CHAPTER 4

Research and Development: U.S. Trends and International Comparisons

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Highlights

Recent Trends in U.S. R&D Performance

R&D performed in the United States totaled $495.1 billion (current dollars) in 2015 and an estimated $475.4 billion in 2014. These numbers compare to U.S. R&D totals of $433.6 billion in 2012 and $454.0 billion in 2013. In 2008, just ahead of the onset of the main economic effects of the national and international financial crises and the Great Recession, U.S. R&D totaled $404.8 billion.

- These data reflect increases of $20.3 billion in 2013, $21.5 billion in 2014, and $19.7 billion in 2015. These sizeable yearly increases in the U.S. total arise mainly from increased business R&D performance. Across the other main R&D-performing sectors, the annual changes were far smaller—and, in some cases, were declines.
- Adjusted for inflation, growth in U.S. total R&D averaged 1.4% annually over the 7-year period 2008–15, marginally behind the 1.5% average pace of U.S. gross domestic product (GDP) over the same period. By comparison, the average annual rate of growth was notably higher in the prior 10-year period (1998–2008): 3.6% for total R&D and 2.2% for GDP. The smaller rate of growth in 2008–15 partly reflects inclusion of the Great Recession years. Nonetheless, considering only the 5-year period of 2010–15, the average annual pace of growth for total R&D is 2.3%, just ahead of 2.2% for GDP.

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

- The business sector performed $355.8 billion of R&D in 2015, or 72% of the U.S. total, drawing on business, federal, and other sources of R&D funding.
- The business sector itself provided $333.2 billion of funding for R&D in 2015, or 67% of the U.S. total, most of which supported R&D performed by business.
- The level of business R&D performance declined in 2009 and 2010, compared with the 2008 level, but returned to an expansionary path in 2011 through 2015. Even with these declines, business R&D performance has continued to account for most of the nation's R&D growth over the last 10 years.
- The academic sector was the second largest performer of U.S. R&D, accounting for $64.7 billion in 2015, or about 13% of the national total.
- The federal government was the second largest funder of U.S. R&D, accounting for $120.9 billion, or 24% of U.S. total R&D performance in 2015.

Most of U.S. basic research is conducted at higher education institutions and is funded by the federal government. However, the largest share of U.S. total R&D is experimental development, which is mainly performed by the business sector. The business sector also performs the majority of applied research. Although the absolute dollar values and actual shares have changed over time, these broad trends have remained mostly consistent for several decades.

- In 2015, basic research was about 17% ($83.5 billion) of total U.S. R&D performance, applied research was 20% ($97.2 billion), and experimental development was about 64% ($314.5 billion).
- Higher education institutions historically have been the main performers of U.S. basic research, and they accounted for just under half (49%) of all U.S. basic research in 2015. The business sector is also now a sizable performer of

basic research, accounting for 26% of the basic research total in 2015. The federal government remained the largest funder of basic research, accounting for about 44% of all such funding in 2015.

- The business sector was the predominant performer of applied research, accounting for 58% of all U.S. applied research in 2015. Business also provided 53% of the funding for the applied research total, with most of this support remaining within the sector. The federal government accounted for 36% of the funding.
- Experimental development was by far the largest component of U.S. R&D. The business sector performed 88% of it in 2015 and provided 82% of the funding. Federal funding accounted for only 16% of this experimental development, with the business sector (especially defense-related industries) and federal intramural laboratories and federally funded R&D centers (FFRDCs) being the largest recipients.

Cross-National Comparisons of R&D Performance

Worldwide R&D performance totaled an estimated $1.918 trillion in 2015, up from $1.415 trillion in 2010 and $722 billion in 2000. Fifteen countries or economies performed $20 billion or more of R&D in 2015, accounting for 85% of the global total. The top rankings at present continue to be dominated by the United States and China.

