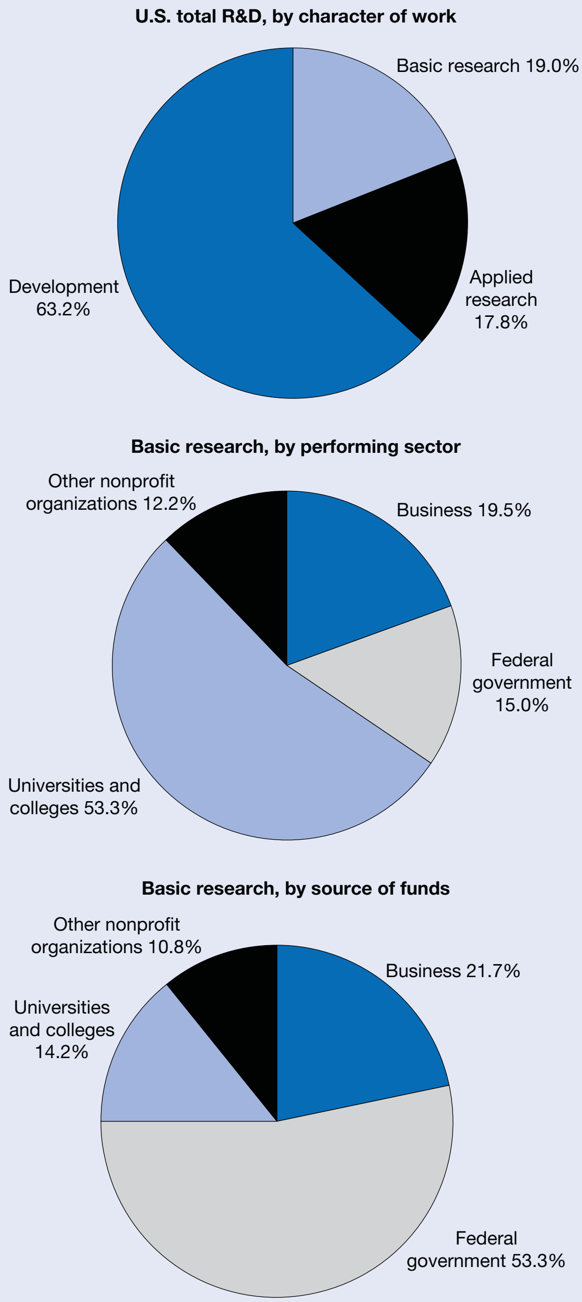
Development, the most sizable component of U.S. R&D, accounted for 63% ($253.2 billion) of total national R&D in 2009 (table 4-4).[7] Development's share of total national R&D has been near or above 60% for several decades.

The business sector performed 90% ($226.6 billion) of this development total, and the federal government (agency intramural labs, FFRDCs), another 9%—much of it defense-related, with the federal government the main consumer. By contrast, academic and other nonprofit organizations perform very little of U.S. development, each performing less than 1% of the total in 2009.

The business sector also provided about three-quarters (78%) of development funding ($196.5 billion) in 2009, nearly all of it in support of business development activities (table 4-3). The federal government provided 21% ($53.9 billion) of the funding, with more than half going to business development—especially in defense-related industries—and most of the remainder going to federal intramural labs and FFRDCs.

Universities and colleges and other nonprofit organizations provide small amounts of funding to support development performance in their own sectors.

Figure 4-6
U.S. R&D by character of work, basic research by performing sector, and basic research by source of funds: 2009



NOTES: Some figures involve estimates and may later be revised. National R&D expenditures estimated at $400.5 billion in 2009. National basic research expenditures estimated at $76.0 billion in 2009. Federal performers include federal agencies and federally funded research and development centers. State and local government support to industry included in industry support for industry performance. State and local government support to universities and colleges included in universities and colleges support of universities and college performance.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources (annual series). See appendix tables 4-3, 4-6, and 4-8.

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R&D, GDP Growth, and Innovation-Related Metrics

Intangible inputs such as R&D are important sources of long-term economic growth (Corrado et al. 2006; Jorgenson 2007; Van Ark and Hulten 2007). The role of R&D in U.S. GDP has been estimated based on a methodology published in the Bureau of Economic Analysis (BEA)/NSF R&D Satellite Account (Lee and Schmidt 2010). This methodology treats R&D as an investment rather than as an expense. Using this methodology, a preliminary estimate of R&D on inflation-adjusted GDP from 1959 to 2007 suggests faster average annual GDP growth of 0.07 percentage point over treatment of R&D as an expense.[8]

Over this period, the difference in average growth estimates using these two methodologies was higher in the immediate post-War boom, dropped to almost zero from 1974 to 1994 (a period that includes the productivity slowdown of the 1970s), and then increased relative to the overall average since 1995—years associated with IT-led productivity growth (Jorgenson et al. 2005b) (table 4-5). For other data developments activities, see sidebar, "Recent Developments in Innovation-Related Metrics."

U.S. Business R&D

Businesses engage in R&D with a variety of objectives and partners on a global basis. Most business R&D is aimed at developing new and improved goods, services, and processes; maintaining or increasing market share; and improving operating efficiency. Such activities reflect firms' perceptions of the market's demand and expectations about the profitability of new or newly applied technology.

Businesses located in the United States, both domestic- and foreign-owned, performed $290.7 billion in R&D in the United States in 2008 (table 4-6).[9] Among these, companies that owned firms outside the United States performed an

Table 4-5
U.S. average annual real GDP growth rates, unadjusted and R&D adjusted: 1959–2007
(Percent)

Period	Unadjusted real GDP[a]	R&D-adjusted real GDP[b]	Difference
1959–2007	3.32	3.39	0.07
1959–73	4.20	4.33	0.13
1974–94......	3.02	3.03	0.01
1995–2001...	3.76	3.93	0.17
2002–07......	2.75	2.87	0.12

GDP = gross domestic product

[a]As published in the national income and product accounts.
[b]Real GDP with R&D treated as investment, deflated by aggregate output price index. Double-counting of R&D software removed.

SOURCE: Bureau of Economic Analysis estimates in Lee and Schmidt (2010).

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Recent Developments in Innovation-Related Metrics

Innovation is defined as the introduction of new or significantly improved products (goods or services), processes, organizational methods, and marketing methods in internal business practices or in the open marketplace (OECD/Eurostat 2005). R&D and other intangible investments such as investments in software, higher education, and worker training are key inputs driving innovation. Improved and internationally comparable measurements of these inputs and associated outcomes have been identified as important components in evidence-based policymaking. New analytical and policy questions suggest the need for continuous enhancements (NRC 2005, 2007; OECD 2010c, 2010d). Questions include how innovation addresses ultimate social and economic goals, how it may affect (or be affected by) business cycles (economic downturns and recovery), business dynamics (new or small firms), and globalization (Filippetti and Archibugi 2011; Hasan and Tucci 2010; OECD 2010b, 2010c, 2010d; Stiglitz et al. 2009). Ongoing research and data development initiatives in innovation-related metrics include:

- As part of its Innovation Strategy in support of economic growth and recovery, the OECD* has been working on a measurement agenda for innovation, including links between innovation and macroeconomic performance (OECD 2010c). International statistical manuals have been updated or developed. The latter include an updated United Nations System of National Accounts (SNA) manual (EU et al. 2009), which recognizes R&D and other intangibles as investments or capital assets, and a new OECD Handbook on the treatment of intangibles in national economic accounts (OECD 2010a).
- In the United States, the Commerce Department's Bureau of Economic Analysis and NSF's National Center for Science and Engineering Statistics (NCSES) have jointly developed an R&D Satellite Account** which considers R&D as a capital investment with long-term benefits rather than an expense (that is, it capitalizes R&D). This work will guide the incorporation of R&D in U.S. GDP and other national income and product accounts (NIPAs) in 2013, consistent with the revised SNA manual (Aizcorbe et al. 2009; Jorgenson et al. 2006).
- NCSES's new Business R&D and Innovation Survey covers global activities of U.S.-located companies on a broad range of R&D, employment, intellectual property (IP), technology transfer, and innovation variables. See sidebar, "U.S. Business R&D and Innovation Survey."
- NSF Science of Science and Innovation Policy (SciSIP) program supports theoretical and empirical research designed to advance the scientific basis of science and innovation policy. SciSIP-funded research aims to develop, improve, and expand theories, models, analytical tools, data, and metrics bearing on science policy and innovation.
- STAR METRICS (Science and Technology for America's Reinvestment: Measuring the Effect of Research on Innovation, Competitiveness, and Science) is an interagency project conducted under the auspices of the White House Office of Science Technology and Policy (OSTP).*** It seeks to build an infrastructure to integrate data on R&D inputs, outputs, and outcomes in order to analyze the impacts of science investments (Lane and Bertuzzi 2011).

* http://www.oecd.org/innovation/strategy
** http://www.bea.gov/national/newinnovation.htm
*** https://www.starmetrics.nih.gov; http://scienceofscience policy.net

additional $61.5 billion abroad (appendix table 4-14). This section will also cover details on funding sources (appendix table 4-15).

Domestic R&D Performance and Funding Sources

U.S. business R&D performance can be paid with funds from company-owned units, other businesses not owned by the company, and other external sources. Internal and external funders may be located in the United States or abroad.

U.S. business R&D performance totaled $290.7 billion in 2008, including $232.5 billion (80%) from businesses' own funds and $58.2 billion (20%) paid for by others not owned by the company, regardless of the location of funders (table 4-6).

Companies in manufacturing industries performed $203.8 billion of R&D domestically representing 70% of all business R&D performed in the United States in 2008; nonmanufacturing industries performed $86.9 billion. The split between own company funds and funding by others for manufacturing and nonmanufacturing industries was similar to the split for overall business R&D (about 80% and 20%).

Businesses vary in R&D intensity—how much R&D they do relative to production, value added, or sales—across industry and size. In this section, business R&D intensity is the ratio of domestic R&D performed and paid for by the company to domestic net sales. In 2008, the ratio across all businesses within scope of the Business R&D and Innovation Survey (BRDIS) was 3.0%; 3.5% for manufacturers and 2.2% for companies in nonmanufacturing industries (appendix table 4-16). Some industries have considerably higher R&D intensities, such as the computer and electronic products, chemicals, and information industries (figure 4-7).

Table 4-6
Domestic R&D performed by the company, by industry and company size: 2008
(Millions of U.S. dollars)

Industry and company size	NAICS code	Domestic R&D performance: Total	Paid for by company	Paid for by others
All industries	21–23, 31–33, 42–81	290,681	232,505	58,176
Manufacturing industries	31–33	203,754	164,386	39,368
Nonmanufacturing industries	21–23, 42–81	86,925	68,118	18,807
All companies	21–23, 31–33, 42–81	290,681	232,505	58,176
Small companies (number of domestic employees)[a]	—	58,136	46,395	11,741
5–99	—	33,256	24,890	8,366
100–249	—	14,662	12,933	1,729
250–499	—	10,218	8,572	1,646
Medium and large companies (number of domestic employees)	—	232,544	186,110	46,434
500–999	—	11,886	9,673	2,213
1,000–4,999	—	46,337	39,010	7,327
5,000–9,999	—	24,764	20,358	4,406
10,000–24,999	—	48,737	43,049	5,688
25,000 or more	—	100,820	74,020	26,800

NAICS = North American Industry Classification System

[a]Upper bound based on U.S. Small Business Administration's definition of a small business; Business R&D and Innovation Survey does not include companies with fewer than five domestic employees.

NOTES: Detail may not add to total because of rounding. Industry classification based on dominant business code for domestic R&D performance where available. For companies that did not report business codes, classification used for sampling was assigned.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics and Census Bureau, Business R&D and Innovation Survey (2008).

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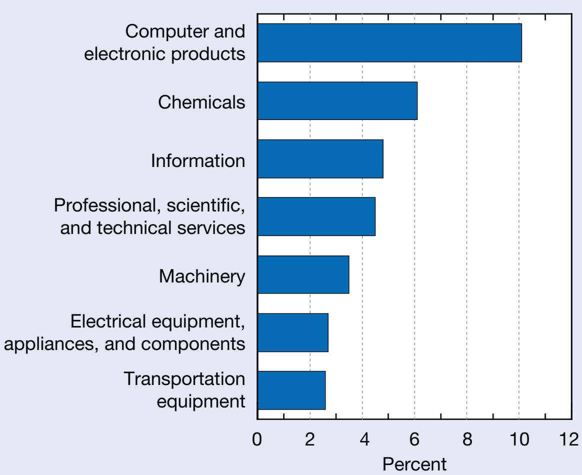
Figure 4-7
Domestic R&D performed and paid for by the company as a percentage of domestic net sales: 2008



SOURCE: National Science Foundation, National Center for Science and Engineering Statistics and U.S. Census Bureau, Business R&D and Innovation Survey (2008).

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Domestic R&D Performance Funded by Others

Of the $58.2 billion (20% of $290.7 billion) in funding by others outside of individual companies, the U.S. federal government accounted for $36.4 billion, independent domestic firms $12.2 billion, and $8.9 billion was funded by companies located outside of the United States (both independent companies and foreign parents). Other nonfederal sources accounted for less than $1 billion.

Federal R&D funding figures prominently in two defense-related industries. The aerospace products and parts industry performed $25.8 billion in federally funded R&D, almost 70% of their $36.9 billion in domestically performed R&D in 2008. The navigational, measuring, electromedical, and control instruments industry performed $3.6 billion in federally funded R&D, almost a quarter of its $15.5 billion of domestic R&D performance (table 4-7 and appendix table 4-15).

Domestic R&D Performance by Size of Company

Small companies, those with 5–499 domestic employees, performed $58.1 billion (20%) of $290.7 billion in U.S. business R&D performance; 80% ($46.4 billion) of the domestic

R&D performance by small companies was paid for with their own funds, the remainder by other business or organizations, regardless of location (table 4-6). The largest companies, those with 25,000 or more domestic employees, performed $100.8 billion (35%) of U.S. business R&D, with 73% of that amount ($74.0 billion) paid for with their own funds.

The domestic operations of small companies were more R&D intensive (6.3%) than the domestic operations of the largest companies (2.3%) in 2008 (appendix table 4-16).[10]

Table 4-7
Sources of funds for domestic R&D performed by the company, by selected industry and company size: 2008
(Millions of U.S. dollars)

Industry and company size	NAICS code	Total	R&D paid for by the company	R&D paid for by others: Total	R&D paid for by others: U.S. federal government	R&D paid for by others: Nonfederal sources[a]
All industries	21–23, 31–33, 42–81	290,681	232,505	58,176	36,360	21,816
Manufacturing	31–33	203,754	164,386	39,368	31,102	8,266
Chemicals	325	58,249	55,042	3,207	197	3,010
Pharmaceuticals and medicines	3254	48,131	45,169	2,962	137	2,825
Other chemicals	other 325	10,118	9,873	245	60	185
Computer and electronic products	334	60,463	52,912	7,551	4,646	2,905
Navigational, measuring, electromedical, and control instruments	3345	15,460	10,463	4,997	3,635	1,362
Other computer and electronic products	other 334	45,003	42,449	2,554	1,011	1,543
Transportation equipment	336	50,552	23,039	27,513	25,941 i	1,572
Aerospace products and parts	3364	36,941	10,371	26,570	25,805 i	765
Other transportation equipment	other 336	13,611	12,668	943	136	807
Other manufacturing	other 31–33	34,490	33,393	1,097	318	779
Nonmanufacturing	21–23, 42–81	86,925	68,118	18,807	5,258	13,549
Professional, scientific, and technical services	54	37,954	20,539	17,415	4,844	12,571
Scientific research and development services	5417	17,913	8,708	9,205	2,115	7,090
Other professional, scientific, and technical services	other 54	20,041	11,831	8,210	2,729	5,481
Other nonmanufacturing	other 21–23, 42–81	48,971	47,579	1,392	414	978
All companies	21–23, 31–33, 42–81	290,681	232,505	58,176	36,360	21,816
Small companies (number of domestic employees)[b]	—	58,136	46,395	11,741	4,117	7,624
5–99	—	33,256	24,890	8,366	2,667	5,699
100–249	—	14,662	12,933	1,729	718	1,011
250–499	—	10,218	8,572	1,646	732	914
Medium and large companies (number of domestic employees)	—	232,544	186,110	46,434	32,243	14,191
500–999	—	11,886	9,673	2,213	747	1,466
1,000–4,999	—	46,337	39,010	7,327	2,162 i	5,165
5,000–9,999	—	24,764	20,358	4,406	1,168	3,238
10,000–24,999	—	48,737	43,049	5,688	3,024	2,664
25,000 or more	—	100,820	74,020	26,800	25,142 i	1,658

i = more than 50% of the estimate is a combination of imputation and reweighting to account for nonresponse

NAICS = North American Industry Classification System

[a]Companies located in the United States funded $12.2 billion; $8.9 billion was funded by companies located outside of the United States, including R&D paid for by the foreign parents of U.S. affiliates. For manufacturing industries, the amounts were $3.4 billion and $4.7 billion, respectively, and for nonmanufacturing industries, $8.7 billion and $4.2 billion, respectively.

[b]Upper bound based on U.S. Small Business Administration's definition of a small business; the Business R&D and Innovation Survey does not include companies with fewer than five domestic employees.

NOTES: Detail may not add to total because of rounding. Industry classification based on dominant business code for domestic R&D performance where available. For companies that did not report business codes, classification used for sampling was assigned.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics and Census Bureau, Business R&D and Innovation Survey (2008).

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Largest Domestic R&D-Performing Industries

Business R&D intensity is generally greater in the manufacturing sector (3.5% overall) than in nonmanufacturing (2.2%). Nonetheless, R&D plays a large role in some service industries and R&D intensity in some manufacturing sectors is relatively low (appendix table 4-16).

Six industry groups—four in manufacturing (chemicals, computer and electronic products, aerospace and defense manufacturing, and automotive manufacturing) and two in services (software and computer-related products, and R&D services)—accounted for three-quarters of both 2008 total business R&D performed in the United States ($225.8 billion) and company-funded/company-performed R&D ($173.3 billion) in the United States. They also accounted for 96% ($34.8 billion) of federally funded U.S. business R&D in 2008 (table 4-8).[11]

Chemicals (Including Pharmaceuticals)

The chemical industries accounted for the largest share of business R&D performed in the United States—20% or $58.2 billion of $290.7 billion in 2008 (figure 4-8). Within the chemicals industry, the largest subsector is pharmaceuticals and medicines. In 2008, pharmaceutical companies performed $45.2 billion of company-funded R&D in the United States and $10.9 billion abroad (appendix table 4-14).

Software and Computer-Related Services

Software and computer-related services industries—software publishing, computer systems design and Internet service providers, web search portals and data processing services industries—performed $46.9 billion of domestic R&D in 2008, making it the second largest industry group for domestic R&D performance, and $8.5 billion abroad. The R&D of these industries, 16% of business R&D performance in the United States, combined with that of the computer and electronic product manufacturers (below), accounted for 32% of all business R&D performed in the United States in 2008 (table 4-8). As computing, information technology, and Internet-linked activity has become more integrated with every sector of the economy, the demand for services associated with these technologies has increased.

Computer and Electronic Products

Companies in the computer and electronic product manufacturing industries include producers of communications equipment, semiconductors, computers and computer peripherals, and components for such products.[12] The design and use of integrated circuits and the application of highly specialized miniaturization technologies are common elements in the production processes of the computer and electronic products sector. In 2008, companies in this industry group performed $45.0 billion of R&D, or 15% of all domestic business R&D, and $13.0 billion abroad. Funds for domestic R&D came mostly from the companies themselves ($42.4 billion) and relatively little ($2.6 billion) came from other sources. Two relatively high R&D-intensive 4-digit NAICS (North American Industry Classification System) industries are included in this group, semiconductor and communications equipment manufacturing. Their domestic R&D/domestic sales ratios were 20% and 13%, respectively (appendix table 4-16).

Aerospace and Defense Manufacturing

Although it is common to refer to the "defense industry," the NAICS system does not include such a classification. Thus, to approximate the cost of defense-related R&D, included here are data on aerospace products and parts plus federally funded R&D in the following industries: navigational, measuring, electromedical, and control instruments, as well as other transportation manufacturing industries. Companies in this "defense sector" perform the majority of the Department of Defense's (DOD's) extramural R&D (table 4-8). In 2008, these industries reported performing $40.7 billion of R&D in the United States. Federally funded R&D accounted for 73% ($29.6 billion) of the sector total and 81% of all federally funded business R&D performed in the United States. This total accounts for more than half of the $56.0 billion in DOD outlays for FY 2008 (NSF 2010d).

R&D and Related Services

The R&D and related services group includes companies that provide scientific R&D, engineering, and architectural services to other firms or for their own use.[13] Companies in this group performed $21.3 billion of R&D in the United States during 2008; $10.1 billion paid for from company funds and $11.2 billion paid for by others.[14] Of the $11.2 billion paid for by others, $3.0 billion was funded by the U.S. federal government, the highest amount outside the aerospace and defense manufacturing group (table 4-8).