- The United States remained the largest R&D-performing country in 2015, with gross domestic expenditures on R&D of $497 billion, a 26% share of the global total, and an R&D-to-GDP ratio of 2.7%. China was a decisive second, with R&D expenditures of $409 billion, a 21% global share, and an R&D-to-GDP ratio of 2.1%.
- Japan ($170 billion, 9% global share, ratio of 3.3%) and Germany ($115 billion, 6% global share, ratio of 2.9%) were the comparatively distant third and fourth largest R&D-performing countries. The other 11 countries or economies in the top 15 were South Korea, France, India, the United Kingdom, Brazil, Russia, Taiwan, Italy, Canada, Australia, and Spain—with the annual national R&D expenditure totals ranging from about $61 billion (France) down to $20 billion (Spain).
- Total global R&D increased (current dollars) more than two and a half times from 2000 to 2015. About 19% of this increase reflected the growth of U.S. R&D over this period, 17% from the European Union (EU) as a whole (including Germany, France, and the United Kingdom), as well as 5%–6% each from Japan and South Korea. Nonetheless, the largest contributor by far was China, which accounted for 31% of the decade and a half increase. The pace of growth in China's overall R&D over this period remained exceptionally high, at just over 18% annually (or around 16% adjusted for inflation).
- The U.S. share of worldwide R&D was notably higher in 2000 (37%) than in 2015 (26%), continuing to decline over this 15-year period. The EU also exhibited a decline over the same period: from 25% of the global total in 2000, down to 20% in 2015. The expansion was clearly driven by the economies of East/Southeast and South Asia—including China, Japan, South Korea, India, and Taiwan—which represented 25% of the global R&D total in 2000, rising to about 40% in 2015.

U.S. Business R&D

The business sector remains by far the largest performer in the U.S. R&D system. R&D is performed across a wide range of manufacturing and nonmanufacturing sectors. R&D intensity is concentrated, however, in a few industries.

- The R&D performed domestically by U.S. businesses occurs mainly in five business sectors: chemicals manufacturing (particularly the pharmaceuticals industry); computer and electronic products manufacturing;

transportation equipment manufacturing (particularly the automobile and aerospace industries); information (particularly the software publishing industry); and professional, scientific, and technical services (particularly the computer systems design and scientific R&D services industries).

- In 2015, these five business sectors accounted for 83% of the $355.8 billion total domestic business R&D performance that year. Similarly, in 2008, the five sectors accounted for 84% of the business total.
- Considering U.S. business as a whole, domestic R&D is mainly funded through performing companies' own funds: 83% in 2015 (and similar shares for recent years). For the remaining 17%, where the R&D is performed by companies but funded by others, the largest source of funding is the federal government, whose funding accounted for about 8% of the business R&D performance total in 2015. Other companies located domestically contributed another 4% of the funding, and foreign companies about 5% of the funding. Nonfederal governments and both domestic and foreign nonprofit organizations also were sources but at very small levels. (Some notable departures from these aggregate average shares occur when specific sectors and industries are considered.)
- Large companies (those with 25,000 or more domestic employees) accounted for 36% of all U.S. business R&D performance in 2015. Micro companies (those with 5-9 domestic employees) and small companies (10-49 domestic employees) together accounted for 5%. The other 59% was spread among the size classifications between these extremes. This distribution of business R&D performance share by size has not greatly changed in recent years.

Recent Trends in Federal Support for U.S. R&D

Federal funding for the R&D performed by federal departments and agencies, as well as most of the other major U.S. R&D performers, increased annually (in both current and constant dollar terms) from the late 1990s through FY 2010. Over the years since, however, the levels of federal support have dropped noticeably.