Automotive Manufacturing

Companies in automotive manufacturing industries reported performing $14 billion of company-funded R&D in 2008, accounting for 5% of all such R&D performed by businesses in the United States (table 4-8). In 2008, out of the about 4,000 companies in the automobiles, bodies, trailers, and parts industries (NAICS 3361, 3362, and 3363), 13 reported domestic R&D performed by the company of $100 million or more, collectively representing 84% of R&D performed by that group of industries.

Business Activities for Domestic R&D

Industry-based data above are the result of classifying each company's R&D in only one industry. However, companies in different industries and even in the same industry perform R&D relating to a variety of different business lines of activities. For example, a company classified as a pharmaceutical company may also perform R&D in medical equipment. A feature of BRDIS is the collection of information on R&D performed by business activity—both R&D paid for by the company and paid for by others. See sidebar,

Table 4-8
Business R&D performed in the United States by the company, paid for by the company and by others, by industry group: 2008
(Millions of U.S. dollars)

Industry	Total	R&D paid for by the company	R&D paid for by others: Total	R&D paid for by others: U.S. federal government	R&D paid for by others: Nonfederal sources
All	290,681	232,505	58,176	36,360	21,816
Highlighted industries	225,813 L	173,318	52,495 L	34,788 L	17,707
Chemicals	58,249	55,042	3,207	197	3,010
Basic chemicals	4,074	4,012	62	33	29
Pharmaceuticals and medicines	48,131	45,169	2,962	137	2,825
Soap, cleaning compound, and toilet preparation	2,108	2,099	9	6	3
Other chemicals	3,936	3,762	174	21	153
Software and computer-related services[a]	46,935	42,727	4,208	961	3,247
Software publishers	28,221	27,665	556	176	380
Computer systems design and related services	12,146	8,569	3,577	784	2,793
Internet service providers, web search portals, and data processing services	6,568	6,493	75	1	74
Computer and electronic products[b]	45,003	42,449	2,554	1,011	1,543
Communications equipment	12,903	11,484	1,419	D	D
Semiconductor and other electronic components	22,324	21,588	736	D	D
Computer and peripheral equipment and other computer and electronic products	9,776	9,377	399	D	D
Aerospace and defense manufacturing[c]	40,712	10,371	30,341 i	29,576 i	765
Aerospace products and parts	36,941	10,371	26,570 i	25,805 i	765
Navigational, measuring, electromedical, and control instruments (U.S. federal government funded only)	3,635	—	3,635	3,635	—
Transportation equipment (U.S. federal government funded only)	136	—	136 i	136 i	—
R&D and related services[d]	21,335	10,086	11,249	3,043	8,206
Architectural, engineering, and related services	3,422	1,378	2,044	928	1,116
Scientific research and development services	17,913	8,708	9,205	2,115	7,090
Automotive manufacturing[e]	13,579 L	12,643	936 L	D	936
Automobiles, bodies, trailers, and parts	13,140 L	12,234	906 L	D	906
Other transportation equipment (not aerospace or defense related)	439 L	409	30 L	D	30
All other	64,868 L	59,187	5,681 L	1,572 L	4,109

D = suppressed to avoid disclosure of confidential information; i = more than 50% of the estimate is a combination of imputation and reweighting to account for nonresponse; L = lower-bound estimate, potential disclosure of individual company operations only allows lower-bound estimates for some industry groups

NAICS = North American Industry Classification System

[a]Includes domestic R&D performance for software publishers (NAICS 5112), computer systems design and related service industries (NAICS 5415), and Internet service providers, web search portals, and data processing services (NAICS 518).
[b]Includes domestic R&D performance for the computer and electronics industry (NAICS 334), except for federal R&D for the navigational, measuring, electromedical, and control instruments industry (NAICS 3345), which is included in the aerospace and defense manufacturing sector.
[c]Includes domestic R&D performance for the aerospace products and parts industry (NAICS 3364), plus all federal R&D for the navigational, measuring, electromedical, and control instruments (NAICS 3345) and transportation equipment manufacturing industries.
[d]Includes domestic R&D performance for the architectural, engineering, and related services (NAICS 5413) and scientific R&D services industries (NAICS 5417).
[e]Includes domestic R&D performance for automobiles, bodies, trailers, and parts (NAICS 3361-3363) and transportation equipment (NAICS 336) industries, except federally funded components that are included in the aerospace and defense manufacturing group.

NOTES: Detail may not add to total because of rounding. Industry classification based on dominant business code for domestic R&D performance where available. For companies that did not report business codes, classification used for sampling was assigned.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics and Census Bureau, Business R&D and Innovation Survey (2008).

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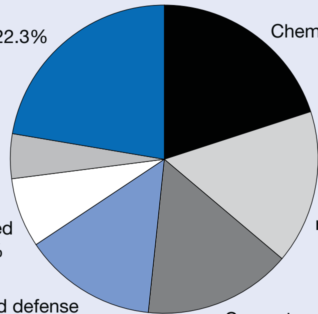
Figure 4-8
Shares of domestic R&D performed in the United States, by industry group: 2008



SOURCE: National Science Foundation, National Center for Science and Engineering Statistics and U.S. Census Bureau, Business R&D and Innovation Survey (2008).

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"U.S. Business R&D and Innovation Survey."[15] The number of these activities is large, as indicated in appendix table 4-17, but most companies performed R&D in only one business activity area. However, some companies, especially large diversified firms, performed R&D in multiple business activity areas. In BRDIS, 92% of companies reported domestic R&D paid for by the company related to only one business activity; 4% related to two business activities, and 4% related to three or more business activities. For domestic R&D paid for by others, the percentages were 91%, 6%, and 3%, respectively.

The top 10 business activities for which companies used their *own* funds to perform R&D in the United States accounted for 60% of these companies' R&D funds ($140.6 billion of $232.5 billion) (table 4-9). The top 10 activities for which companies used *others'* funds to perform R&D accounted for 68% of the total amount of company-performed R&D paid for by others (table 4-10).

U.S. Business R&D and Innovation Survey

To better understand and measure how R&D is conducted in today's innovation- and global-based economy (NRC 2005), NSF and the U.S. Census Bureau launched a new Business R&D and Innovation Survey (BRDIS). BRDIS expands on R&D data collected by its predecessor, the Survey of Industrial Research and Development, to cover (among other areas) global R&D funding or expenses by U.S.-located businesses, and introduces preliminary innovation and intellectual property questions that will be further developed.

Chapters 3, 4, 6, and 8 in this edition of *Science and Engineering Indicators* include selected preliminary data from the 2008 pilot survey. Detailed 2008 estimates and data for subsequent survey cycles are available at http://www.nsf.gov/statistics/industry/. BRDIS questionnaires are available at http://www.nsf.gov/statistics/question.cfm#13. Listed below are the main data collection areas.

- ♦ Company information:
  - Ownership
  - Business activities
- ♦ Measures of R&D activity paid for by the company:
  - Domestic and worldwide sales, revenue, and R&D activity
  - Company-funded R&D by business activity, type of costs, and location
  - Projected R&D costs
  - Capital expenditures for R&D (buildings, software, equipment)
- ♦ Measures related to R&D management and strategy:
  - Character of work (basic research, applied research, and development)
  - R&D applications and R&D in new business areas
  - R&D relationships with others outside the company
- ♦ Measures of company R&D activity funded by others:
  - Funds for worldwide and domestic R&D activity
  - R&D funded by others by business activity, type of organization, type of cost, state, and location (domestic vs. foreign)
- ♦ Measures of R&D employment:
  - R&D headcount (domestic and worldwide) by occupation and sex
  - Number of U.S. R&D employees working under a visa (H-1B, L-1, etc.)
  - R&D full-time equivalent counts
- ♦ Measures of intellectual property (IP), technology transfer, and innovation:
  - Participation in activities to introduce new or significantly improve existing goods, services, methods of production and distribution, or support systems
  - Selected patenting and licensing information
  - Participation in specific technology transfer activities and importance of types of IP protection

For more information see NSF 2008, 2010a, 2010b, and 2010c.

Table 4-9
Domestic R&D performance paid for by the company for top 10 business activities: 2008
(Millions of U.S. dollars)

Business activity	Business code[a]	R&D paid for by the company
All business activities	21100–81390	232,505
Top 10 business activities	—	140,632
Pharmaceutical, medicinal, botanical, and biological products (except diagnostic) manufacturing	32541	41,593
Software publishers (except Internet)	51120	23,860
Semiconductor and other electronic components manufacturing	33440	22,674
Computers and peripheral equipment manufacturing	33410	9,223
Medical equipment and supplies manufacturing	33910	8,521
Scientific research and development services	54170	8,464
Computer systems design and related services	54150	8,384
Motor vehicles manufacturing	33610	8,305
Telephone apparatus manufacturing	33421	5,424
Radio and television broadcasting and wireless communications equipment manufacturing	33422	4,184
All other business activities including undistributed amounts	—	91,873

[a]Business codes and descriptions based on North American Industry Classification System industry definitions.

NOTES: Data tabulated independent of the industry classification of the company. Detail may not add to total because of rounding

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics and Census Bureau, Business R&D and Innovation Survey (2008).

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Table 4-10
Domestic R&D performance paid for by others for top 10 business activities: 2008
(Millions of U.S. dollars)

Business activity	Business code[a]	R&D paid for by others
All business activities	21100–81390	58,176
Top 10 business activities	—	39,776
Scientific research and development services	54170	8,093
Aircraft manufacturing	33641	5,881
Architectural, engineering, and related services	54130	5,558
Search, detection, navigation, guidance, aeronautical, and nautical system and instruments manufacturing	33452	4,962
Guided missiles, space vehicles, and parts manufacturing	33644	4,725
Computer systems design and related services	54150	3,085
Pharmaceutical, medicinal, botanical, and biological products (except diagnostic) manufacturing	32541	2,797
Aircraft engine and engine parts manufacturing	33642	1,918
Electromedical, electrotherapeutic, and irradiation apparatus manufacturing	33451	1,899
Radio and television broadcasting and wireless communications equipment manufacturing	33422	858
All other business activities including undistributed amounts	—	18,400

[a]Business codes and descriptions based on North American Industry Classification System industry definitions.

NOTES: Data tabulated independent of the industry classification of the company. Detail may not add to total because of rounding.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics and Census Bureau, Business R&D and Innovation Survey (2008).

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R&D Performed Abroad by U.S.-Owned Companies

Foreign operations of U.S. businesses performed $61.5 billion in R&D outside the United States, based on 2008 BRDIS pilot survey. Of this performance abroad, $56.9 billion was paid by the own company and $4.6 billion was paid by others outside of the company (table 4-11).[16]

By far, the industry that performed the most R&D outside of the United States was the pharmaceuticals and medicines industry ($10.9 billion), based on BRDIS data (appendix table 4-14). Other industries with high levels of R&D performed abroad were automobiles, automobile bodies, trailers, and parts manufacturers ($8.4 billion), semiconductor and other electronic components manufacturers ($7.1 billion), and software publishers ($6.3 billion).

R&D by Multinational Companies

This section covers statistics on R&D performed by majority-owned affiliates of foreign multinational corporations (MNCs) located in the United States, and R&D performed by U.S. MNCs and their majority-owned foreign affiliates, collected by the Bureau of Economic Analysis (BEA). See sidebar, "Foreign Direct Investment in R&D."

R&D arising from foreign direct investment (FDI) activities is quantitatively important since MNCs are the largest performers of business R&D in the United States (discussed below) and in other economies (Dunning and Lundan 2009). Both home country and international opportunities and policies affect R&D and other innovation-related activities by MNCs (Breznitz 2009; Athukorala and Kohpaiboon 2010). In turn, MNC activities influence the ultimate impacts of national and international R&D on national economic growth and productivity.

The majority of R&D by U.S. MNCs continues to be performed in the United States. Outside the United States, R&D by U.S.-owned foreign affiliates is performed mostly in Western Europe, Canada, and Japan, followed more recently by other locations in the Asia-Pacific region. Information on character of work for MNCs' R&D is presented in the sidebar, "Linking MNC Data from International Investment and Business R&D Surveys."

Foreign Direct Investment in R&D

Foreign direct investment (FDI) is one of several channels for the creation, exploitation, and diffusion of new knowledge along with international trade, licensing, and technology partnerships (Saggi 2002). Direct investment is defined as ownership or control of 10% or more of the voting securities of a business (affiliate) in another country. The cross-country location of R&D activities via FDI is driven by factors ranging from costs and long-term market and technological opportunities to infrastructure and policy considerations, such as human resources and intellectual property protection.

Statistics on R&D by affiliates of foreign companies located in the United States, and by foreign affiliates of U.S. MNCs and their parent companies, are from BEA's Survey of Foreign Direct Investment in the United States (FDIUS) and BEA's Survey of U.S. Direct Investment Abroad (USDIA). Affiliate data presented in this section cover majority-owned affiliates, that is, those in which the ownership stake of parent companies totals more than 50%. Annual changes in FDI R&D reflect a combination of mergers and acquisitions; newly built factories, service centers, or laboratories; and activities in existing facilities. Data exclude commercial banks, savings institutions, credit unions, bank holding companies, and financial holding companies

U.S. Affiliates of Foreign Companies

Majority-owned affiliates of foreign MNCs located in the United States (U.S. affiliates) performed $40.5 billion of R&D or 13.9% of the $290.7 in U.S. business R&D performed in 2008 (preliminary BEA estimate).[17] Since 1999, the share of these companies in U.S.-located business R&D,

Table 4-11
R&D performed abroad by U.S.-owned companies: 2008
(Millions of U.S. dollars)

Industry	NAICS code	Foreign performance		
		Total	Paid for by company	Paid for by others
All industries	21–23, 31-33, 42–81	61,475	56,899	4,576
Manufacturing industries	31–33	46,572	45,274	1,298
Nonmanufacturing industries	21–23, 42–81	14,903	11,625	3,278

NAICS = North American Industry Classification System

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics and Census Bureau, Business R&D and Innovation Survey (2008).

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Linking MNC Data from International Investment and Business R&D Surveys

In 2007, the nature of R&D carried out by U.S. affiliates of foreign-owned MNCs was very similar to U.S.-based R&D of U.S. MNC parents: 4.4%–4.5% of R&D expenditures was devoted to basic research, 19.4%–19.9% to applied research, and 75.8%–76.1% to development.

This new insight into the distribution of character of work of MNCs R&D is made possible by linking and comparing reports for 2004–07 from the same set of companies responding to NSF/Census Survey of Industrial Research and Development (SIRD),* the predecessor of BRDIS, with two different BEA surveys: Foreign Direct Investment in the United States and U.S. Direct Investment Abroad.

* http://www.nsf.gov/statistics/industry/

as collected in NSF R&D surveys, has fluctuated narrowly between 13% and 15%. About 90% of R&D by U.S. affiliates of foreign MNCs is performed by firms owned by European, Japanese, and Canadian parent companies (appendix table 4-18).

The share of U.S. affiliates' R&D performed by manufacturing companies has decreased from over 80% in the late 1990s to 74.7% in 2007 and 69.6% in 2008. Country ownership patterns and industry focus have remained relatively unchanged, with Swiss- and British-owned companies, for example, performing close to two-thirds of R&D by U.S. affiliates classified in chemicals (which includes pharmaceuticals) and German-owned companies performing close to one-quarter of R&D by U.S. affiliates classified in transportation equipment in 2008 (table 4-12). Among the largest nonmanufacturing R&D-performing industries for U.S. affiliates in 2008 were wholesale trade in electrical goods ($2.4 billion); professional, scientific, and technical services ($2.3 billion); and information services ($2.1 billion) (see appendix tables 4-19, 4-20, and 4-21).

U.S. MNCs Parent Companies and Their Foreign Affiliates

In 2008, parent companies of U.S. MNCs performed $199.1 billion of the $290.7 billion of R&D performed by businesses in the United States. Their majority-owned foreign affiliates performed $37.0 billion according to preliminary BEA data (see table 4-13 and appendix tables 4-22 through 4-26).).[18] Since 1999, U.S. MNCs have performed, on average, about 86% of their annual global R&D in the United States. In turn, U.S. MNC parents accounted, on average, for about 72% of annual U.S. business R&D performed over the same period.

Table 4-12
R&D performed by majority-owned affiliates of foreign companies in the United States, by selected NAICS industry of affiliate and country: 2008
(Millions of current U.S. dollars)

		Manufacturing						Nonmanufacturing		
Country	All industries	Total	Chemicals	Machinery	Computer and electronic products	Electrical equipment	Transportation equipment	Information	Professional, technical, scientific services	Wholesale trade
All countries	40,519	28,190	14,121	2,535	4,259	499	4,015	2,108	2,347	7,404
Canada	1,435	429	124	D	D	D	194	D	D	D
France	5,978	4,672	1,408	D	D	D	102	D	91	D
Germany	5,520	4,763	2,017	D	101	21	930	D	D	227
Netherlands	1,789	D	D	D	236	4	16	0	3	D
Switzerland	6,926	5,743	5,435	43	11	D	9	3	934	245
United Kingdom	7,369	6,683	3,665	47	292	6	D	D	106	D
Japan	4,637	1,643	516	64	515	42	282	11	678	2,242
Other	6,865	D	D	595	D	D	D	D	D	2,911

D = suppressed to avoid disclosure of confidential information

NAICS = North American Industry Classification System

NOTES: Preliminary 2008 estimates for majority-owned (>50%) nonbank affiliates of nonbank U.S. parents by country of ultimate beneficial owner and industry of affiliate. Expenditures included for R&D conducted by foreign affiliates, whether for themselves or others under contract. Expenditures excluded for R&D conducted by others for affiliates under contract.

SOURCE: Bureau of Economic Analysis, Survey of Foreign Direct Investment in the United States (annual series), http://www.bea.gov/international/index.htm#omc, accessed 4 February 2011.

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Table 4-13
R&D performed by U.S. multinational companies: 1999–2008

Year	Location of R&D performed (current US$millions)			Shares of U.S. MNCs R&D performance (%)	
	United States (by parents of U.S. MNCs)	Outside United States (by MOFAs)	Total by U.S. MNCs	United States	Outside United States
1999	126,291	18,144	144,435	87.4	12.6
2000	135,467	20,457	155,924	86.9	13.1
2001	143,017	19,702	162,719	87.9	12.1
2002	136,977	21,063	158,040	86.7	13.3
2003	139,884	22,793	162,677	86.0	14.0
2004	164,189	25,840	190,029	86.4	13.6
2005	177,598	27,653	205,251	86.5	13.5
2006	184,428	29,583	214,011	86.2	13.8
2007	203,678	34,446	238,124	85.5	14.5
2008	199,105	36,991	236,096	84.3	15.7

MNC = multinational company; MOFA = majority-owned foreign affiliate

NOTE: MOFAs are affiliates in which combined ownership of all U.S. parents is >50%.

SOURCE: Bureau of Economic Analysis. Survey of Foreign Direct Investment in the United States (annual series).

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R&D by foreign affiliates of U.S. MNCs has gradually shifted from traditional host countries, including Japan, towards other Asian venues. The combined share of Europe, Canada, and Japan as hosts of R&D by U.S.-owned foreign affiliates declined from about 90% in the mid- and late 1990s to around 80% since 2006. European-located affiliates have performed about two-thirds of R&D by affiliates of U.S. MNCs since 2003, after declining in the late 1990s and early 2000s (figure 4-9 and appendix table 4-22).

On the other hand, the share of R&D performed by Asia-located affiliates (other than in Japan) increased from about 5% to 14% from 1997 to 2008. In particular, the share of U.S.-owned affiliates' R&D performed in China, South Korea, Singapore, and India rose from a half percentage point or less in 1997 to 4% for China, just under 3% for South Korea, and just under 2% each for Singapore and India in 2008.

Manufacturing affiliates accounted for 80% of foreign affiliates' R&D in 2008, including two-thirds performed in three industries: transportation equipment (25%), chemicals (including pharmaceuticals) (24%), and computer and electronic products (17%) (table 4-14). Professional, technical, and scientific services accounted for another 11% and information services for 5% (see appendix tables 4-23 and 4-24).

The country and industry distribution of U.S. MNCs' foreign R&D is related, among other factors, to historical S&T strengths in the host countries. United Kingdom and Germany, for example, hosted 20.4% and 12.0% of U.S.-owned overseas R&D in chemicals (which includes pharmaceuticals), whereas affiliates located in Germany performed almost two-fifths of R&D by transportation equipment affiliates (table 4-14).

Within the professional, technical, and scientific services industry, affiliates located in the UK performed 22.3% of foreign affiliates' R&D total, followed by Canada (12.5%) and India (6.3%), according to available country detail. Lastly, about four-fifths of affiliates' R&D in information services (which includes software and Internet publishing and telecommunications) in 2008 was performed in three areas: Ireland (30.7%), Canada (22.3%), and Asia outside Japan (25.5%).