- Federal obligations for the total of R&D and R&D plant were $129 billion in FY 2008, $145 billion in FY 2009, and $147 billion in FY 2010. But the years thereafter have been marked by several large declines—in FYs 2011 and 2013, with only modest offsetting increases in FYs 2012, 2014, and 2015. Federal R&D funding had dropped to $131 billion in FY 2015—a decline of 18% from the FY 2010 level, when adjusted for inflation.
- Fifteen federal departments and 12 other agencies engage in and/or fund R&D in the United States. Eight of these departments or agencies reported R&D obligations in FY 2015 in excess of $1 billion: U.S. Department of Agriculture, Department of Commerce, Department of Defense (DOD), Department of Energy, Department of Health and Human Services (HHS), Department of Homeland Security, National Science Foundation, and National Aeronautics and Space Administration. These together accounted for 97% of all federal obligations for R&D that year.
- DOD has historically accounted for half or more of annual federal R&D funding. Health-related R&D accounts for the majority of federal nondefense R&D funding. DOD and HHS have borne the brunt of the federal R&D funding decline since FY 2010, with the other nondefense categories being much less affected.

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Introduction

Chapter Overview

Scientific discoveries, new technologies, and the aggressive application of cutting edge knowledge are essential for success in a competitive global economy. As such, the strength of a country's overall R&D enterprise—including both the public and private realms of this system—is an important marker of current and future national economic advantage.

This chapter identifies the essential current trends in the performance and funding of the U.S. R&D system. The discussion covers the sectors mainly responsible for present U.S. R&D performance and funding: the business sector, federal government, nonfederal government, higher education institutions, and other nonprofit organizations. At numerous points, the chapter directly contrasts these U.S. R&D indicators with broadly comparable data from the world's other major economies.

Chapter Organization

This chapter is organized into four principal sections on the following discussion topics: the recent trends (particularly over the last 5–10 years) in overall U.S. R&D performance, comparison of U.S. R&D performance to that of other leading countries, the U.S. business sector's large role in the nation's overall R&D activity, and the federal government's roles in supporting and conducting U.S. R&D.

Recent Trends in U.S. R&D Performance

The U.S. R&D system consists of the R&D activities of a variety of performers and sources of funding. Included here are private businesses, the federal government, nonfederal government, higher education (universities and colleges), and other nonprofit organizations. The organizations that perform R&D often receive significant levels of outside funding; furthermore, those that fund R&D may also themselves be significant performers. This section discusses the current levels and notable recent trends in overall U.S. R&D performance and the sources funding these activities. (Definitions for key terms in this section appear in this chapter's Glossary. The sidebar Measured and Unmeasured R&D discusses the main data sources for the indicators and analyses in this section of the chapter. In addition to the data presented in this section's figures and tables, National Center of Science and Engineering Statistics [NCSES] statistics on U.S. R&D performance go back to 1953; this historical time series can be found in Appendix Table 4-1 through Appendix Table 4-9.)

SIDEBAR

Measured and Unmeasured R&D

The statistics on U.S. R&D discussed in this section reflect the periodic *National Patterns of R&D Resources* reports from the National Center of Science and Engineering Statistics (NCSES) within the National Science Foundation (NSF), which provide a comprehensive account of total U.S. R&D performance. The *National Patterns* data, in turn, derive from six major NCSES surveys of the organizations that perform or fund the bulk of U.S. R&D:

- Business R&D and Innovation Survey
- Higher Education Research and Development Survey
- Survey of Federal Funds for Research and Development
- Federally Funded Research and Development Center R&D Survey
- Survey of State Government Research and Development
- Survey of Research and Development Funding and Performance by Nonprofit Organizations

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

Because of practical constraints in the surveys, some elements of R&D performance are omitted from the U.S. totals. In evaluating R&D performance trends over time and in international comparisons, it is important to be aware of these omissions.

The U.S. business R&D estimates are derived from a survey of R&D-performing companies with five or more employees. No estimates of R&D performance currently are available for companies with fewer than five employees. Nonetheless, NCSES survey development efforts have been underway over the last several years such that R&D data on this micro business population are expected to be available in the future.

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

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

Statistics on R&D performed by state governments are collected in an annual NCSES and U.S. Census Bureau survey. Although these data represent small amounts (typically totaling only several hundred million dollars annually), they are now included in the *National Patterns* totals. Estimates for the R&D performed in the U.S. by nonprofit organizations remain based on parameters in NSF's 1996–97 survey of this sector. A pilot test for a new and expanded nonprofit R&D survey has recently been completed; a full fielding of the new survey is now anticipated in 2018.