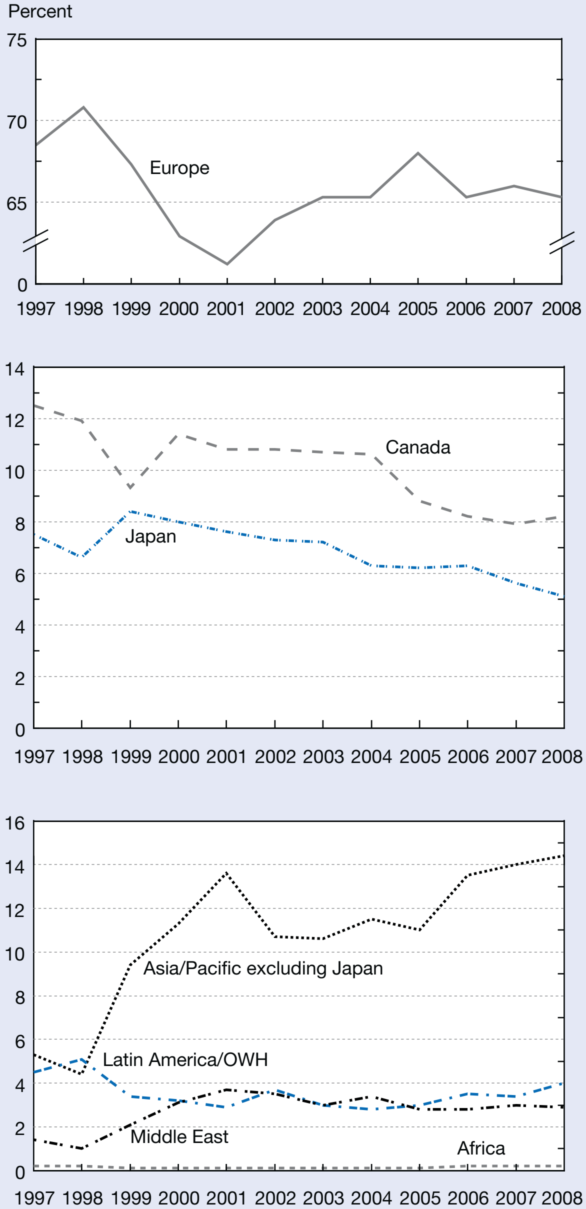
Exports and Imports of R&D-Related Services

Cross-border transactions of business services, published by BEA as part of international transactions accounts, include research, development, and testing (RDT) services under the category of business, professional, and technical services. RDT services include commercial and noncommercial research as well as product development and testing services. In 2009, U.S. RDT exports and imports stood at $18.2 billion and $15.8 billion, respectively, for a balance of $2.5 billion (appendix table 4-27).[19]

Transactions in RDT services provide insights into business R&D-related transactions, including exchanges among unaffiliated or independent companies (unaffiliated trade) and trade within MNCs (affiliated trade). As described below, most transactions in these R&D-related services occur within multinational corporations. Further, the patterns of U.S. RDT exports and imports differ for U.S. and foreign MNCs.

Most RDT trade occurs within companies. Since 2001, when affiliated RDT trade data were first available, transactions among MNCs members (parent companies and subsidiaries) have represented around 85% of total RDT exports annually. This share is consistent with the large role of MNCs (including U.S. parents and foreign-owned

Figure 4-9
Regional shares of R&D performed abroad by foreign affiliates of U.S. MNCs: 1997–2008



MNC = multinational company; OWH = other Western Hemisphere

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

SOURCE: Bureau of Economic Analysis, Survey of U.S. Direct Investment Abroad (annual series).

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companies) in U.S. business R&D performance. (See section "R&D by Multinational Companies.") Likewise, within-company imports accounted for 66% to 78% of total RDT imports annually over the same period. The large share of this affiliated or within-company RDT trade reflects the need for management control and proprietary protection in cross-border transactions involving intangible assets.

Foreign MNCs with operations in the U.S. are exporting more RDT services to their foreign parents (and other members of the foreign MNCs) compared with their level of imports. Foreign MNCs with activities in the U.S. reported average annual net exports of $3.9 billion between 2006 and 2009, with net exports fluctuating between $3.4 billion to $4.5 billion over this period. On the other hand, U.S. MNC parents imported annually about the same or slightly more of those services relative to their exports over the same period (table 4-15).[20] In 2009, U.S. parents imported $602 million more RDT services from their foreign affiliates than they exported to their affiliates.

Europe accounted for about half of U.S. total RDT exports and imports in 2009 (appendix table 4-27). Latin America was the second largest destination of RDT exports (23%) whereas Asia was the second largest origin of RDT imports (about 30%). The latter included 9.1% of RDT imports from India in 2009 (compared with 4.6% in 2006), 8.6% from Japan (compared with 5.9% in 2006), and 5.4% from China (compared with 1.0% in 2006).

Federal R&D

The U.S. government supports the nation's R&D system through various policy tools. The most direct is federal performance and funding of R&D. This section provides statistics on these federally performed or funded activities, including budget authority by national objectives, obligations by agency, and obligations by research field (for definition of these terms see sidebar, "Federal Budgetary Concepts and Related Terms"). This section also covers federal tax credits for business R&D.

Federal R&D Budget by National Objectives

Federal support for the nation's R&D spans a range of broad objectives, including defense, health, space, energy, natural resources/environment, general science, and various other categories. To assist the president and Congress in planning and setting the federal budget and its components, the Office of Management and Budget classifies agency budget requests into specific categories called *budget functions*. These functions include a number of categories that distinguish the various R&D objectives. Descriptions of the budget authority provided annually to federal agencies in terms of these R&D budget functions afford a useful picture of the present priorities and trends in federal support for U.S. R&D.

In FY 2009, budget authority for federal agency spending on R&D totaled an estimated $156.0 billion, including a one-time $15.1 billion increase provided under the American Recovery and Investment Act of 2009 (appendix tables 4-28 and 4-29).

Defense-Related R&D

As in previous years, defense was the largest of the R&D budget functions, accounting for 55% ($85.2 billion) of the total. Defense R&D is supported primarily by the Department

Table 4-14
R&D performed abroad by majority-owned foreign affiliates of U.S. parent companies, by selected NAICS industry of affiliate and region/country/economy: 2008
(Millions of current U.S. dollars)

		Manufacturing						Nonmanufacturing		
Region/country/economy	All industries	Total	Chemicals	Machinery	Computer and electronic products	Electrical equipment, appliances, and components	Transportation equipment	Information	Professional, technical, scientific services	Wholesale trade
All countries	36,991	29,385	8,754	1,457	6,354	586	9,163	1,954	3,963	1,461
Canada	3,040	1,981	685	28	482	19	653	436	494	78
Europe	24,155	19,416	6,255	1,076	2,762	313	6,601	870	2,680	1,089
Belgium	1,259	891	783	24	D	15	14	*	350	12
France	2,171	1,878	448	133	501	35	456	45	188	53
Germany	7,039	6,485	1,051	388	858	132	3,527	D	194	D
Ireland	1,503	848	438	0	313	0	2	599	D	D
Italy	582	475	246	52	22	4	73	*	D	D
Netherlands	1,484	1,267	778	41	73	D	D	D	D	D
Sweden	1,576	1,478	33	12	59	D	D	D	D	7
Switzerland	1,123	728	262	88	173	24	D	D	229	118
United Kingdom	5,157	3,844	1,790	185	464	49	912	76	884	341
Latin America/OWH	1,465	1,354	371	40	191	D	642	1	37	29
Brazil	791	770	175	35	D	0	444	1	4	16
Mexico	329	D	80	4	7	D	169	*	D	3
Africa	57	44	14	1	*	0	23	2	*	2
South Africa	43	34	13	*	*	0	D	2	*	2
Middle East	1,063	869	D	D	650	0	0	5	174	15
Israel	1,060	867	D	D	650	0	0	D	174	D
Asia and Pacific	7,210	5,722	D	D	2,268	D	1,244	640	578	247
Australia	923	851	234	10	6	20	D	7	20	41
China	1,517	1,180	D	24	965	66	40	D	D	43
Hong Kong	102	52	9	0	10	5	0	5	37	7
India	582	222	58	D	D	D	32	D	250	D
Japan	1,872	1,529	930	64	244	D	81	142	D	D
Malaysia	360	358	3	*	345	1	0	0	*	2
Singapore	621	390	30	1	343	1	2	D	D	9
South Korea	966	931	34	17	207	D	D	7	7	D
Taiwan	102	D	D	1	48	5	2	D	8	8
Thailand	69	67	7	3	27	0	17	0	0	2

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

NAICS = North American Industry Classification System; OWH = other Western Hemisphere

NOTES: Preliminary 2008 estimates for majority-owned (>50%) nonbank affiliates of nonbank U.S. parents by country of ultimate beneficial owner and industry of affiliate. Expenditures included for R&D conducted by foreign affiliates, whether for themselves or others under contract. Expenditures excluded for R&D conducted by others for affiliates under contract.

SOURCE: Bureau of Economic Analysis, Survey of U.S. Direct Investment Abroad (annual series), http://www.bea.gov/international/index.htm#omc, accessed 4 February 2011.

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of Defense (DOD), but also includes some R&D by the Department of Energy (DOE) and the Department of Justice (where some R&D by the Federal Bureau of Investigation comes under a defense category).

Defense has accounted for the majority of R&D budget authority throughout the last two decades (figure 4-10, appendix table 4-28); the share has fluctuated year to year in the 50%–70% range. In FY 1980, it roughly equaled nondefense R&D, but by FY 1985 it was more than double. From 1986 to 2001, nondefense R&D surged, and the share of defense R&D shrank to 53%. After September 11, 2001, defense R&D became more prominent, accounting for 59% of the federal R&D budget in FY 2008. The drop to 55% in FY 2009 reflects chiefly the effect of the one-time ARRA

Table 4-15
U.S. trade balance in research, development, and testing services, by affiliation: 2006–09
(Millions of current U.S. dollars)

Affiliation	2006	2007	2008	2009
Total	3,534	2,593	1,142	2,481
Unaffiliated	–660	–1,008	–1,473	–1,020
Affiliated	4,193	3,601	2,615	3,500
By U.S. parents from/to their foreign affiliates	–334	185	–1,100	–602
By U.S. affiliates from/to their foreign parent groups[a]	4,528	3,416	3,715	4,103

[a]In addition to transactions with its foreign parent, U.S. affiliates' exports and imports include transactions with other members of their foreign parent group.

NOTES: Trade balance is exports minus imports. Positive amounts represent a trade surplus; negative amounts represent a trade deficit.

SOURCE: Bureau of Economic Analysis, U.S. International Services, http://www.bea.gov/international/international_services.htm, accessed 4 February 2011.

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spending authority that expanded health, energy, and general science research.

Nondefense R&D

Budget authority for nondefense R&D totaled $70.8 billion in FY 2009, or about 45% of the total that year (appendix table 4-28). Nondefense R&D includes health, space research/technology, energy, general science, natural resources/environment, transportation, agriculture, education, international affairs, veterans' benefits, and a number of other small categories related to economic and governance matters.

The most striking change in federal R&D priorities over the past two decades has been the considerable increase in health-related R&D—which now accounts for well over half of all nondefense R&D (figure 4-10). Health R&D has risen from about 12% of total federal R&D budget authority in FY 1980 to 21% in FY 2008 and 26% in FY 2009 because of the ARRA increment. The increase in share accelerated after 1998, when policymakers set the National Institutes of Health (NIH) budget on course to double by FY 2003.

The budget allocation for space-related R&D peaked in the 1960s, during the height of the nation's efforts to surpass the Soviet Union in space exploration. It stood at 10%–11% of total R&D authority throughout the 1990s. The loss of the space shuttle *Columbia* and its entire crew in February 2003 prompted curtailment of manned space missions. In FY 2005, the space R&D share was down to about 6%; by FY 2009, it had declined to around 4%.

Federal nondefense R&D classified as general science had about a 4% share of total federal R&D in the mid 1990s, growing to 8% in FY 2009. However, this change reflected chiefly a reclassification, starting in FY 1998, of several DOE programs from energy to general science.

Federal Budget for Basic Research

In FY 2009, federal budget authority for all basic research totaled $36.4 billion (appendix table 4-29). This represented some 23% of the $156.0 billion of total federal budget authority for R&D that year. The vast majority of basic research reflects the budgets of agencies with nondefense objectives, such as general science (notably NSF), health (NIH), and space research and technology (NASA).

Over the past several years, budget authority levels for basic research have been mostly flat, after adjusting for inflation, excepting the 2009 ARRA boost. In FY 2002, basic research budget authority was $25.8 billion (constant 2005 dollars); in FY 2008, $26.4 billion; and $33.0 billion in FY 2009.

Federal Budgetary Concepts and Related Terms

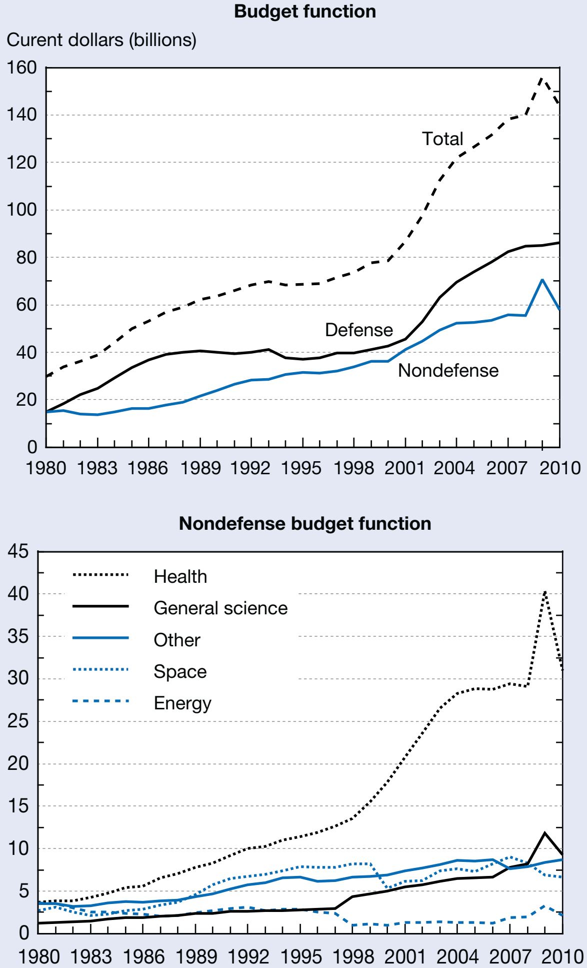
Budget authority. This refers to the funding authority conferred by federal law to incur financial obligations that will result in outlays. The basic forms of budget authority are appropriations, contract authority, and borrowing authority.

Obligations. Federal obligations represent the dollar amounts for orders placed, contracts and grants awarded, services received, and similar transactions during a given period, regardless of when funds were appropriated or payment was required.

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

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

Figure 4-10
Federal budget authority for R&D, by budget function: FY 1980–2010



NOTES: Data for FY 2010 are preliminary. Data for FY 2009 include the additional federal funding for R&D appropriated by the American Recovery and Reinvestment Act of 2009. Other includes all nondefense functions not separately graphed, such as agriculture and transportation.1998 increase in general science and decrease in energy, and 2000 decrease in space were results of reclassification.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Federal R&D Funding by Budget Function (FY 2009–11). See appendix table 4-28.

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Federal Spending on R&D by Agency

Budget authority, discussed above, lays out the themes of the broad federal spending plan. Federal obligations reflect federal dollars as they are spent, that is, the implementation of the plan by federal agencies (see appendix tables 4-30 and 4-31).

In FY 2009, federal obligations for R&D and R&D plant together totaled an estimated $137.0 billion: $133.3 billion for R&D and an additional $3.6 billion for R&D plant (table 4-16). Federal obligations for R&D have, in general, increased annually on a current-dollar basis since the mid-1990s (figure 4-11). Earlier figures are $68.2 billion for R&D in FY 1995 and an additional $2.3 billion for R&D plant, $75.9 billion and $4.5 billion in FY 2000, $118.9 billion and $3.8 billion in FY 2005 (appendix table 4-30). When adjusted for inflation, however, the growth has been slower after FY 2005. NSF's latest statistics indicate that the boost to R&D from the ARRA appropriations translated to an additional $10.1 billion of federal R&D obligations in FY 2009—$8.7 billion for R&D, another $1.4 billion for R&D plant, with the main recipients the Department of Health and Human Services (HHS), NSF, and DOE (table 4-16).

(The figures for federal funding of U.S. R&D cited in table 4-1 earlier in this chapter are somewhat lower. These earlier figures are based on performers' reports of their R&D expenditures from federal funds. This difference between performer and source of funding reports of the level of R&D expenditures has been present in the U.S. data for more than 15 years and reflects various technical issues. See sidebar, "Tracking R&D: The Gap between Performer- and Source-Reported Expenditures.")

Fifteen federal departments and a dozen other agencies engage in and/or fund R&D in the U.S.[21] Seven departments/agencies that reported spending on R&D in excess of $1 billion annually accounted for 97% of the total (table 4-16). Another eight of the departments/agencies reported spending above $100 million annually.

Department of Defense

In FY 2009, DOD obligated a total of $68.2 billion for R&D and R&D plant (table 4-16)—which represented half (50%) of all federal spending on R&D and R&D plant that year. Nearly the entire DOD total was R&D spending ($68.1 billion) with the remainder spent on R&D plant.

Twenty-seven percent ($18.7 billion) of the total was spending by the department's intramural labs, related agency R&D program activities, and FFRDCs (table 4-16). Extramural performers—private businesses, universities/colleges, state/local governments, other nonprofit organizations, and foreign performers—accounted for 73% ($49.5 billion) of the obligations, with the bulk going to business firms ($46.3 billion).

Considering just the R&D component, relatively small amounts were spent on basic research ($1.7 billion, 3%) and applied research ($5.1 billion, 7%) in FY 2009 (table 4-17). The vast majority of obligations, $61.3 billion (90%), went to development. Furthermore, the bulk of this DOD development ($54.9 billion) was allocated for "major systems development," which includes the main activities in developing, testing, and evaluating combat systems (figure 4-12). The remaining DOD development ($6.4 billion) was allocated for "advanced technology development," which is more similar to other agencies' development obligations.

Department of Health and Human Services

HHS is the main federal source of spending for health-related R&D. In FY 2009, the department obligated an estimated $35.7 billion for R&D and R&D plant, or 26% of the

Table 4-16
Federal obligations for R&D and R&D plant, by agency and performer: FY 2009
(Millions of dollars)

Agency	Total	R&D	R&D plant	ARRA funds R&D	ARRA funds R&D plant	Total by performers: Intramural and FFRDCs	Percent of total	Extramural performers	Percent of total
All agencies	136,996.5	133,349.0	3,647.5	8,714.1	1,367.8	42,954.7	31.4	94,041.8	68.6
Department of Defense	68,230.2	68,113.0	117.2	184.2	0.0	18,695.1	27.4	49,535.1	72.6
Department of Health and Human Services	35,735.9	35,584.0	151.9	4,889.0	49.7	7,546.7	21.1	28,189.2	78.9
Department of Energy	11,562.2	9,889.9	1,672.3	1,393.4	813.2	8,853.3	76.6	2,709.0	23.4
National Science Foundation	6,924.8	6,095.2	829.6	1,807.6	388.5	303.8	4.4	6,618.2	95.6
National Aeronautics and Space Administration	5,937.1	5,937.0	0.1	314.7	0.0	1,958.1	33.0	3,979.0	67.0
Department of Agriculture	2,347.2	2,269.7	77.5	0.4	11.0	1,576.9	67.2	770.3	32.8
Department of Commerce	1,533.3	1,146.9	386.4	46.0	98.7	1,181.4	77.0	351.9	23.0
Department of Homeland Security	983.6	672.5	311.1	0.0	0.0	596.5	60.6	387.0	39.3
Department of Transportation	846.3	826.0	20.3	0.0	0.0	280.5	33.2	565.7	66.8
Department of the Interior	738.8	732.4	6.4	59.6	0.0	602.5	81.6	136.3	18.4
Environmental Protection Agency	552.8	552.8	0.0	0.0	0.0	414.1	74.9	138.8	25.1
Department of Veterans Affairs	510.0	510.0	0.0	0.0	0.0	510.0	100.0	0.0	0.0
Department of Education	322.4	322.4	0.0	0.0	0.0	15.6	4.8	306.7	95.2
Smithsonian Institution	226.7	152.0	74.7	0.0	6.7	226.7	100.0	0.0	0.0
Agency for International Development	160.1	160.1	0.0	0.0	0.0	10.6	6.6	149.5	93.4
All other agencies	385.1	385.1	0.0	19.2	0.0	183.0	47.5	204.9	53.2

FFRDC = federally funded research and development center

NOTES: Table lists all agencies with R&D obligations greater than $100 million in FY 2009. Data include obligations from the additional federal R&D funding appropriated by the American Recovery and Reinvestment Act of 2009. R&D is basic research, applied research, and development; does not include R&D plant. Intramural activities include actual intramural R&D performance and costs associated with planning and administration of both intramural and extramural programs by federal personnel. Extramural performers includes federally funded R&D performed in the United States and U.S. territories by industry, universities and colleges, other nonprofit institutions, state and local governments, and foreign organizations. All other agencies includes Department of Housing and Urban Development, Department of Justice, Department of Labor, Department of State, Department of the Treasury, Appalachian Regional Commission, Federal Communications Commission, Federal Trade Commission, Library of Congress, National Archives and Records Commission, Nuclear Regulatory Commission, and Social Security Administration.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Federal Funds for Research and Development (FY 2009–11). See appendix table 4-31.

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total of federal obligations that year. Nearly all of this was for R&D ($35.6 billion). Furthermore, much of the total, $34.6 billion, represented the R&D activities of the NIH. Obligations from the ARRA-appropriated funds totaled $4.9 billion for HHS in FY 2009, the largest by far of all the federal agencies (table 4-16). Again, nearly all of this was NIH R&D.

For the department as a whole, R&D and R&D plant obligations for agency intramural activities and FFRDCs accounted for 21% ($7.5 billion) of the total. Extramural performers accounted for 79% ($28.2 billion). Universities and colleges ($20.5 billion) and other nonprofit organizations ($5.3 billion) conducted the most sizable of these extramural activities (appendix table 4-31).

Nearly all of HHS R&D funding is allocated to research—almost 53% for basic research and 47% for applied research (table 4-17).

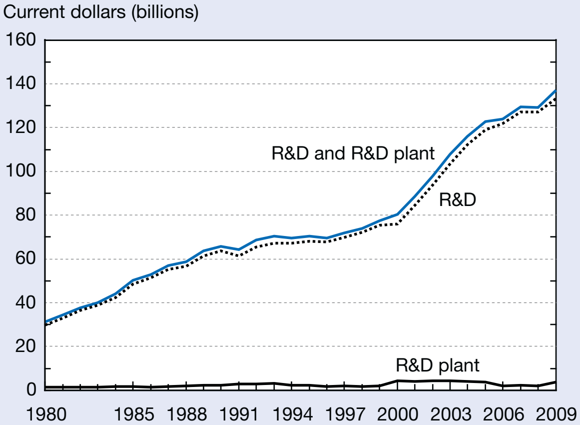
Department of Energy

DOE obligated an estimated $11.6 billion for R&D and R&D plant in FY 2009, about 8% of the federal obligations total that year. Of this amount, $9.9 billion was for R&D and $1.7 billion for R&D plant. Obligations this year stemming from the ARRA appropriation totaled $2.2 billion, the third largest among the agencies (behind HHS and NSF).

The department's intramural laboratories and FFRDCs accounted for 77% of the total obligations. Many of DOE's research activities require specialized equipment and facilities available only at its intramural laboratories and FFRDCs. Accordingly, DOE invests more resources in its intramural laboratories and FFRDCs than other federal agencies. The 23% of obligations to extramural performers were chiefly to businesses and universities/colleges.

For the $9.9 billion obligated to R&D, basic research accounted for 41%, applied research 32%, and development 27%. DOE R&D activities are rather evenly distributed among defense (much of it funded by the department's

Figure 4-11
Federal obligations for R&D and R&D plant: FY 1980–2009



NOTES: Data for FY 2009 include obligations from the additional federal R&D funding appropriated by the American Recovery and Reinvestment Act of 2009.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Federal Funds for Research and Development (FY 2009–11). See appendix table 4-30.

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National Nuclear Security Administration), energy, and general science (much of which is funded by the department's Office of Science).

National Science Foundation

NSF obligated $6.9 billion for R&D and R&D plant in FY 2009, or 5% of the federal total. Extramural performers, chiefly universities and colleges ($6.6 billion), represented 96% of this total. ARRA-related obligations were $2.2 billion (R&D and R&D plant), the second largest among the agencies. Basic research accounted for about 92% of the R&D component. NSF is the federal government's primary source of funding for academic basic science and engineering research and the second-largest federal source (after HHS) of R&D funds for universities and colleges.

National Aeronautics and Space Administration

NASA obligated an estimated $5.9 billion to R&D in FY 2009, 4% of the federal total. Sixty-seven percent of these obligations were for extramural R&D, given chiefly to industry performers. Agency intramural R&D and that by FFRDCs represented 33% of the NASA obligations total. By character of work, 71% of the NASA R&D obligations funded development activities; 17%, basic research; and 12%, applied research.

Department of Agriculture

USDA obligated an estimated $2.3 billion for R&D in FY 2009, with the main focus on life sciences. The agency is also one of the largest research funders in the social sciences, particularly agricultural economics. Of USDA's total obligations for FY 2009, about 67% ($1.6 billion) funded R&D by agency intramural performers, chiefly the Agricultural Research Service. Basic research accounts for about 41%; applied research, 51%; and development, 8%.

Department of Commerce

DOC obligated an estimated $1.5 billion for R&D in FY 2009, most of which represented the R&D and R&D plant spending of the National Oceanic and Atmospheric Administration (NOAA) and the National Institute of Standards and Technology (NIST). Seventy-seven percent of this total was for agency intramural R&D; 23% went to extramural performers, primarily businesses and universities/colleges. For the R&D component, 12% was basic research; 72%, applied research; and 16%, development.

Department of Homeland Security

DHS obligated an estimated $1.0 billion for R&D and R&D plant in FY 2009, nearly all of which was for activities by the department's Science and Technology Directorate. Sixty-one percent of this obligations total was for agency intramural and FFRDC activities. Just over 39% was conducted by extramural performers—mainly businesses, but also universities/colleges and other nonprofit organizations. Of the obligations for R&D, 15% was basic research; 37%, applied research; and 48%, development.

Other Agencies

The eight other departments/agencies obligating more than $100 million annually for R&D in FY 2009 were the Departments of Education, Interior, Justice, Transportation, and Veterans Affairs; and the Environmental Protection Agency, Agency for International Development, and Smithsonian Institution (tables 4-16 and 4-17). These agencies varied with respect to the character of the research and the roles of intramural, FFRDC, and extramural performers.

Federal Spending on Research by Field

Federal agencies' research covers the whole range of science and engineering fields. These fields vary in their funding levels and have different growth paths (see appendix tables 4-34 and 4-35).

Funding for basic and applied research combined accounted for $63.7 billion (about 48%) of the $133.3 billion total of federal obligations for R&D in FY 2009 (table 4-17). Of this amount, $33.3 billion (52% of $63.7 billion) supported research in the life sciences (figure 4-13; appendix table 4-34). The fields with the next-largest amounts were engineering ($10.3 billion, 16%) and the physical sciences ($5.8 billion, 9%), followed by environmental sciences ($3.8 billion, 6%), and mathematics and computer sciences ($3.6 billion, 6%). The balance of federal obligations for research in FY 2009 supported psychology, the social sciences, and all other sciences ($7.0 billion overall, or 11% of the total for research).

HHS accounted for the largest share (56%) of federal obligations for research in FY 2009 (appendix table 4-34). Most

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

In the United States—and in some other OECD countries—the figures for total government support of R&D reported by government agencies differ from those reported by the performers of R&D. In keeping with international guidance and standards, most countries provide totals and time series of national R&D expenditures based primarily on data reported by R&D performers (OECD 2002). Differences in the data provided by funders and performers can arise for numerous reasons, such as the different calendars for reporting government obligations (fiscal years) and performance expenditures (calendar years). In the U.S., there has been a sizable gap between performer and funder data for federal R&D over the past decade or more.

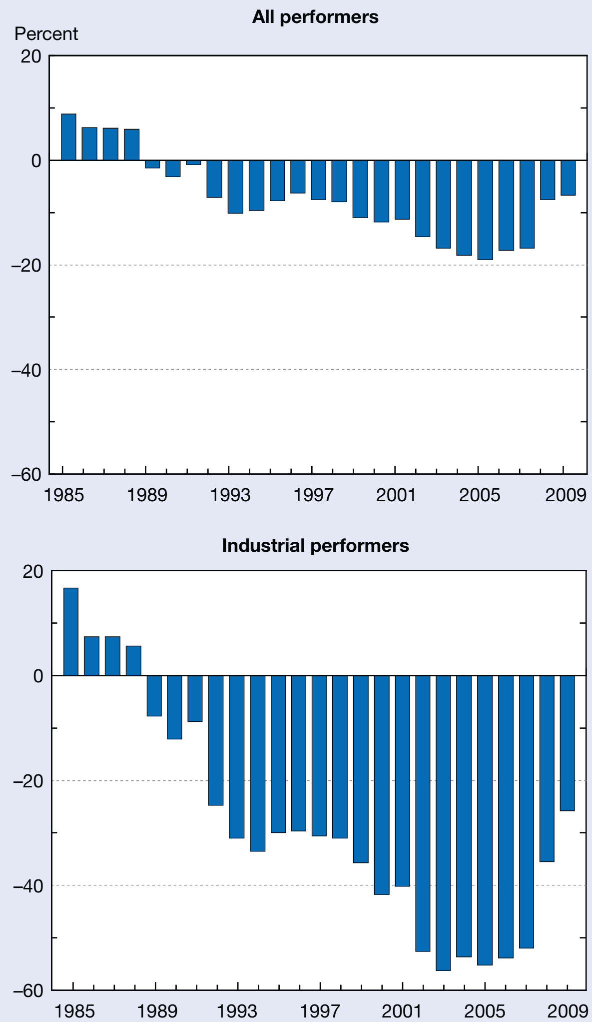
In the mid-1980s, performer-reported federal R&D in the United States exceeded federal reports of funding by $3 billion to $4 billion annually (5%–10% of the government total). This pattern reversed itself, however at the end of the decade: in 1989, the government-reported R&D total exceeded performer reports by almost $1 billion. The government-reported excess increased noticeably from then through to 2007, when federal agencies reported obligating $127 billion in total R&D to all R&D performers ($55 billion to the business sector) compared with $106 billion in federal funding reported by the performers of R&D ($27 billion by businesses). In other words, the business-reported total was some 50% smaller than the federally reported R&D support to industry in FY 2007 (see figure 4-A and appendix table 4-32). These differences in federal R&D totals were seen primarily in DOD funding of development activities by industry. The figures for 2008 and 2009 suggest a narrowing of the federal agency reporting excess, but are primarily the result of a manual imputation procedure for business R&D performers in these years.

Several investigations into the possible causes for the data gap have produced insights but no conclusive explanation. According to a General Accounting Office investigation (GAO 2001):

> Because the gap is the result of comparing two dissimilar types of financial data [federal obligations and performer expenditures], it does not necessarily reflect poor quality data, nor does it reflect whether performers are receiving or spending all the federal R&D funds obligated to them. Thus, even if the data collection and reporting issues were addressed, a gap would still exist.

Echoing this assessment, the National Research Council (2005) noted that comparing federal outlays for R&D (as opposed to obligations) to performer expenditures results in a smaller discrepancy. (In FY 2009, federal agencies reported total R&D outlays of $127 billion, compared to a total R&D figure of $124 billion reported by all performers that year. In FY 2007, federal agencies reported R&D outlays of $109 billion, compared to the performer-reported total of $106 billion.)

Figure 4-A
Differences in U.S. performer-reported and agency-reported federal R&D: 1985–2009



NOTE: Difference is defined as percent of federally reported R&D, with a positive difference indicating that performer-reported R&D exceeds agency-reported R&D.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics (NSF/NCSES), National Patterns of R&D Resources (annual series); and NSF/NCSES, Federal Funds for Research and Development (FY 2009–11). See appendix table 4-32.

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Table 4-17
Federal obligations for R&D, by agency and character of work: FY 2009
(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	133,349.0	32,877.9	30,830.9	69,640.2	24.7	23.1	52.2
Department of Defense	68,113.0	1,735.0	5,071.4	61,306.5	2.5	7.4	90.0
Department of Health and Human Services	35,584.0	18,772.2	16,717.7	94.1	52.8	47.0	0.3
Department of Energy	9,889.9	4,061.0	3,127.2	2,701.8	41.1	31.6	27.3
National Science Foundation	6,095.2	5,623.9	471.3	0.0	92.3	7.7	0.0
National Aeronautics and Space Administration	5,937.0	1,021.6	681.8	4,233.5	17.2	11.5	71.3
Department of Agriculture	2,269.7	924.0	1,154.0	191.7	40.7	50.8	8.4
Department of Commerce	1,146.9	138.3	820.8	187.8	12.1	71.6	16.4
Department of Transportation	826.0	0.0	586.7	239.2	0.0	71.0	29.0
Department of the Interior	732.4	47.1	610.5	74.8	6.4	83.4	10.2
Department of Homeland Security	672.5	101.3	245.9	325.3	15.1	36.6	48.4
Environmental Protection Agency	552.8	83.7	384.4	84.7	15.1	69.5	15.3
Department of Veterans Affairs	510.0	203.3	274.0	32.7	39.9	53.7	6.4
Department of Education	322.4	4.2	198.4	119.7	1.3	61.5	37.1
Agency for International Development	160.1	0.6	159.6	0.0	0.4	99.7	0.0
Smithsonian Institution	152.0	152.0	0.0	0.0	100.0	0.0	0.0
All other agencies	385.1	9.7	327.2	48.4	2.5	85.0	12.6

NOTES: Table lists all agencies with R&D obligations greater than $100 million in FY 2009. Data include obligations from the additional federal R&D funding appropriated by the American Recovery and Reinvestment Act of 2009 (ARRA). ARRA funds obligated for R&D totaled $8,714.1 million in FY 2009: $5,115.9 million for basic research, $2,611.3 million for applied research, and $987 million for development. All other agencies includes Department of Housing and Urban Development, Department of Justice, Department of Labor, Department of State, Department of the Treasury, Appalachian Regional Commission, Federal Communications Commission, Federal Trade Commission, Library of Congress, National Archives and Records Commission, Nuclear Regulatory Commission, and Social Security Administration.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Federal Funds for Research and Development (FY 2009–11). See appendix table 4-31.

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of this amount funded research in medical and related life sciences, primarily through NIH. The five next-largest federal agencies for research funding that year were DOE (11%), DOD (11%), NSF (10%), USDA (3%), and NASA (3%).

DOE's $7.2 billion in research obligations provided funding for research in the physical sciences ($2.6 billion) and engineering ($2.5 billion), along with mathematics and computer sciences ($1.0 billion). DOD's $6.8 billion of research funding emphasized engineering ($3.5 billion), but also included mathematics and computer sciences ($0.9 billion), physical sciences ($0.8 billion) and life sciences ($0.9 billion). NSF—not a mission agency in the traditional sense—is charged with "promoting the health of science." Consequently, it had a relatively diverse $6.1 billion research portfolio that allocated about $1.0 billion to $1.3 billion in each of the following fields: environmental, life, mathematics/computer, and physical sciences; and engineering. Lesser amounts were allocated to psychology and the social and other sciences. USDA's $2.1 billion was directed primarily at the life (agricultural) sciences ($1.7 billion). NASA's $1.7 billion for research emphasized engineering ($0.6 billion), followed by the physical sciences ($0.5 billion) and environmental sciences ($0.4 billion).

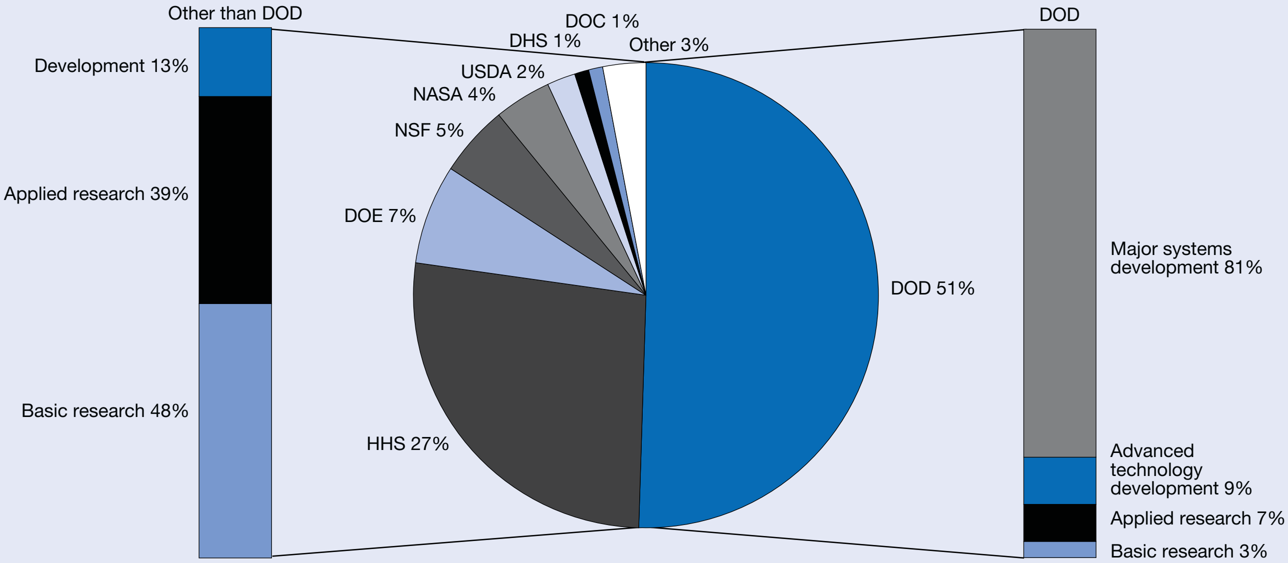
Growth in federal research obligations has slowed since 2004. Federal obligations for research in all S&E fields expanded on average at 3.6% annually (in current dollars) over the last 5 years (FY 2004–09), a much higher 6.6% over the last 10 years, and 5.8% over the last 20 years (appendix table 4-35). Adjusted for inflation, the 2004–09 average growth turns into an average annual increase of only 0.9%, which contrasts with a 10-year real growth of 4.1% and 3.3% over the last 20 years.

Since the late 1990s, growth in federal research obligations in the life sciences and psychology has exceeded the S&E average, leading to growing shares for these fields. Growth for the mathematics and computer sciences was just below the S&E average. The shares of research funding going to physical sciences, behavioral and other social sciences, and engineering, declined. Environmental sciences grew slower than both total research and inflation.

Federal R&E Tax Credits

The federal government makes available tax credits for companies that expand their R&D activities, as a way of counteracting potential business underinvestment in R&D.

Figure 4-12
Federal obligations for R&D, by agency and character of work: FY 2009



DOC = Department of Commerce; DOD = Department of Defense; DOE = Department of Energy; DHS = Department of Homeland Security; HHS = Department of Health and Human Services; NASA = National Aeronautics and Space Administration; NSF = National Science Foundation; USDA = Department of Agriculture

NOTES: Detail may not add to total because of rounding. Includes obligations from the additional federal R&D funding appropriated by the American Recovery and Reinvestment Act of 2009.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Federal Funds for Research and Development (FY 2009–11). See appendix table 4-31.

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Governments stimulate the conduct of R&D through tax incentives—allowances, exemptions, deductions, or tax credits—each of which can be designed with differing criteria for eligibility, allowable expenses, and baselines (OECD 2003). In the United States, federal tax incentives for qualified business R&D expenditures include a deduction under Internal Revenue Code (IRC) Section 174 (C.F.R. Title 26) and a research and experimentation (R&E) tax credit under Section 41.[22] The latter was established in 1981 by the Economic Recovery Tax Act (Public Law 97-34). It was last renewed by the Tax Relief, Unemployment Insurance Reauthorization, and Job Creation Act of 2010, through 31 December 2011.[23] The Obama administration has proposed making this credit permanent (U.S Department of Treasury 2011).