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

The most recent NCSES data indicate that R&D performed in the United States totaled $495.1 billion in 2015 (Table 4-1; Figure 4-1). The corresponding total for 2014 was $475.4 billion. These numbers compare to U.S. R&D totals of $433.6 billion in 2012 and $454.0 billion in 2013. In 2008—just before the onset of the main economic effects of the national and international financial crisis and the Great Recession—the U.S. total was $404.8 billion. (All amounts and calculations are in current dollars, unless otherwise noted.)

TABLE 4-1

U.S. R&D expenditures, by performing sector and source of funds: 2008–15

(Millions of current and constant 2009 dollars)

Sector	2008	2009	2010	2011	2012	2013	2014	2015[a]
Current $millions								
All performing sectors	404,773	402,931	406,580	426,160	433,619	453,964	475,426	495,144
Business	290,680	282,393	278,977	294,092	302,251	322,528	340,728	355,821
Federal government	45,649	47,572	50,798	53,524	52,144	51,086	52,687	54,322
Federal intramural[b]	29,839	30,560	31,970	34,950	34,017	33,406	34,783	35,673
FFRDCs	15,810	17,013	18,828	18,574	18,128	17,680	17,903	18,649
Nonfederal government	491	606	691	694	665	620	583	610
Higher education	52,054	54,909	58,084	60,089	60,896	61,546	62,354	64,653
Other nonprofit organizations[c]	15,898	17,452	18,030	17,762	17,663	18,185	19,075	19,738
All funding sources	404,773	402,931	406,580	426,160	433,619	453,964	475,426	495,144
Business	258,016	246,610	248,124	266,421	275,717	297,167	318,382	333,207
Federal government	117,615	125,765	126,617	127,015	123,838	120,130	118,363	120,933
Nonfederal government	4,221	4,295	4,302	4,386	4,158	4,244	4,214	4,280
Higher education	11,738	12,056	12,262	13,104	14,300	15,378	16,217	17,334
Other nonprofit organizations[c]	13,184	14,205	15,275	15,235	15,607	17,045	18,250	19,390
Constant 2009 $millions								
All performing sectors	407,848	402,931	401,673	412,503	412,127	424,610	436,844	450,080
Business	292,888	282,393	275,610	284,667	287,271	301,673	313,077	323,437
Federal government	45,995	47,572	50,185	51,809	49,560	47,783	48,411	49,378
Federal intramural[b]	30,066	30,560	31,584	33,830	32,331	31,246	31,961	32,427
FFRDCs	15,930	17,013	18,601	17,978	17,229	16,537	16,451	16,951
Nonfederal government	495	606	683	672	632	580	536	555
Higher education	52,450	54,909	57,383	58,163	57,877	57,566	57,293	58,768
Other nonprofit organizations[c]	16,019	17,452	17,812	17,193	16,788	17,009	17,527	17,942
All funding sources	407,848	402,931	401,673	412,503	412,127	424,610	436,844	450,080

Sector	2008	2009	2010	2011	2012	2013	2014	2015[a]
Business	259,975	246,610	245,129	257,883	262,051	277,952	292,544	302,881
Federal government	118,508	125,765	125,089	122,944	117,700	112,363	108,758	109,927
Nonfederal government	4,253	4,295	4,250	4,245	3,952	3,970	3,872	3,890
Higher education	11,827	12,056	12,114	12,684	13,591	14,383	14,901	15,756
Other nonprofit organizations[c]	13,284	14,205	15,091	14,747	14,833	15,943	16,769	17,625

FFRDC = federally funded research and development center.

[a] Some data for 2015 are preliminary and may later be revised.

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

[c] Some components of the R&D performed by other nonprofit organizations are projected and may later be revised.

Note(s)

Data are based on annual reports by performers, except for the nonprofit sector. Expenditure levels for higher education, federal government, and nonfederal government performers are calendar-year approximations based on fiscal year data.