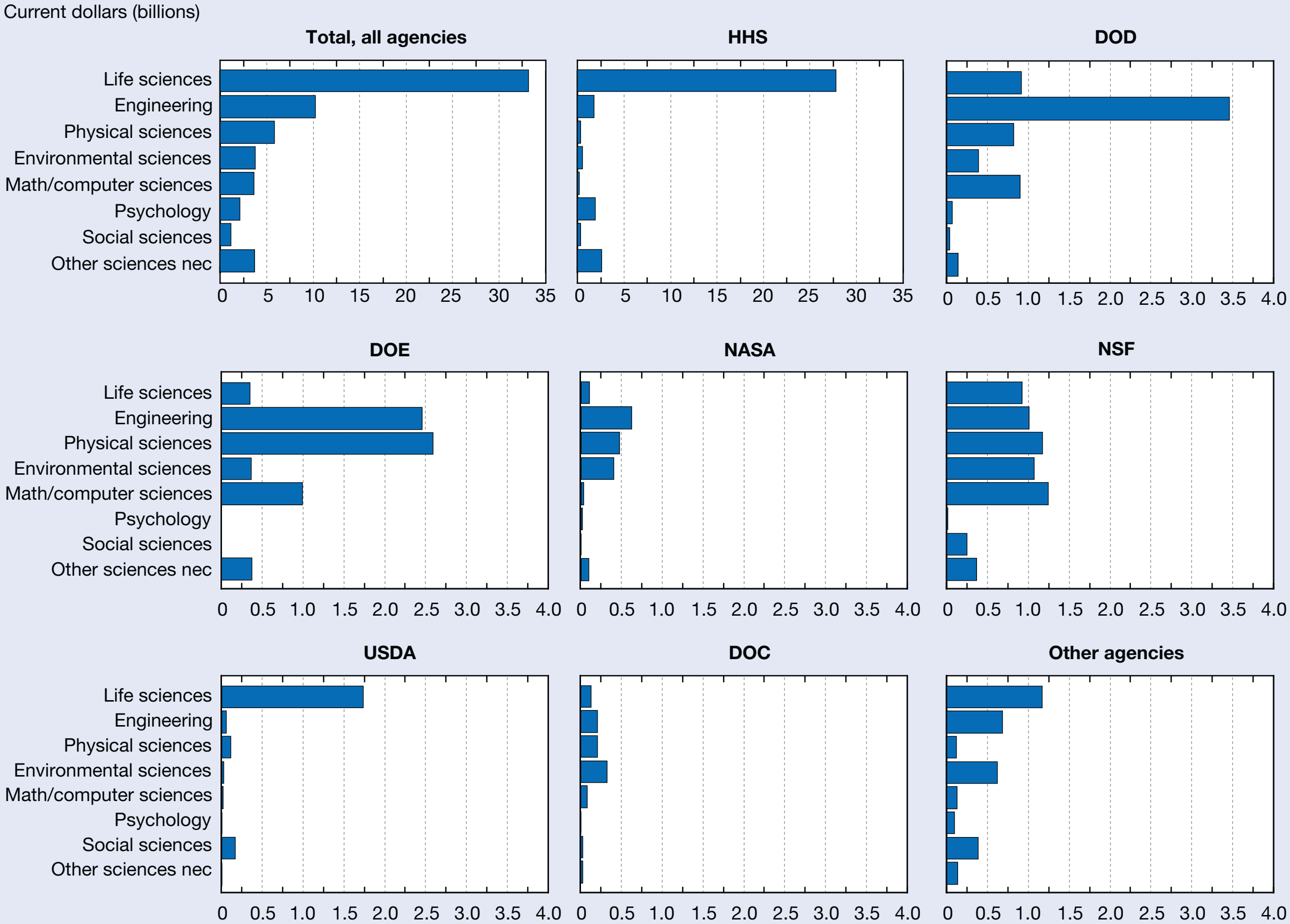
Along with the United States, over 20 OECD countries offer fiscal incentives for business R&D (OECD 2011b). Fiscal incentives for R&D are typically predicated on R&D's role in economic growth along with the recognition that R&D can generate social benefits well beyond those captured by companies investing in such activities (see Hemphill 2009 and references therein).

In the United States there were about $8.3 billion in business R&E tax credit claims both in 2007 and in 2008 (see appendix table 4-36).[24] Five industries accounted for 75% of these claims in 2008: computer and electronic products; chemicals, including pharmaceuticals, and medicines; transportation equipment, including motor vehicles and aerospace; information, including software; and professional, scientific, and technical services, including computer and R&D services.

Since 1998, R&E credit claims have grown at about the same average annual rate as has company-funded domestic R&D, keeping the ratio of R&E credit claims to company-funded domestic R&D in a narrow range (3.3% in 2008).[25] In 2008, more than 12,700 corporate returns claimed at least one component of the R&E tax credit (appendix table 4-37). Corporations with more than $250 million in business receipts accounted for 14% of returns claiming the credit in 2008 and 82% of the dollar value of all claims. In 2001, they had accounted for 9% of returns and 73% of dollar claims.[26]

The federal R&E tax credit encompasses a regular credit and as many as two forms of alternative credit formulas since 1996.[27] Under the regular credit, companies can take a 20% credit for qualified research above a base amount for activities undertaken in the United States (IRC section 41(a)(1)). Thus, the regular credit is characterized as a fixed-base incremental credit. An incremental design is intended to encourage firms to spend more on R&D than they otherwise would by lowering after-tax costs (Guenther forthcoming). Expenses paid or incurred for qualified research include company-funded expenses for wages paid, supplies used in the conduct of qualified research, and certain

Figure 4-13
Federal obligations for research, by agency and major S&E field: FY 2009
Current dollars (billions)



DOC = Department of Commerce; DOD = Department of Defense; DOE = Department of Energy; HHS = Department of Health and Human Services; NASA = National Aeronautics and Space Administration; nec = not elsewhere classified; NSF = National Science Foundation; USDA = Department of Agriculture

NOTES: Scale differs for Total, all agencies and HHS compared to other agencies listed. Includes obligations from the additional federal R&D funding appropriated by the American Recovery and Reinvestment Act of 2009. Research includes basic and applied research.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Federal Funds for Research and Development (FY 2009–11). See appendix table 4-34.

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contract expenses. Further, research "must be undertaken for discovering information that is technological in nature, and its application must be intended for use in developing a new or improved business component."[28] The credit covers U.S.-performed R&D by both domestic and foreign-owned firms and excludes R&D conducted abroad by U.S. companies. Activities generally disallowed for the purposes of the credit include those conducted after the beginning of commercial production and adapting an existing product or process. Research in the social sciences, arts, or humanities and research funded by another entity is also excluded.

Federal Technology Transfer and Other Innovation-Related Programs

This section reviews data on two types of federal programs that support public-private collaboration for technology transfer and innovation.[29] (For academic patents and related knowledge diffusion indicators, see chapter 5; for international business licensing fees and royalties, see chapter 6.) The first type includes federal programs for technology transfer from R&D funded and performed by agencies and laboratories. The second type supports new or small U.S. companies in R&D or technology deployment with R&D funds or technical assistance.

In the late 1970s, concerns about the strength of U.S. industries and their ability to be competitive in the global economy intensified. Issues included the question of whether inventions from federally funded academic research were adequately exploited for the benefit of the national economy and the need to create or strengthen public-private R&D partnerships. Since the 1980s, several U.S. policies have facilitated cross-sector R&D collaboration and technology transfer. One major policy thrust was to enhance formal mechanisms for transferring knowledge arising from federally funded and performed R&D (Crow and Bozeman 1998; NRC 2003). Other policies addressed federally funded academic R&D, the transition of early-stage technologies into the marketplace, and R&D and innovation by small or minority-owned businesses. For an overview of these initiatives, see sidebar, "Major Federal Legislation Related to Technology Transfer and Commercializing R&D."

Federal Technology Transfer

Federal technology transfer refers to the various processes through which inventions and other intellectual assets arising from federal laboratory R&D are conveyed to outside parties for further development and commercial applications. Technology transfer may also involve linking R&D capabilities and the resources of federal laboratories with outside public or private organizations for mutual benefit (FLC 2006).

In response to the Stevenson-Wydler Act of 1980 (as amended) federal agencies with laboratory operations have active efforts to engage in technology transfer as defined above, identify and manage intellectual assets created by their R&D, and participate in collaborative R&D relationships with nonfederal parties (including private businesses, universities, nonprofit organizations) consistent with agency mission goals. Federal labs have also been required to have technology transfer offices (termed an Office of Research and Technology Applications or ORTA) to assist in identifying transfer opportunities and establishing appropriate arrangements for relationships with nonfederal parties (see sidebar "Federal Technology Transfer: Activities and Metrics").

Six agencies continue to account for most of the annual total of federal technology transfer activities: DOD, HHS, DOE, NASA, USDA, and DOC. Statistics for these six agencies in FYs 2004 and 2009, spanning the main activity areas of invention disclosures and patenting, intellectual property licensing, and collaborative relationships for R&D, appear in table 4-18.[30] (Similar statistics for a larger set of agencies, going back over time to FY 2001, appear in appendix table 4-38.)

As is apparent in the distribution of the statistics across the activity types in table 4-18, most agencies engage in all of the transfer activity types to some degree, but there are differences in the emphases. Some agencies are more intensive in patenting and licensing activities (such as HHS, DOE, and NASA); some place greater emphasis on transfer through collaborative R&D relationships (such as USDA and DOC). Some agencies have unique transfer authorities which can confer practical advantages. NASA, for example, can establish collaborative R&D relationships through special authorities it has under the Space Act of 1958; USDA has a number of special options for establishing R&D collaborations other than through CRADAs; DOE's contractor-operated national labs, with their nonfederal staffs, are not constrained by the normal federal limitation on copyright by federal employees and are able to use copyright to protect and transfer computer software. In general, the mix of technology transfer activities pursued by each agency reflects a broad range of considerations such as agency mission priorities, technologies principally targeted for development, intellectual property protection tools and policies, and the types of external parties through which transfer and collaboration are chiefly pursued.

Small Business Innovation-Related Programs

This section focuses on several small business programs. The Small Business Innovation Research (SBIR) program was established by the Small Business Innovation Development Act of 1982[31] to stimulate technological innovation by increasing the participation of small companies in Federal R&D projects, increase private sector commercialization of innovation derived from federal R&D, and foster participation by minority and disadvantaged persons in technological innovation. The Small Business Technology Transfer (STTR) program was created in 1992 to stimulate cooperative R&D and federal technology transfer.[32] SBIR and STTR are both administered by the Small Business Administration (SBA). The last portion of this section covers the Technology Innovation Program (TIP), created by the America COMPETES Act of 2007 and administered by NIST.

The focus on smaller or startup R&D-based companies in these programs is an example of the promotion of innovation-based entrepreneurship via public-private partnerships that enable not only financing but also R&D collaboration and commercialization opportunities (Gilbert et al. 2004; Link and Scott 2010).

According to the SBIR statute, federal agencies with extramural R&D obligations exceeding $100 million must set aside a fixed percentage of such obligations (2.5% since FY 1997) for projects involving small business (those with fewer than 500 employees). In FY 2009, SBIR awards totaled $1.9 billion (SBA 2010). In FY 2008, 11 federal agencies awarded a total of $1.8 billion to about 5,400 SBIR projects (appendix tables 4-39 and 4-40). DOD provides about 50% of total SBIR funds annually, followed by HHS (around 30% since 1999), consistent with their large extramural R&D budgets.

The SBIR program is structured in three phases. Phase I evaluates the scientific and technical merit and feasibility of ideas. Phase II builds on phase I findings, is subject to further scientific and technical review, and requires a commercialization plan. During phase III, the results from phase II R&D are further developed and introduced into private markets or federal procurement using private or non-SBIR

Major Federal Legislation Related to Technology Transfer and Commercializing R&D

Technology Innovation Act of 1980 (Stevenson-Wydler Act) (Public Law 96-480)—established technology transfer as a federal government mission by directing federal labs to facilitate the transfer of federally-owned and originated technology to nonfederal parties.

University and Small Business Patent Procedures Act of 1980 (Bayh-Dole Act) (Public Law 96-517)—permitted small businesses, universities, and nonprofits to obtain titles to inventions developed with federal funds. Also permitted government-owned and government-operated laboratories to grant exclusive patent rights to commercial organizations.

Small Business Innovation Development Act of 1982 (Public Law 97-219)—established the Small Business Innovation Research (SBIR) program, which required federal agencies to set aside funds for small businesses to engage in R&D connected to agency missions.

National Cooperative Research Act of 1984 (Public Law 98-462)—encouraged U.S. firms to collaborate in generic precompetitive research by establishing a rule of reason for evaluating the antitrust implications of research joint ventures.

Patent and Trademark Clarification Act of 1984 (Public Law 98-620)—provided further amendments to the Stevenson-Wydler Act and the Bayh-Dole Act regarding the use of patents and licenses to implement technology transfer.

Federal Technology Transfer Act of 1986 (Public Law 99-502)—enabled federal laboratories to enter cooperative research and development agreements (CRADAs) with outside parties and to negotiate licenses for patented inventions made at the laboratory.

Executive Order 12591, Facilitating Access to Science and Technology (1987)—issued by President Reagan, this executive order sought to ensure that the federal laboratories implemented technology transfer.

Omnibus Trade and Competitiveness Act of 1988 (Public Law 100-418)—in addition to measures on trade and intellectual property protection, the act directed attention to public-private cooperation on R&D, technology transfer, and commercialization. It also established NIST's Manufacturing Extension Partnership (MEP) program.

National Competitiveness Technology Transfer Act of 1989 (Public Law 101-189)—amended the Federal Technology Transfer Act to expand the use of CRADAs to include government-owned, contractor-operated federal laboratories and to increase nondisclosure provisions.

Small Business Innovation Development Act of 1992 (Public Law 102-564)—extended the existing SBIR program, increased the percentage of an agency's budget to be devoted to SBIR, and increased the amounts of the awards. Also established the Small Business Technology Transfer (STTR) program to enhance the opportunities for collaborative R&D efforts between government-owned/contractor-operated federal laboratories and small businesses, universities, and nonprofit partners.

National Cooperative Research and Production Act of 1993 (Public Law 103-42)—relaxed restrictions on cooperative production activities, which enable research joint venture participants to work together in the application of technologies that they jointly acquire.

National Technology Transfer and Advancement Act of 1995 (Public Law 104-113)—amended the Stevenson-Wydler Act to make CRADAs more attractive to federal laboratories, scientists, and private industry.

Technology Transfer Commercialization Act of 2000 (Public Law 106-404)—broadened CRADA licensing authority to make such agreements more attractive to private industry and increase the transfer of federal technology. Established procedures for performance reporting and monitoring by federal agencies on technology transfer activities.

America COMPETES Act of 2007 (America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Sciences [COMPETES] Act) (Public Law 110-69)—authorized increased investment in R&D; strengthened educational opportunities in science, technology, engineering, and mathematics from elementary through graduate school; and further developed the nation's innovation infrastructure. Among other measures, the act established NIST's Technology Innovation Program (TIP) and called for a President's Council on Innovation and Competitiveness.

America COMPETES Reauthorization Act of 2010 (Public Law 111–358)—updates the America COMPETES Act of 2007 and authorizes additional funding to science, technology, and education programs over the succeeding 3 years. The Act's numerous provisions broadly directed strengthening the foundation of the U.S. economy, creating new jobs, and increasing U.S. competitiveness abroad.

Federal Technology Transfer: Activities and Metrics

Federal technology transfer can take a variety of forms (FLC 2006), including the following:

Commercial transfer. Movement of knowledge or technology developed by a federal lab to private organizations in the commercial marketplace.

Scientific dissemination. Publications, conference papers, and working papers, distributed through scientific/technical channels; other forms of data dissemination.

Export of resources. Federal lab personnel made available to outside organizations with R&D needs through collaborative agreements or other service mechanisms.

Import of resources. Outside technology or expertise brought in by a federal lab to enhance the existing internal capabilities.

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

Federal tech transfer metrics cover activities among three main classes of intellectual asset management and transfer:

Invention disclosure and patenting. Counts of invention disclosures filed (typically, an inventing scientist or engineer filing a written notice of the invention with the lab's technology transfer office), patent applications filed with the U.S. Patent and Trademark Office (or abroad), and patents granted.

Licensing. Licensing of intellectual property, such as patents or copyrights, to outside parties.

Collaborative relationships for R&D. Including, but not limited to, Cooperative Research and Development Agreements (CRADAs)

In addition, the statutory annual tech transfer performance reporting by agencies with federal labs, established by the Technology Transfer Commercialization Act of 2000, provides data on downstream outcomes and impacts.

federal funding.[33] Several participating R&D agencies also offer bridge funding to phase III and other commercialization support for startups (NRC 2008:208–216).[34]

Federal agencies with extramural R&D budgets exceeding $1 billion are required to set aside 0.3% of their extramural R&D budget for STTR awards. The program is also structured in three phases and involves R&D performed jointly by small businesses, universities, and nonprofit research organizations. In FY 2008, federal agencies awarded 734 STTR grants valued at $240 million (appendix tables 4-39 and 4-41).

The Technology Innovation Program was set up for "the purpose of assisting U.S. businesses and institutions of higher education or other organizations, such as national laboratories and nonprofit research institutions, to support, promote, and accelerate innovation in the United States through high-risk, high-reward research in areas of critical national need."[35] Two areas of focus in recent funding competitions were advanced manufacturing materials and advanced sensors to support monitoring and assessment of civil infrastructure, such as water pipelines, roads, bridges, and tunnels. From FY 2008 to FY 2010, TIP made 38 competitive awards involving 78 participants including small businesses and universities. Over this period, awards reached $281 million, including $136 million from TIP and $145 million in industry-cost sharing funds (appendix table 4-42).

International R&D Comparisons

Data on R&D expenditures by country and region provide a broad picture of the changing distribution of R&D capabilities and activities around the world. R&D data available from the OECD cover the organization's 34 member countries and 7 nonmembers.[36] The United Nations Educational, Scientific, and Cultural Organization's (UNESCO's) Institute for Statistics provides data on additional countries. The discussion in this section draws on both of these datasets.

International comparisons necessarily involve currency conversions. The analysis in this section follows the international convention of converting foreign currencies into U.S. dollars via purchasing power parity (PPP) exchange rates. (See sidebar, "Comparing International R&D Expenditures.")

Global Patterns of R&D Expenditures

Worldwide R&D expenditures totaled an estimated $1,276 billion (purchasing power parities) in 2009. The corresponding estimate, 5 years earlier in 2004 was $873 billion. Ten years earlier, in 1999, it was $641 billion. By these figures, growth in these global totals has been rapid, averaging nearly 8% annually over the last 5 years and 7% over the last 10 years.

Overall, global R&D performance remains highly concentrated in three geographic regions, North America, Asia, and Europe (figure 4-14). North America (United States, Canada, Mexico) accounted for 34% ($433 billion) of worldwide R&D performance in 2009; the combination of East/Southeast and South Asia (including China, Taiwan, Japan, India, South Korea), 32% ($402 billion); and Europe, including (but not limited to) European Union (EU) countries, 25% ($319 billion). The remainder, approximately 10%, reflects the R&D of countries in the regions of Central and South America, Central Asia, Middle East, Australia/Oceania, and Africa.

Table 4-18

Federal laboratory technology transfer activity indicators, total and selected U.S. agencies: FY 2004 and FY 2009

Technology transfer activity	All federal labs	DOD	HHS	DOE	NASA	USDA	DOC
	FY 2009						
Invention disclosures and patenting							
Inventions disclosed	4,422	831	389	1,439	1,373	153	49
Patent applications	2,080	690	156	919	126	117	19
Patents issued	1,494	404	397	520	114	21	7
Licensing							
All licenses, total active in fiscal year	10,913	432	1,584	5,752	2,497	316	40
Invention licenses	4,226	386	1,304	1,452	504	316	40
Other intellectual property licenses	6,730	46	327	4,300	1,993	0	0
Collaborative relationships for R&D							
CRADAs, total active in fiscal year	7,733	2,870	457	744	1	233	2,386
Traditional CRADAs	4,219	2,247	284	744	1	191	77
Other collaborative R&D relationships	16,319	1	0	0	2,743	9,960	3,608
	FY 2004						
Invention disclosures and patenting							
Inventions disclosed	5,454	1,369	461	1,617	1,612	142	25
Patent applications	1,768	517	216	661	207	81	12
Patents issued	1,391	426	167	520	189	50	12
Licensing							
All licenses, total active in fiscal year	7,567	369	1,424	4,345	861	296	125
Invention licenses	3,804	364	1,173	1,362	338	296	125
Other intellectual property licenses	3,775	5	251	2,983	523	0	0
Collaborative relationships for R&D							
CRADAs, total active in fiscal year	6,015	2,833	220	610	0	205	1,969
Traditional CRADAs	3,546	2,425	119	610	0	185	67
Other collaborative R&D relationships	7,454	0	0	0	3,987	1,166	2,301

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

NOTES: Other federal agencies not listed but included in the All federal labs totals are the Department of Homeland Security, Department of the Interior, Department of Transportation, Department of Veterans Affairs, and Environmental Protection Agency. Invention licenses refers to inventions that are patented or could be patented. Other intellectual property (IP) refers to IP protected through mechanisms other than a patent, e.g., copyright. Total CRADAs refers to all agreements executed under CRADA authority (15 USC 3710a). Traditional CRADAs are collaborative R&D partnerships between a federal lab and one or more nonfederal organizations. Federal agencies have varying authorities for other kinds of collaborative R&D relationships.

SOURCE: National Institute of Standards and Technology, *Federal Laboratory Technology Transfer, Fiscal Year 2009 Summary Report to the President and the Congress*, March 2011, http://www.nist.gov/tpo/publications/upload/Federall-Lab-TT-Report-FY2009.pdf See also appendix table 4-38.

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The geographic concentration is more apparent when looking at specific countries (table 4-19). Three countries account for more than half of global R&D. The United States is by far the largest R&D performer ($402 billion in 2009), accounting for about 31% of the global total, but down from 38% in 1999. China became the second largest performer ($154 billion) in 2009, accounting for about 12% of the global total. Japan moved down to third, at 11% ($138 billion). The largest EU performers spend comparatively less: Germany ($83 billion, 6%), France ($48 billion, 4%), and the United Kingdom ($40 billion, 3%). The most recent figure available for South Korea is 2008, with $44 billion of R&D—in recent years South Korea has typically been among the top seven R&D performing countries, representing 3%–4% of the global total. Taken together, these top seven countries account for about 71% of the global total. Russia, Italy, Canada, India, Brazil, Taiwan, and Spain comprise a next lower rung, with national R&D expenditures ranging from $20 billion to $33 billion.

Besides the generally vigorous pace at which the global total of R&D is now growing, the other major trend has been the rapid expansion of R&D performance in the regions of East/Southeast Asia and South Asia, including countries such as China, India, Japan, Malaysia, Singapore, South Korea, Taiwan, and Thailand. The R&D performed in these two Asian regions represented only 24% of the global R&D total in 1999, but accounted for 32% in 2009, including China (12%) and Japan (11%).

China continues to exhibit the most dramatic R&D growth pattern (figure 4-15). The World Bank revised China's PPP exchange rate in late 2007, significantly lowering the dollar value of its R&D expenditures. Nonetheless, the pace of real growth over the past 10 years (1999–2009) in China's overall R&D remains exceptionally high at about 20% annually.

Comparing International R&D Expenditures

Comparisons of international R&D statistics are hampered by the lack of R&D-specific exchange rates. Two approaches are commonly used to facilitate international R&D comparisons: (1) express national R&D expenditures as a percentage of GDP or (2) convert all expenditures to a single currency. The first method is straightforward but permits only gross comparisons of R&D intensity. The second method permits absolute level-of-effort comparisons and finer-grain analyses but entails choosing an appropriate method of currency conversion. The choice is between market exchange rates (MERs) and purchasing power parities (PPPs), both of which are available for a large number of countries over an extended period.

MERs represent the relative value of currencies for cross-border trade of goods and services but may not accurately reflect the cost of non-traded goods and services. They are also subject to currency speculation, political events, wars or boycotts, and official currency intervention.

PPPs were developed to overcome these shortcomings (Ward 1985). They take into account the cost differences of buying a similar market basket of goods and services covering tradables and nontradables. The PPP basket is assumed to be representative of total GDP across countries. PPPs are the preferred international standard for calculating cross-country R&D comparisons and are used in all official R&D tabulations of the OECD.*

Because MERs tend to understate the domestic purchasing power of developing countries' currencies, PPPs can produce substantially larger R&D estimates than MERs for these countries. For example, China's 2006 R&D expenditures (as reported to the OECD) are $38 billion using MERs but $87 billion using PPPs. (Appendix table 4-2 lists the relative difference between MERs and PPPs for a number of countries.)

However, PPPs for large, developing countries such as India and China are often rough approximations and have other shortcomings. For example, structural differences and income disparities between developing and developed countries may result in PPPs based on markedly different sets of goods and services. In addition, the resulting PPPs may have very different relationships to the cost of R&D in different countries.

R&D performance in developing countries often is concentrated geographically in the most advanced cities and regions in terms of infrastructure and level of educated workforce. The costs of goods and services in these areas can be substantially greater than for the country as a whole.

*Recent research raises some questions about the use of GDP PPPs for deflating R&D expenditures. In analyzing the manufacturing R&D inputs and outputs of six industrialized OECD countries, Dougherty et al. (2007) conclude that "the use of an R&D PPP will yield comparative costs and R&D intensities that vary substantially from the current practice of using GDP PPPs, likely increasing the real R&D performance of the comparison countries relative to the United States." The issue remains unresolved.

The rate of growth in South Korea's R&D has also been relatively high, averaging nearly 10% annually over the 10-year period. Growth in Japan has been slower, at an annual average rate of 4.0%.

By comparison, while the U.S. remains atop the list of the world's R&D performing nations, its pace of growth in R&D performance has averaged 5.0% over the same 1999–2009 period, and its share of global R&D has declined from 38% to 31% over this time. Total R&D by EU nations has been growing (current dollars) over the same 10 years at an average annual rate of 5.8%. The pace of growth during the same period for Germany, France, and the United Kingdom has been somewhat slower, averaging 5.3%, 4.5%, and 4.5%, respectively. The EU countries accounted for 23% total global R&D in 2009, down from 27% in 1999.[37]

Comparison of Country R&D Intensities

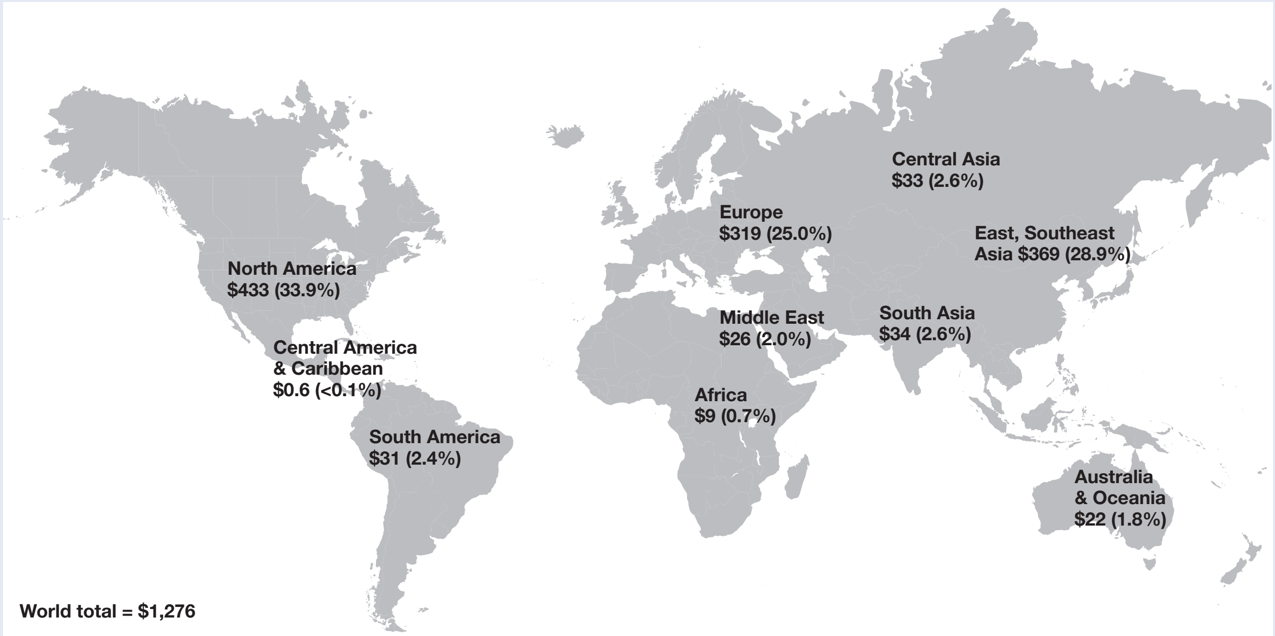
R&D intensity provides another basis for international comparisons of R&D performance. This approach does not require conversion of a country's currency to a standard international benchmark yet still provides a way to adjust for differences in the sizes of national economies. (For additional background on R&D intensity and how it is affected by the economic make-up of a country, see sidebar, "R&D Intensity and the Composition of Gross Domestic Product.")

Total R&D/GDP Ratios

The U.S. R&D/GDP ratio was just under 2.9% in 2009 (table 4-19). At this level, the United States is eighth among the economies tracked by the OECD and UNESCO. Israel continues to have the highest ratio, at 4.3%—although Finland is not far back at 4%. Sweden, Japan, and South Korea all have ratios well above 3%; Switzerland and Taiwan are slightly above the U.S. figure.

The R&D/GDP ratio in the United States has ranged from 1.4% in 1953 to a high of 2.9% in 1964, and has fluctuated in the range of 2.6% to 2.7% in recent years (figure 4-16). Most of the growth over time in the U.S. R&D/GDP ratio can be attributed to increases in nonfederal R&D spending, financed primarily by business. Nonfederally financed R&D increased from about 0.6% of GDP in 1953 to about 2.0% of GDP in 2009. This increase in the nonfederal R&D/GDP ratio reflects the growing role of business R&D in the national R&D system and, more broadly, the growing prominence of R&D-derived products and services in the national and global economies.

Figure 4-14
Global R&D expenditures by region: 2009
U.S. PPP dollars (billions)



PPP = purchasing power parity

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

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, estimates, July 2011. Based on data from Organisation for Economic Co-operation and Development, Main Science and Technology Indicators (2011/1); and United Nations Educational, Scientific, and Cultural Organization (UNESCO) Institute for Statistics, http://stats.uis.unesco.org/unesco/ReportFolders/ReportFolders.aspx, table 25, accessed 13 July 2011.

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Among other top seven R&D-performing countries, total R&D/GDP ratios over the 1999–2009 period show mixed trends (figure 4-16). Compared with 1999 R&D/GDP ratios, the 2009 ratios were substantially higher in Japan, Germany, and South Korea. (However, Japan's rising ratio reflects the confluence of declining GDP and largely flat R&D spending.) Most notably, China's ratio more than doubled over this 10-year period. For the United Kingdom, the 2009 ratio remained about the same, and for France, it slightly increased.

In addition to the United States, countries in Nordic and Western Europe and the most advanced areas of Asia have R&D/GDP ratios above 1.5%. This pattern broadly reflects the global distribution of wealth and level of economic development. Countries with high incomes tend to emphasize the production of high-technology goods and services and are also those that invest heavily in R&D activities. Private sectors in low-income countries often have a low concentration of high-technology industries, resulting in low overall R&D spending and, therefore, low R&D/GDP ratios.

Nondefense R&D and Basic Research

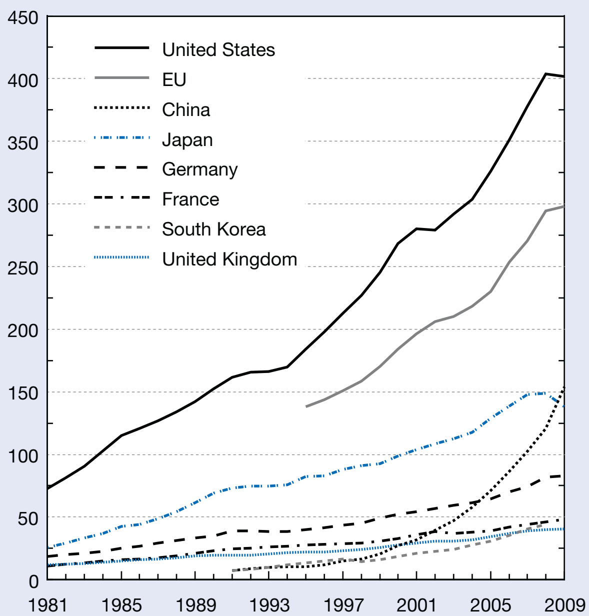
Further perspective is provided by the ratio of nondefense R&D expenditures to GDP. This ratio more directly measures civilian R&D intensity and is useful when comparing nations with substantially different financial commitments to national defense. Table 4-20 provides such figures for the top seven R&D performing nations, for 2009 or most recent data year. The U.S. ratio (2.3% in 2009) ranks ahead of that for the United Kingdom and France but lags behind Japan, South Korea, and Germany. (Data on this metric for China are not currently available.)

Another perspective comes from the extent to which spending on basic research accounts for a country's total R&D/GDP ratio. Estimates of the relative volume of basic research spending can provide a glimpse of the extent to which R&D resources are directed toward advancing the scientific knowledge base.

In 2009, the U.S. basic research/R&D ratio is about 0.6% and accounts for about a fifth of the total R&D/GDP ratio (table 4-20). France's basic research ratio is slightly below the U.S. figure and accounts for just over a quarter of its total ratio. South Korea's basic research ratio is close to the U.S. and French figures. The basic research ratios for Japan, the United Kingdom, and, especially, China are below the U.S. figure.

Figure 4-15
Gross domestic expenditures on R&D by the United States, EU, and selected other countries: 1981–2009

Constant PPP dollars (billions)



EU = European Union; PPP = purchasing power parity

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

SOURCE: Organisation for Economic Co-operation and Development, Main Science and Technology Indicators (2011/1). See appendix table 4-43.

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R&D by Performing Sector and Source of Funds

The business sector is the predominant R&D performer for all seven of the top R&D performing nations (table 4-21).[38] For the U.S., the business sector accounted for 70% of gross expenditures on R&D in 2009. Japan's business sector was the highest, accounting for almost 76% of the country's total R&D. China and South Korea were also well above the U.S. level. France and the United Kingdom were somewhat lower, at, respectively, 62% and 60%.

R&D performance by the government ranges over 9%–19% of total national R&D for the seven countries. Japan (9%) and the United Kingdom (9%) are on the lower end of this range. China (19%) and France (16%) are at the high end. The U.S., South Korea, and Germany lie in between.

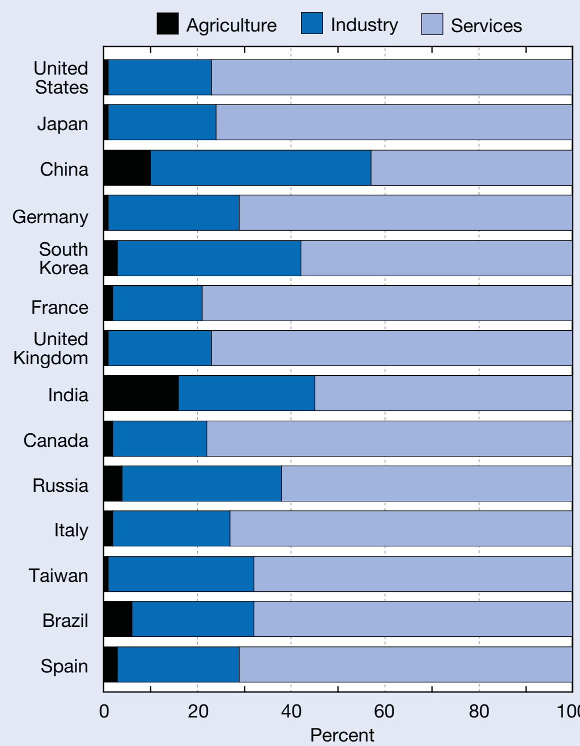
Academic R&D ranges from 8% to 28% of total national R&D performance for these countries. China is the low point, at 8%. The United Kingdom is the highest, at 28%. The U.S. (14%), Japan (13%), and South Korea (11%) have lower shares; Germany (18%) and France (21%), higher shares.

R&D Intensity and the Composition of Gross Domestic Product

The structure of a nation's economy can be a consideration in interpreting and comparing national R&D intensity statistics. That is, the relative prominence of major sectors such as agriculture, manufacturing, and services can directly influence the ratio of overall R&D expenditures to gross domestic product. Businesses and organizations differ widely in their relative need for investment in the latest science and technology. So, countries whose overall GDP depends more heavily on advanced technology industries will typically exhibit higher R&D/GDP ratios than other countries.

Agriculture is a comparatively small component (6% or less) for all but 2 of the top 14 R&D performing countries (figure 4-B). The exceptions are India, where agriculture currently accounts for about 16% of its GDP, and China, where it is 10%. Industrial production (manufacturing) is 20%–30% of GDP for all but three of the countries. China is a much higher 47%; South Korea is 39% and Russia 34%. Services are 60%–70% of national GDP for all but 2 of the 14 countries. China is substantially less services-dependent, at 44% of GDP, and India is somewhat less so, at 55%.

Figure 4-B
Composition of gross domestic product, for selected countries/economies, by sector: 2010



NOTES: Data are estimates. Latest data for South Korea are 2008. Fourteen largest R&D performing countries (see table 4-20).

SOURCE: Central Intelligence Agency, *The World Factbook*, https://www.cia.gov/library/publications/the-world-factbook/index.html, accessed 16 March 2011.

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Table 4-19
International comparisons of gross domestic expenditures on R&D and R&D share of gross domestic product, by region and selected country/economy: 2009 or most recent year

Region/country/economy	GERD (PPP $millions)	GERD/GDP (%)
North America		
United States (2009)[a]	401,576.5	2.88
Canada (2009)	24,551.3	1.92
Mexico (2007)	5,719.6	0.37
South America		
Brazil (2008)	21,649.4	1.08
Argentina (2007)	2,678.8	0.51
Chile (2004)	1,227.7	0.68
Europe		
Germany (2009)	82,730.7	2.78
France (2009)	47,953.5	2.21
United Kingdom (2009)	40,279.5	1.85
Italy (2009)	24,752.6	1.27
Spain (2009)	20,496.4	1.38
Sweden (2009)	12,494.9	3.62
Netherlands (2009)	12,273.8	1.82
Switzerland (2008)	10,512.7	3.00
Austria (2009)	8,931.3	2.75
Belgium (2009)	7,684.9	1.96
Finland (2009)	7,457.8	3.96
Denmark (2009)	6,283.8	3.02
Norway (2009)	4,734.1	1.76
Poland (2009)	4,874.9	0.68
Portugal (2009)	4,411.0	1.66
Czech Republic (2009)	4,094.8	1.53
Ireland (2009)	3,164.6	1.79
Ukraine (2009)	2,485.7	0.86
Hungary (2009)	2,333.8	1.15
Romania (2009)	1,471.5	0.47
Greece (2007)	1,867.9	0.59
Belarus (2009)	813.3	0.65
Slovenia (2009)	1,043.6	1.86
Croatia (2009)	743.1	0.84
Luxembourg (2009)	708.5	1.68
Slovak Republic (2009)	595.5	0.48
Middle East		
Israel (2009)	8,810.1	4.28
Turkey (2009)	8,681.2	0.85
Iran (2008)	6,465.2	0.79
Africa		
South Africa (2008)	4,689.3	0.93
Egypt (2009)	997.3	0.21
Morocco (2006)	765.1	0.64
Tunisia (2009)	1,048.5	1.21
Central Asia		
Russian Federation (2009)	33,368.1	1.24
South Asia		
India (2007)	24,439.4	0.76
Pakistan (2009)	2,055.2	0.46
East, Southeast Asia		
Japan (2009)	137,908.6	3.33
China (2009)	154,147.4	1.70
South Korea (2008)	43,906.4	3.36
Taiwan (2009)	21,571.8	2.93
Singapore (2009)	5,626.5	2.35
Malaysia (2006)	2,090.9	0.64
Thailand (2007)	1,120.8	0.21
Australia, Oceania		
Australia (2008)	18,755.0	2.21
New Zealand (2007)	1,422.5	1.17
Selected country groups		
EU (2009)	297,889.6	1.90
OECD (2008)	965,629.1	2.33
G-20 countries (2009)	1,181,263.7	2.01

EU = European Union; GDP = gross domestic product; GERD = gross expenditures (domestic) on R&D; OECD = Organisation for Economic Co-operation and Development; PPP = purchasing power parity

[a] Figures for the United States in this table may differ slightly from those cited earlier in the chapter. Data here reflect international standards for calculating GERD, which vary slightly from NSF protocol for tallying U.S. total R&D.

NOTES: Year of data listed in parentheses. Foreign currencies converted to dollars through purchasing power parities. Countries with annual GERD of $500 million or more. Countries are grouped according to the regions described by the *The CIA World Factbook,* www.cia.gov/library/publications/the-world-factbook/index.html. No countries in the Central America/Caribbean region had annual GERD of $500 million or more. Data for Israel are civilian R&D only. See sources below for GERD statistics on additional countries.

SOURCES: OECD, Main Science and Technology Indicators (2011/1); United Nations Educational, Scientific, and Cultural Organization (UNESCO) Institute for Statistics, http://stats.uis.unesco.org/unesco/ReportFolders/ReportFolders.aspx, table 25, accessed 13 July 2011.

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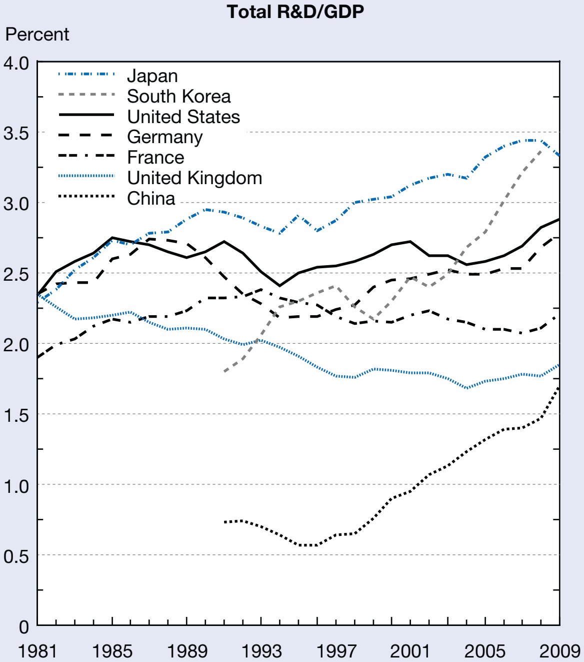
With regard to the funding of R&D, the business sector is again the predominant source for all seven of the top R&D performing nations (table 4-22). In 2009, funding for about 75% of Japan's total national R&D came from the business sector. The corresponding figures for South Korea, China, and Germany are also high, in the 67%–73% range. R&D funding from business is lower, but still predominant, in the U.S., at 60%. The corresponding figures for France (51%) and the United Kingdom (45%) are notably lower.

Government is the second major source of R&D funding for these seven countries. France is the highest, at 39%. The lowest is Japan at 18%. The United Kingdom (33%),

Figure 4-16
Gross expenditures on R&D as share of gross domestic product, for selected countries: 1981–2009



GDP = gross domestic product

NOTES: Top seven R&D performing countries. Data not available for all countries for all years. Figures for the United States reflect international standards for calculating gross expenditures on R&D, which differ slightly from the NSF protocol for tallying U.S. total R&D. Data for Japan, for 1996 onward, may not be consistent with earlier data due to changes in methodology.

SOURCE: Organisation for Economic Co-operation and Development, Main Science and Technology Indicators (2011/1). See appendix table 4-43.

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Germany (28%), and United States (31%) are on the higher side. South Korea (25%) and China (23%) are in between.

Funding from abroad refers to funding from businesses, universities, governments, and other organizations located outside of the country. Table 4-22 shows this funding category for selected OECD countries. For the U.S., data on funding from abroad is available only for the business sector.

Government R&D Priorities

The mix of government funding for R&D across differing objectives (e.g., defense, health, space, general research) provides insights into government R&D priorities. The OECD compiles such statistics annually on its member countries and selected others: government budget appropriations or outlays for R&D (GBAORD). GBAORD indicators for the United States and other top R&D performing countries appear in table 4-23, broken down by a number of major socioeconomic objectives.

Defense is an objective for government funding of R&D for all the top R&D-performing countries, but the share varies widely (table 4-23). Defense accounted for 52% of U.S. federal R&D support in 2009, but was markedly lower elsewhere: a smaller but still sizable 28% in France and 18% in the United Kingdom, 17% in South Korea, and below 6% in both Germany and Japan.

Defense has remained the focus of more than 50% of the federal R&D budget in the United States for much of the past 25 years. It was 63% in 1990 as the long Cold War period drew to a close, but dropped in subsequent years. The defense share of government R&D funding for the other countries over the past 25 years has generally declined or remained at a stable, low level.

The health and environment objective now accounts for some 56% of nondefense federal R&D budget support in the United States and 29% in the United Kingdom. For both countries, the share has expanded dramatically over the share prevailing several decades ago. The health and environment share is currently 19% in South Korea, 15% in France, and 10% or less in Germany and Japan. The funding under this objective goes primarily into the health arena in the United States and the United Kingdom (appendix table 4-45). In the other countries, it is more balanced between health and the environment.

The economic development objective encompasses agriculture, fisheries and forestry, industry, infrastructure, and energy. The share of nondefense government R&D support allocated to economic development has generally declined over the past 25 years across the OECD countries. In the United States, it was 36% of all nondefense federal support for R&D in 1981, dropping to 13% in 2009.[39] In the United Kingdom, it was 39% in 1981, declining to 9% in 2009. Despite a decline, support for this objective remains substantial in some countries: 23% in Germany and 24% in France (both with particular attention to industrial production and technology) and 31% in Japan (notably in energy and industrial production and technology). South Korea currently has by far the largest share for this objective, 52%, with a particularly strong emphasis in recent years on industrial production and technology.

The civil space objective now accounts for 11% of nondefense federal R&D funding in the United States. The share has been above or around 20% in the United States for much of the past 25 years. The share in France is currently about 13%, and has been around that level for almost 20 years. The share has been well below 10% for the rest of the top R&D countries.

Both the non-oriented research and general university funds (GUF) objectives reflect government funding for R&D by academic, government, and other performers that is directed chiefly at the general advancement of knowledge in the natural sciences, engineering, social sciences, humanities, and related fields. For some of the countries, the sum of these two objectives currently represents by far the largest part of nondefense GBAORD: Germany (58%), Japan (54%), the United Kingdom (54%), and France (45%). The corresponding 2009 shares for the United States (18%) and South Korea (23%) are substantially smaller. Nevertheless, cross-national comparisons of these particular indicators can be difficult, since some countries (notably the U.S.) do not use the GUF mechanism to

Table 4-20
Expenditures on R&D as share of gross domestic product for all R&D, nondefense R&D, and basic research, by selected country/economy: 2009 or most recent year

Country/economy	All R&D/GDP	Nondefense R&D/GDP	Fraction of all (%)	Basic research R&D/GDP	Fraction of all (%)
United States (2009)[a]	2.88	2.3	81	0.55	19
China (2009)	1.70	NA	NA	0.08	5
Japan (2009)	3.33	3.3	99	0.42	13
Germany (2008)	2.68	2.6	97	NA	NA
France (2008)	2.11	1.9	90	0.54	26
South Korea (2008)	3.36	3.2	95	0.54	16
United Kingdom (2009)	1.85	1.7	92	0.21	11
Russian Federation (2009)	1.24	NA	NA	0.25	20
India (2007)	0.76	NA	NA	NA	NA
Italy (2009)	1.27	1.3	102	0.33	26
Canada (2009)	1.92	NA	NA	NA	NA
Brazil (2008)	1.08	NA	NA	NA	NA
Taiwan (2009)	2.93	2.9	99	0.30	10
Spain (2008)	1.35	1.3	96	0.23	17

NA = not available
GDP = gross domestic product

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

NOTES: Top 14 countries globally in annual gross expenditures on R&D. Year of data listed in parentheses.

SOURCE: Organisation for Economic Co-operation and Development, Main Science and Technology Indicators (2011/1). Data for Brazil and India from United Nations Educational, Scientific, and Cultural Organization (UNESCO) Institute for Statistics, http://stats.uis.unesco.org/unesco/ReportFolders/ReportFolders.aspx, table 26, accessed 13 July 2011.

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Table 4-21
Gross expenditures on R&D by performing sector, by selected country/economy: 2009 or most recent year
(Percent)

Country/economy	Business	Government	Higher education	Private nonprofit
United States (2009)[a]	70.3	11.7	13.5	4.4
China (2009)	73.2	18.7	8.1	0.0
Japan (2009)	75.8	9.2	13.4	1.6
Germany (2009)	67.5	14.9	17.6	**
France (2009)	61.9	16.3	20.6	1.2
South Korea (2008)	75.4	12.1	11.1	1.4
United Kingdom (2009)	60.4	9.2	27.9	2.5
Russian Federation (2009)	62.4	30.3	7.1	0.2
India (2007)	33.9	61.7	4.4	**
Italy (2009)	51.5	13.9	31.4	3.2
Canada (2009)	51.7	10.1	37.6	0.6
Brazil (2004)	40.2	21.3	38.4	0.1
Taiwan (2008)	70.1	16.8	12.8	0.4
Spain (2009)	51.9	20.1	27.8	0.2

** = included in other performing sectors

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

NOTES: Top 14 R&D performing countries. Year of data listed in parentheses. Percentages may not add to 100 due to rounding.

SOURCES: Organisation for Economic Co-operation and Development, Main Science and Technology Indicators (2011/1). Data for Brazil and India from United Nations Educational, Scientific, and Cultural Organization (UNESCO) Institute for Statistics, http://stats.uis.unesco.org/unesco/ReportFolders/ReportFolders.aspx, table 27, accessed 18 July 2011.

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Table 4-22
Gross expenditures on R&D by funding source, by selected country/economy: 2009 or most recent year
(Percent)

Country/economy	Business	Government	Other domestic	From abroad
United States (2009)[a]	59.7	31.3	7.2	1.9
China (2009)	71.7	23.4	NA	1.3
Japan (2009)	75.3	17.7	6.6	0.4
Germany (2008)	67.3	28.4	0.3	4.0
France (2008)	50.7	38.9	2.3	8.0
South Korea (2008)	72.9	25.4	1.4	0.3
United Kingdom (2009)	44.5	32.6	6.3	16.6
Russian Federation (2009)	26.6	66.5	0.5	6.5
India (2007)	33.9	66.1	**	NA
Italy (2008)	45.2	42.9	4.1	7.8
Canada (2009)	47.6	33.4	12.1	6.9
Brazil (2008)	43.9	54.0	2.2	NA
Taiwan (2009)	69.7	28.9	1.3	*
Spain (2008)	45.0	45.6	3.8	5.7

NA = not available; * = <0.05%.; ** = included in other funding sectors

[a]Figures for the United States in this table reflect international standards for calculating gross expenditures on R&D, which vary slightly from NSF protocol for tallying U.S. total R&D. Figures for funding from abroad based primarily on funding for business R&D.

NOTES: Top 14 R&D performing countries. Year of data listed in parentheses. Percentages may not add to 100 due to rounding. For the United States, data on R&D funding from abroad are not separately identified and instead are included in sector totals. In most other countries, funding from abroad is a distinct and separate category.

SOURCES: Organisation for Economic Co-operation and Development, Main Science and Technology Indicators (2011/1). Data for Brazil and India from United Nations Educational, Scientific, and Cultural Organization (UNESCO) Institute for Statistics, http://stats.uis.unesco.org/unesco/ReportFolders/ReportFolders.aspx, table 28, accessed 18 July 2011.

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fund general advancement of knowledge R&D, do not separately account for GUF funding (e.g., South Korea), and/or more typically direct R&D funding to project-specific grants or contracts (which are then assigned to the more specific socioeconomic objectives). For a further discussion of this topic, see the sidebar "Government Funding Mechanisms for Academic Research" later in this chapter.

Finally, the education and society objective represents a comparatively small component of nondefense government R&D funding for all seven of the countries. However, it is notably higher in Germany (4%), France (4%), and the United Kingdom (6%), than in the United States (2%) and Japan (1%). South Korea is in between at 3%.

Business R&D Focus

Business R&D varies substantially among countries in terms of both industry concentration and sources of funding. Because businesses account for the largest share of total R&D performance in the United States and most OECD countries, differences in business structure can help explain international differences in more aggregated statistics such as R&D/GDP. For example, countries with higher concentrations of R&D-intensive industries (such as communication, television, and radio equipment manufacturing) are likely to also have higher R&D/GDP ratios than countries whose business structures are weighted more heavily toward less R&D-intensive industries.

Using internationally comparable data, no one industry accounted for more than 19% of total business R&D in the United States in 2008[40] (figure 4-17 and appendix table 4-46), based on OECD's Analytical Business Enterprise R&D-Statistical Analysis Database (ANBERD-STAN) (OECD 2011a). This is largely a result of the size of business R&D expenditures in the United States, which makes it difficult for any one sector to dominate. However, the diversity of R&D investment by industry in the United States is also an indicator of how the nation's accumulated stock of knowledge and well-developed S&T infrastructure have made it an attractive location for R&D performance in a broad range of industries.

Compared with the United States, smaller economies shown in figure 4-17 display much higher concentration in particular industries. For example, in South Korea, one of the world's top producers of communication, TV, and radio equipment industry, which includes semiconductors, this industry accounted for 46% of the country's business R&D.[41]

The spread of global production networks and value chains is also reflected in these indicators. Automotive manufacturers rank among the largest R&D-performing companies in the world (see sidebar, "Global R&D Expenses of Public Corporations"). The automotive industry has also highly distributed production and technical sites globally. Thus, countries that are home to major automotive MNCs and/or serve as host countries for MNCs affiliates, their

Table 4-23
Government R&D support by major socioeconomic objectives, by selected region/country: 1981–2009

Region/country and year	GBAORD (current US$ millions, PPP)	Percent of GBAORD		Percent of nondefense					
		Defense	Nondefense	Economic development programs	Health and environment	Education and society	Civil space	Non-oriented research	General university funds (GUF)
United States									
1981	33,735.0	54.6	45.4	36.1	31.2	3.6	20.3	8.7	na
1990	63,781.0	62.6	37.4	22.2	40.2	3.4	24.2	10.1	na
2000	83,612.5	51.6	48.4	13.4	49.9	1.8	20.9	13.8	na
2009	164,292.0	51.6	48.4	13.3	55.9	1.5	11.4	17.8	na
EU									
1981	na	na	na	na	na	na	na	na	na
1990	na	na	na	na	na	na	na	na	na
2000	73,559.9	13.1	86.9	22.7	11.6	3.4	6.1	15.7	34.9
2008	110,238.5	9.6	90.4	23.5	14.8	5.9	4.9	17.3	33.8
Germany									
1981	8,572.5	8.9	91.1	34.9	9.6	4.5	4.5	46.5	0.0
1990	13,269.1	13.5	86.5	25.9	10.8	2.9	6.8	15.2	37.6
2000	16,806.2	7.8	92.2	21.6	9.4	3.9	5.1	17.5	42.4
2009	25,857.8	5.7	94.3	23.0	10.3	4.1	5.4	18.2	39.6
France									
1981	8,531.3	38.4	61.6	37.9	13.3	2.0	6.7	39.1	0.0
1990	13,228.6	40.0	60.0	32.8	9.3	0.8	13.0	24.6	18.9
2000	14,738.0	21.4	78.6	17.7	9.7	1.1	13.2	27.4	28.5
2008	16,171.9	28.3	71.7	24.3	15.0	3.6	12.5	6.4	39.0
United Kingdom									
1981	6,731.2	46.3	53.7	38.5	13.1	1.5	3.8	10.6	29.6
1990	8,113.8	43,5	56.5	31.9	18.1	4.0	5.5	10.3	29.8
2000	10,357.6	36.2	63.8	12.1	28.3	6.4	3.5	18.8	30.4
2009	15,146.3	18.3	81.7	9.3	28.8	5.7	2.3	23.8	30.1
Japan									
1981	NA	NA	NA	NA	NA	NA	NA	NA	NA
1990	10,142.0	5.4	94.6	33.9	4.5	1.1	6.9	8.4	45.1
2000	21,223.0	4.1	95.9	33.4	6.6	1.0	5.8	14.6	37.0
2009	31,072.5	3.7	96.3	30.5	7.2	1.0	7.5	18.3	35.5
China									
1981	NA	NA	NA	NA	NA	NA	NA	NA	NA
1990	NA	NA	NA	NA	NA	NA	NA	NA	NA
2000	NA	NA	NA	NA	NA	NA	NA	NA	NA
2009	NA	NA	NA	NA	NA	NA	NA	NA	NA
South Korea									
1981	NA	NA	NA	NA	NA	NA	NA	NA	NA
1990	NA	NA	NA	NA	NA	NA	NA	NA	NA
2000	5,024.7	20.5	79.5	53.4	14.8	3.8	3.1	24.9	**
2009	13,209.6	16.7	83.3	52.0	18.6	2.8	3.7	22.8	**

** = included in other categories; na = not applicable; NA = not available

EU = European Union; GBAORD = government budget appropriations or outlays for R&D; PPP = purchasing power parity

NOTES: Foreign currencies converted to dollars through purchasing power parities. Most recent data available for France and the EU are 2008. EU data for all years based on current 27 member countries. GBAORD data are not yet available for China. The socioeconomic objective categories are aggregates of the 14 categories identified by Eurostat's 2007 Nomenclature for the Analysis and Comparison of Scientific Programs and Budgets (NABS).

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (August 2010) of federal R&D budget authority by spending category; Organisation for Economic Co-operation and Development, Main Science and Technology Indicators (2011/1). See appendix table 4-45.

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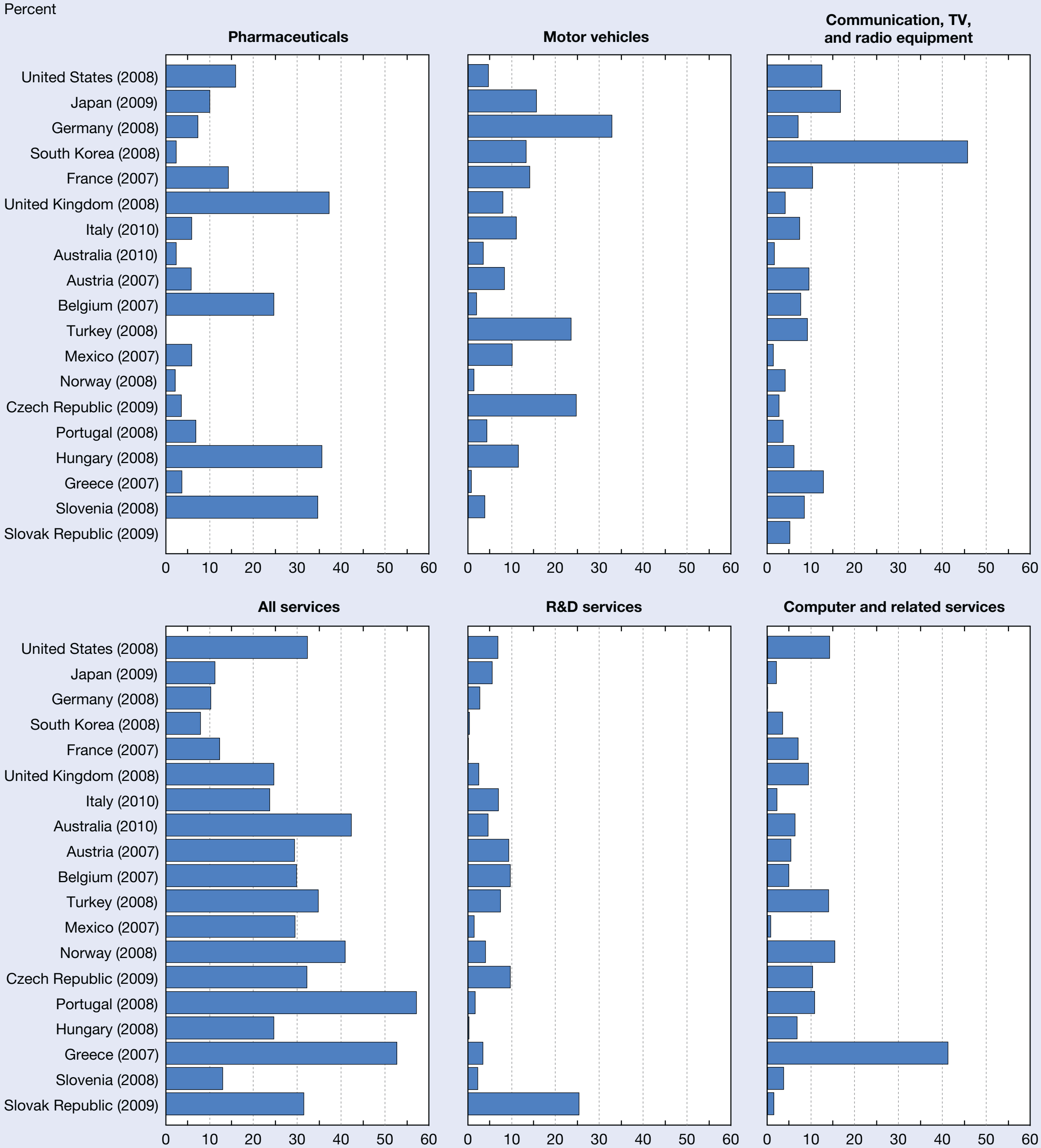
Figure 4-17
Share of industrial R&D, by industry sector and selected country: 2007–10



NOTES: Source data for U.S. business R&D in this figure are preliminary (NSF 2010a); final U.S. statistics were used elsewhere in chapter 4. Countries listed in descending order by amount of total business R&D. Data years are in parentheses.

SOURCES: Organisation for Economic Co-operation and Development, Analytical Business Enterprise R&D (ANBERD)-Statistical Analysis Database (STAN)-R&D Expenditure in Industry, http://www.oecd.org/document/17/0,3746,en_2649_34451_1822033_1_1_1_1,00.html, accessed 27 July 2011; National Science Foundation, National Center for Science and Engineering Statistics and U.S. Census Bureau, Business R&D and Innovation Survey (2008).

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part suppliers, or technical contractors, may have relatively larger share of motor vehicles R&D, as shown for Germany, the Czech Republic, and Turkey.

A significant trend in both U.S. and international business R&D activity has been the growth of R&D in the service sector. According to national statistics for recent years, the service sector accounted for 30% or more of all business R&D in 8 of the 19 OECD countries shown in figure 4-17 and less than 10% in only one of the countries. In the United States, service industries accounted for 32% of all business R&D in 2008.[42]

Internationally comparable data for selected non-OECD members are also available from the same database (ANBERD-STAN) (OECD 2011a). Percentage shares by industry of total business R&D for China, the Russian Federation, Singapore, South Africa, and Taiwan are given in appendix table 4-46. Among these economies, the communication, television, and radio equipment industry, which includes semiconductors, accounted for over 50% of all business R&D in Singapore (2008). Motor vehicle R&D accounted for 5% of business R&D in South Africa (2007); pharmaceutical R&D accounted for 3% in China (2009) and R&D in the computer, office and accounting machines industry accounted for 3% of the business R&D performed in Taiwan (2009). Among OECD countries, the service sector accounted for as little as 8% of business R&D

Global R&D Expenses of Public Corporations

Most firms that make significant investments in R&D track their R&D expenses separately in their accounting records and financial statements. The annual reports of public corporations often include data on these R&D expenses. Research organizations and consulting companies interested in tracking and ranking businesses compile R&D expenditures and related operations and performance data. According to one such ranking, the 20 public corporations with the largest reported worldwide R&D expenditures spent $129 billion on R&D in 2009 (Booz & Company 2010). The six companies with the largest reported R&D expenses—Roche Holding, Microsoft, Nokia, Toyota, Pfizer, and Novartis—each spent between $7.4 billion and $9.1 billion (table 4-B). Eight companies in the computing and electronic sector spent a total of $50.4 billion (39% of the total for the top 20). Seven companies in the health sector spent a total of $49.5 billion (38% of the total). The remaining five companies on the list are automobile manufacturers and they reported combined spending of $29.1 billion on R&D (23% of the total). The top 20 companies are headquartered in 8 countries, with 9 headquartered in the United States. In addition, most companies in this list have production, distribution, and/or research and technical facilities in multiple countries. (For related industry-level information, see "R&D by Multinational Companies" in this chapter and chapter 6.)

Table 4-B
Global R&D spending by top 20 corporations: 2009

R&D rank	Company	Country	R&D expense ($millions)	Sales ($millions)	R&D intensity (%)
1	Roche Holding AG	Switzerland	9,120	45,606	20.1
2	Microsoft Corp	United States	9,010	58,437	15.4
3	Nokia OYJ	Finland	8,240	57,150	14.4
4	Toyota Motor Corp	Japan	7,822	204,363	3.8
5	Pfizer Inc	United States	7,739	50,009	15.5
6	Novartis AG	Switzerland	7,469	44,267	16.9
7	Johnson & Johnson	United States	6,986	61,897	11.3
8	Sanofi-Aventis SA	France	6,391	40,866	15.6
9	GlaxoSmithKline PLC	United Kingdom	6,187	44,422	13.9
10	Samsung Electronics Co Ltd	South Korea	6,002	109,541	5.5
11	General Motors Co	United States	6,000	104,589	5.7
12	International Business Machines	United States	5,820	95,759	6.1
13	Intel Corp	United States	5,653	35,127	16.1
14	Merck & Co Inc	United States	5,613	27,428	20.5
15	Volkswagen AG	Germany	5,359	146,677	3.7
16	Siemens AG	Germany	5,285	103,866	5.1
17	Cisco Systems Inc	United States	5,208	36,117	14.4
18	Panasonic Corp	Japan	5,143	79,994	6.4
19	Honda Motor Co Ltd	Japan	4,996	92,516	5.4
20	Ford Motor Co	United States	4,900	118,308	4.1

SOURCE: Booz & Company, The global innovation1000-how the top innovators keep winning (2010). http://www.booz.com/media/file/sb61_10408-R.pdf and http://www.booz.com/media/file/keep_winning_11_2010.pdf. Both accessed 10 August 2011.

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in South Korea (2008) to as much as 65% in Israel (2010). For the non-OECD economies examined here, the percentage of business R&D accounted for by the service sectors ranged from 7% in Taiwan (2009) to 86% in the Russian Federation (2009).

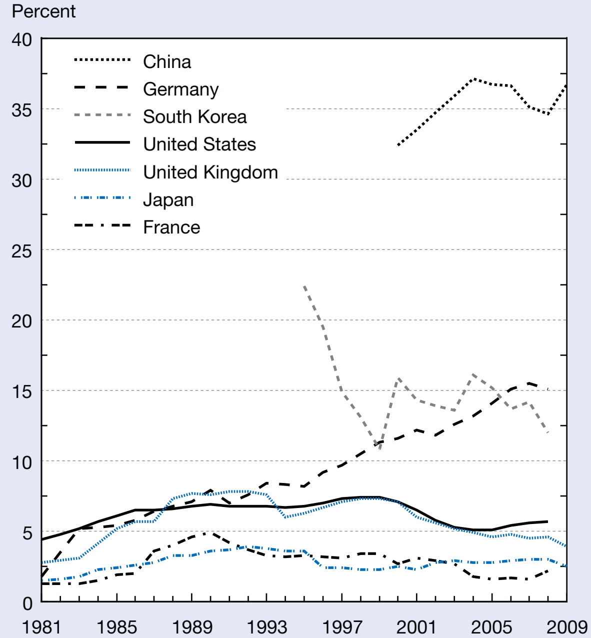
Business Support for Academic R&D

For most countries, the government is (and has long been) the largest source of academic research funding. (See sidebar, "Government Funding Mechanisms for Academic Research.") Nevertheless, business support for academic R&D has increased over the past 25 years among the OECD countries as a whole. It was around 3% in the early 1980s, nearly 6% in 1990, almost 7% in 2000, and still around 7% in 2007.

In the United States, business support for academic R&D was about 4% in the early 1980s and rose to about 7% later in that decade and through the 1990s, but has dropped to below 6% since 2000. Some commentators note concern about this recent trend of decline, given the significant role that academic basic research plays in providing a foundation for technological innovation that is important to the national economy.

The proportion of academic R&D financed by business is more varied among the other top R&D-performing countries (figure 4-18). Among the other top seven R&D-performing countries, the highest figure for business support of academic R&D is currently in China (37%). The figures are also high in Germany (15%) and South Korea (12%), whereas Japan, France, and the United Kingdom occupy the low end, with figures under 5%.

Figure 4-18
Academic R&D financed by business, for selected countries: 1981–2009



NOTES: Top seven R&D performing countries. Data not available for all countries for all years. Data for Japan for 1996 onward may not be consistent with earlier data due to changes in methodology. Data for China for 2001 and 2002 are estimated by National Science Foundation.

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

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Government Funding Mechanisms for Academic Research

U.S. universities generally do not maintain data on departmental research (i.e., research that is not separately budgeted and accounted). As such, U.S. R&D totals are understated relative to the R&D effort reported for other countries. The national totals for Europe, Canada, and Japan include the research component of general university fund (GUF) block grants provided by all levels of government to the academic sector. These funds can support departmental R&D programs that are not separately budgeted. GUF is not equivalent to basic research. The U.S. federal government does not provide research support through a GUF equivalent, preferring instead to support specific, separately budgeted R&D projects. However, some state government funding probably does support departmental research, not separately accounted, at U.S. public universities.

The treatment of GUF is one of the major areas of difficulty in making international R&D comparisons. In many countries, governments support academic research primarily through large block grants that are used at the discretion of each higher education institution to cover administrative, teaching, and research costs. Only the R&D component of GUF is included in national R&D statistics, but problems arise in identifying the amount of the R&D component and the objective of the research. Moreover, government GUF support is in addition to support provided in the form of earmarked, directed, or project-specific grants and contracts (funds that can be assigned to specific socioeconomic categories).

In several large European countries (France, Germany, Italy, and the United Kingdom), GUF accounts for 50% or more of total government R&D funding to universities. In Canada, GUF accounts for about 38% of government academic R&D support. Thus, international data on academic R&D reflect not only the relative international funding priorities but also the funding mechanisms and philosophies regarded as the best methods for financing academic research.

Conclusion

Growth in global R&D has been rapid, averaging 7% annually over the last 10 years, reaching an estimated $1,276 billion (in purchasing power parities) in 2009. The United States is by far the largest R&D performer, accounting for about 31% of the global total, but down from 38% in 1999. Average annual growth in U.S. R&D spending has outpaced U.S. GDP growth over the last several decades. However, in 2009 U.S. R&D spending was somewhat below the 2008 level. The 2009 slowdown primarily reflects a drop in business R&D in the face of the 2008–09 financial crisis and the economic recession. On the other hand, U.S. R&D spending in other performing sectors continued to rise, notably for federal and academic R&D, in part because of the one-time federal R&D funding increase appropriated in the American Recovery and Reinvestment Act of 2009.

The other major trend has been the rapid expansion of R&D performance in Asia. The region represented 24% of the global R&D total in 1999 but accounted for 32% in 2009, including China (12%) and Japan (11%). The pace of real growth over the past 10 years in China's overall R&D remains exceptionally high at about 20% annually. The rate of growth in South Korea's R&D has also been relatively high, averaging nearly 10% annually over the 10-year period. Growth in Japan has been slower, at an annual average rate of 4.0%.

The R&D/GDP ratio, or R&D intensity, constitutes another basis for international comparisons. The U.S. ratio was about 2.9% in 2009 and has fluctuated between 2.6% and 2.8% during the prior 10 years, largely reflecting changes in business R&D spending. In 2009, the United States ranked eighth in R&D intensity—surpassed by Israel, Sweden, Finland, Japan, South Korea, Switzerland, and Taiwan (but all perform far less R&D annually than the U.S.). China's ratio remains relatively low, at 1.7%, but has more than doubled from 0.8% in 1999.

The majority of R&D by U.S. MNCs continues to be performed in the United States. Indeed, parent companies of U.S. MNCs performed just over two-thirds of U.S. business R&D. U.S. MNCs performed most of their foreign R&D in Europe, Canada, and Japan. However, from 1997 to 2008 the share of R&D performed by U.S. majority-owned affiliates in Asia (other than Japan) more than doubled, including increases in the share performed in China, South Korea, Singapore, and India.

Notes

1. America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science [COMPETES] Act (Public Law 110-69, January 4, 2007) and America COMPETES Reauthorization Act of 2010 (Public Law 111-358, January 4, 2011).

2. For an annotated compilation of definitions of R&D by U.S. statistical agencies, tax statutes, accounting bodies, and other official sources, see NSF (2006).

3. Adjustments for inflation reported in this chapter are based on the GDP implicit price deflator. GDP deflators are calculated on an economy-wide rather than an R&D-specific basis. As such, they should be interpreted as measures of real resources engaged in R&D rather than in other activities, such as consumption or physical investment. They are not a measure of cost changes in performing R&D. See appendix table 4-1 for GDP deflators used in this chapter.

4. R&D funding by business in this section refers to nonfederal funding for domestic business R&D plus business funding for U.S. academic R&D and nonprofit R&D performers.

5. Federal support for R&D reported by federal agencies in the form of obligations differs from expenditures of federal R&D funds reported by R&D performers. For a discussion of the reasons for, and the magnitude of these discrepancies, see sidebar "Tracking R&D: The Gap Between Performer- and Source-Reported Expenditures" later in this chapter.

6. Contemporary discussions often note the extensive feedback loops among basic research, applied research, and development that prevail in the conduct of R&D. On this basis, there is often-heard criticism that this standard trio is simplistic and erroneously implies a linear progression. Even so, an alternative framework has yet to be identified to wide acceptance. Accordingly, the chapter relies for its analysis on the standard trio of categories, which have been longstanding, widely used, and internationally comparable (OECD 2002).

7. The OECD notes that in measuring R&D, the greatest source of error often is the difficulty of locating the cutoff point between experimental development and the related activities required to realize an innovation (OECD 2002, paragraph 111). Most definitions of R&D set the cutoff at the point when a particular product or process reaches "market readiness." At this point, the defining characteristics of the product or process are substantially set (at least for manufacturers if not also for services), and further work is primarily aimed at developing markets, engaging in preproduction planning, and streamlining the production or control system.

8. These estimates measure solely the direct impact of R&D investment. Although indirect productivity impacts of R&D are included in BEA's industry output measures, estimates of the impact of R&D based on the R&D Satellite Account do not separately identify spillovers, the indirect benefits to firms that did not pay for the R&D. For R&D spillovers in the context of national accounts measures, see Sveikauskas (2007).

9. The sample for the Business R&D and Innovation Survey (BRDIS) was selected to represent all for-profit nonfarm companies with five or more domestic employees, publicly or privately held, that perform or fund R&D or engage in innovative activities in the United States. For worldwide expense data from this survey, see appendix table 4-13.

10. Recall that BRDIS excludes companies with fewer than five domestic employees.

11. Because federal R&D funding is concentrated among a few companies in a small number of industries than is R&D in general, estimates for federally funded business R&D are often suppressed. Consequently, the percentage of federally funded business R&D for these six industry groups is based on a lower bound estimate.

12. Estimates for computer and electronic product manufacturing in this section refer to NAICS 334 except the federally funded R&D component of navigational, measuring, electromedical, and control instruments industry (NAICS 3345), which is included in aerospace and defense manufacturing.

13. Specifically, this industry group includes domestic R&D performance for architectural, engineering, and related services (NAICS 5413) and scientific R&D services industries (NAICS 5417).

14. Although companies in the R&D and related-services sector and their R&D activities are classified as nonmanufacturing, they serve many manufacturing industries. For example, many biotechnology companies in this sector license their technology to companies in the pharmaceutical manufacturing industry. The R&D of a research firm that is a subsidiary of a manufacturing company rather than an independent contractor would be classified as R&D in a manufacturing industry. Consequently, growth in R&D services may, in part, reflect a more general pattern of industry's increasing reliance on outsourcing and contract R&D.

15. Data are tabulated independent of the industry classification of the company.

16. Funded by others outside the company includes funded by foreign parents.

17. See appendix tables 4-18 through 4-21.

18. The BEA estimate for R&D performance by majority-owned foreign affiliates of U.S. MNCs is much lower than the $61.5 billion based on BRDIS 2008. BEA, NSF, and the Census Bureau are researching measures of R&D by foreign affiliates as part of the R&D linking project, which is discussed in sidebar "Linking MNC Data from International Investment and Business R&D Surveys." This research should lead to improvements in both data sets.

19. Data in this section cover international transactions in RDT services by U.S.-located companies from BEA's Survey of Transactions in Selected Services and Intangible Assets with Foreign Persons. Separate data for R&D versus "testing" services are not available (further, testing services may have both R&D and non-R&D components). Other fee-based measures on intangibles trade include international licensing and royalty payments and receipts (see chapter 6). RDT services cover activities by companies in any industrial classification, *not* just companies classified in services or in NAICS 5417 (Scientific research and development services). For further methodological information, see http://www.bea.gov/surveys/iussurv.htm.

20. U.S. RDT exports by foreign MNCs in 2008 were about 16% of their U.S. R&D performance as reported in the section "R&D by Multinational Companies," whereas the corresponding ratio for U.S. parents was 4%. Thus a substantial share of foreign-owned R&D in the U.S. is apparently devoted to service foreign parents and other members of the foreign MNC. See Moris (2009) for caveats on these cross-survey comparisons.

21. Federal agencies also sponsor FFRDCs; see appendix table 4-33.

22. For information on R&D credits at the state level, see NSB (2008, chapter 4) and Wilson (2009).

23. See Section 731 of H. R. 4853, Public Law 111-312. The statute also renewed the credit retroactively for activities after December 31 2009, given that the credit had expired on the latter date according to the Emergency Economic Stabilization Act of 2008 (H.R.1424, Public Law 110-343, Division C, Title III, Section 301). This credit has now been extended 14 times despite its temporary status since its inception.

24. Based on data from the Internal Revenue Service/Statistics of Income (IRS/SOI). Data are sample-based estimates and are subject to sampling and nonsampling errors. For statistical methodology, see section 3 in IRS (2010).

25. This percentage is based on company and other nonfederal funds for business R&D.

26. Based on IRS/SOI figures B and C in http://www.irs.gov/taxstats/article/0,,id=164402,00.html (accessed 25 February 2011). See also IRS (2008).

27. The alternative incremental tax credit was in place from 1996 to 2008; a simplified alternative credit has been in place since 2006. See IRS (2008) and Guenther (forthcoming).

28. See IRS tax form 6765 at http://www.irs.gov/pub/irs-pdf/f6765.pdf.

29. Science or research parks, another example of public-private collaboration, may facilitate knowledge diffusion, technology development and deployment, and entrepreneurship by involving universities, government laboratories, and business startups. Two recent U.S. workshops focused on science parks. A December 2007 NSF workshop was aimed at fostering a better understanding and measurement of science parks' activities, including the role of science parks in the national innovation system. Participants identified a need for systematic studies on topics such as the social benefits of public investment in science parks, ways in which the university-science park interaction engenders entrepreneurial activity, and lessons that U.S. science parks can learn from comparative studies with European and Asian parks. For material from this workshop, see http://www.nsf.gov/statistics/workshop/sciencepark07. A subsequent workshop sponsored by the National Academies explored international models and best practices in science parks (NRC 2009).

30. Notably missing among these indicators are technical articles published in professional journals, conference papers, and other kinds of scientific communications. Most federal lab scientists, engineers, and managers view this traditional form of new knowledge dissemination as an essential tech transfer component. Nevertheless, few agencies and

their associated federal labs regularly tabulate and report this information.

31. P.L. 97–219. At the time of writing, SBIR was authorized until November 18, 2011 (Public Law 112–36).

32. Small Business Technology Transfer Act of 1992 (Public Law 102-564, Title II).

33. To obtain federal funding under this program, a small company applies for a phase I SBIR grant of up to $100,000 for up to 6 months to assess the scientific and technical feasibility of ideas with commercial potential. If the concept shows further potential, the company may receive a phase II grant of up to $750,000 over a period of up to 2 years for further development.

34. SBA's Federal and State Technology (FAST) partnership program also provides support associated with SBIR/STTR. The Consolidated Appropriations Act of 2010 (Public Law 111-117) authorized $2 million for FAST. In October 2010, SBA granted $100,000 awards to 20 state and local economic development agencies, business development centers, and colleges and universities. The program is designed to help socially and economically disadvantaged firms compete in SBIR and STTR. The project and budget periods are for 12 months, starting September 30, 2010. See SBA Press Release No. 10-62, http://www.sba.gov/about-sba-services/7367/11391, accessed 4 March 2011.

35. Public Law 110-69, Section 3012. See NSB (2010) pages 4–57 and appendix table 4-47 of that publication for information and data on the predecessor program, the Advanced Technology Program.

36. See appendix tables 4-43 through 4-46.

37. EU real growth over 1999–2009 and the 1999 share are based on all current 27 EU member countries.

38. For related 2008 data, see appendix table 4-44.

39. Some analysts argue that the low nondefense GBAORD share for economic development in the United States reflects the expectation that businesses will finance industrial R&D activities with their own funds. Moreover, government R&D that may be useful to industry is often funded with other purposes in mind, such as defense and space, and is therefore classified under other socioeconomic objectives.

40. Data for the United States included in the Organisation for Economic Co-operation and Development's Analytical Business Enterprise R&D (ANBERD)-Statistical Analysis Database (STAN) are preliminary (NSF 2010a); final statistics were used for the business R&D analyses earlier in chapter 4.

41. For information on global valued added, trade, and related statistics for high technology industries, see chapter 6.

42. Share in OECD/ANBERD based on preliminary U.S. business R&D data (NSF 2010a); final U.S. statistics were used elsewhere in chapter 4.

Glossary

Affiliate: A company or business enterprise located in one country but owned or controlled (in terms of 10% or more of voting securities or equivalent) by a parent company in another country; may be either incorporated or unincorporated.

Applied research: The objective of applied research is to gain knowledge or understanding to meet a specific, recognized need. In industry, applied research includes investigations to discover new scientific knowledge that has specific commercial objectives with respect to products, processes, or services.

Basic research: The objective of basic research is to gain more comprehensive knowledge or understanding of the subject under study without specific applications in mind. Although basic research may not have specific applications as its goal, it can be directed in fields of present or potential interest. This is often the case with basic research performed by industry or mission-driven federal agencies.

Development: Development is the systematic use of the knowledge or understanding gained from research directed toward the production of useful materials, devices, systems, or methods, including the design and development of prototypes and processes.

Company-funded R&D: R&D paid for with a company's own funds, no matter the location of R&D activity or who performs or conducts the R&D (the company itself or others outside the funding company). Company-funded R&D is also known as R&D expense for certain tax, accounting, and data collection purposes.

EU: Prior to 2004, the European Union (EU) consisted of 15 member nations: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, and the United Kingdom. In 2004, the membership expanded to include an additional 10 countries: Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, and Slovenia. Bulgaria and Romania were added in January 2007, bringing the total of current EU member countries to 27.

Federally funded research and development center (FFRDC): R&D-performing organizations that are exclusively or substantially financed by the federal government either to meet a particular R&D objective or, in some instances, to provide major facilities at universities for research and associated training purposes. Each FFRDC is administered by an industrial firm, a university, or a nonprofit institution.

Foreign affiliate: Company located outside the United States but owned by a U.S. parent company.

Foreign direct investment (FDI): Ownership or control of 10% or more of the voting securities (or equivalent) of a business located outside the home country.

General university fund (GUF): Block grants provided by all levels of government in Europe, Canada, and Japan to the academic sector that can be used to support departmental R&D programs that are not separately budgeted; the

U.S. federal government does not provide research support through a GUF equivalent.

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

Innovation: The introduction of new or significantly improved products (goods or services), processes, organizational methods, and marketing methods in internal business practices or in the open marketplace (OECD/Eurostat 2005).

Majority-owned affiliate: Company owned or controlled, by more than 50% of the voting securities (or equivalent), by its parent company.

Multinational company (MNC): A parent company and its foreign affiliates.

National income and product accounts (NIPAs): The economic accounts of a country that display the value and composition of national output and the distribution of incomes generated in this production.

Organisation for Economic Co-operation and Development (OECD): An international organization of 34 countries, headquartered in Paris, France. The member countries are Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom, and United States. Among its many activities, the OECD compiles social, economic, and science and technology statistics for all member and selected nonmember countries.

Public-private partnership: Collaboration between private or commercial organizations and at least one public or nonprofit organization such as a university, research institute, or government laboratory. Examples include cooperative research and development agreements (CRADAs), industry-university alliances, and science parks.

R&D: Research and development, also called research and experimental development; comprises creative work undertaken on a systematic basis to increase the stock of knowledge—including knowledge of man, culture, and society—and its use to devise new applications (OECD 2002).

R&D intensity: A measure of R&D expenditures relative to size, production, financial, or other characteristic for a given R&D-performing unit (e.g., country, sector, company). Examples include R&D to GDP ratio, company-funded R&D to net sales ratio, and R&D expenditures per employee.

Technology transfer: The process by which technology or knowledge developed in one place or for one purpose is applied and exploited in another place for some other purpose. In the federal setting, technology transfer is the process by which existing knowledge, facilities, or capabilities developed under federal research and development funding are utilized to fulfill public and private needs.

U.S. affiliate: Company located in the United States but owned by a foreign parent.

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