Source(s)

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

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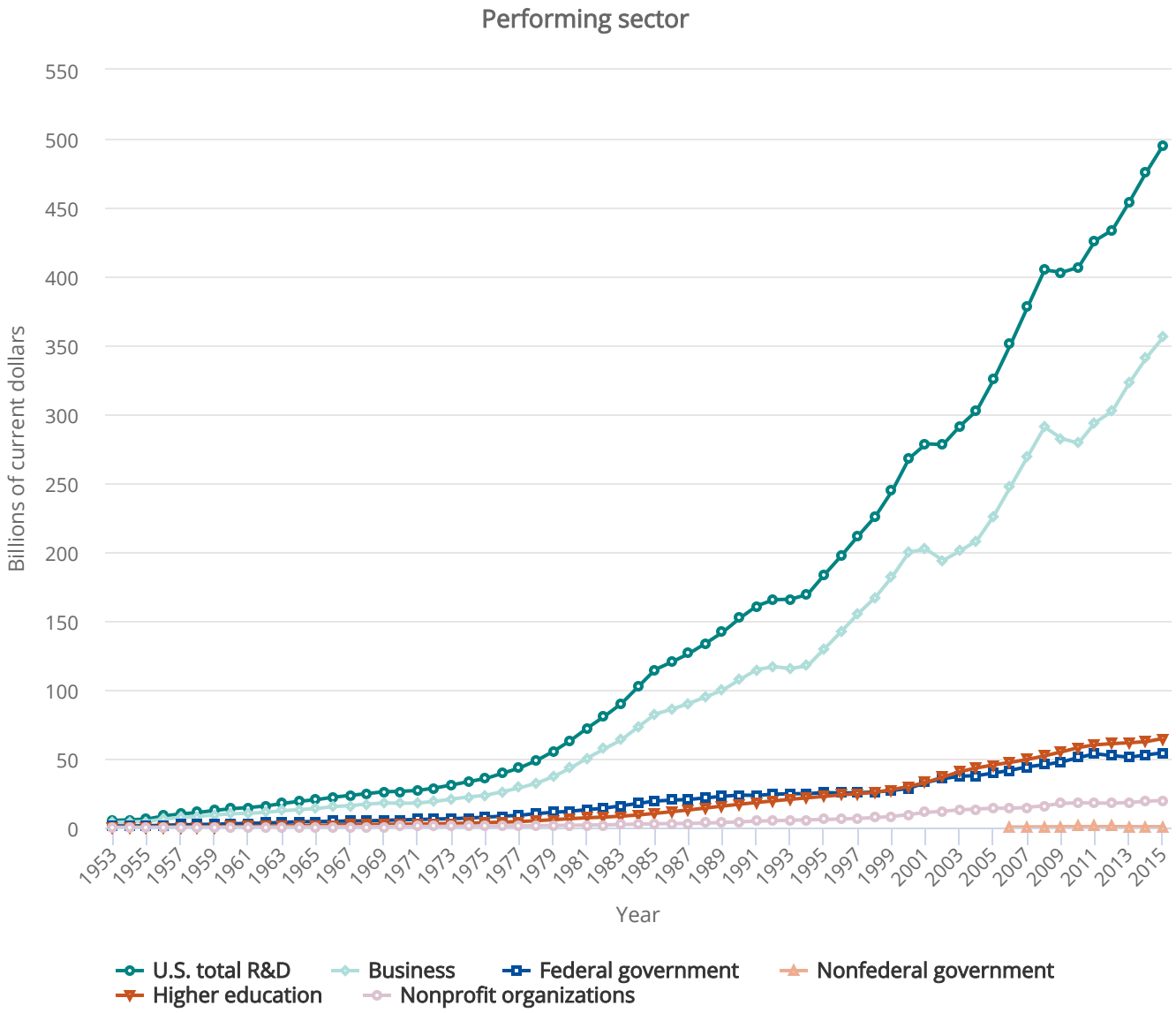
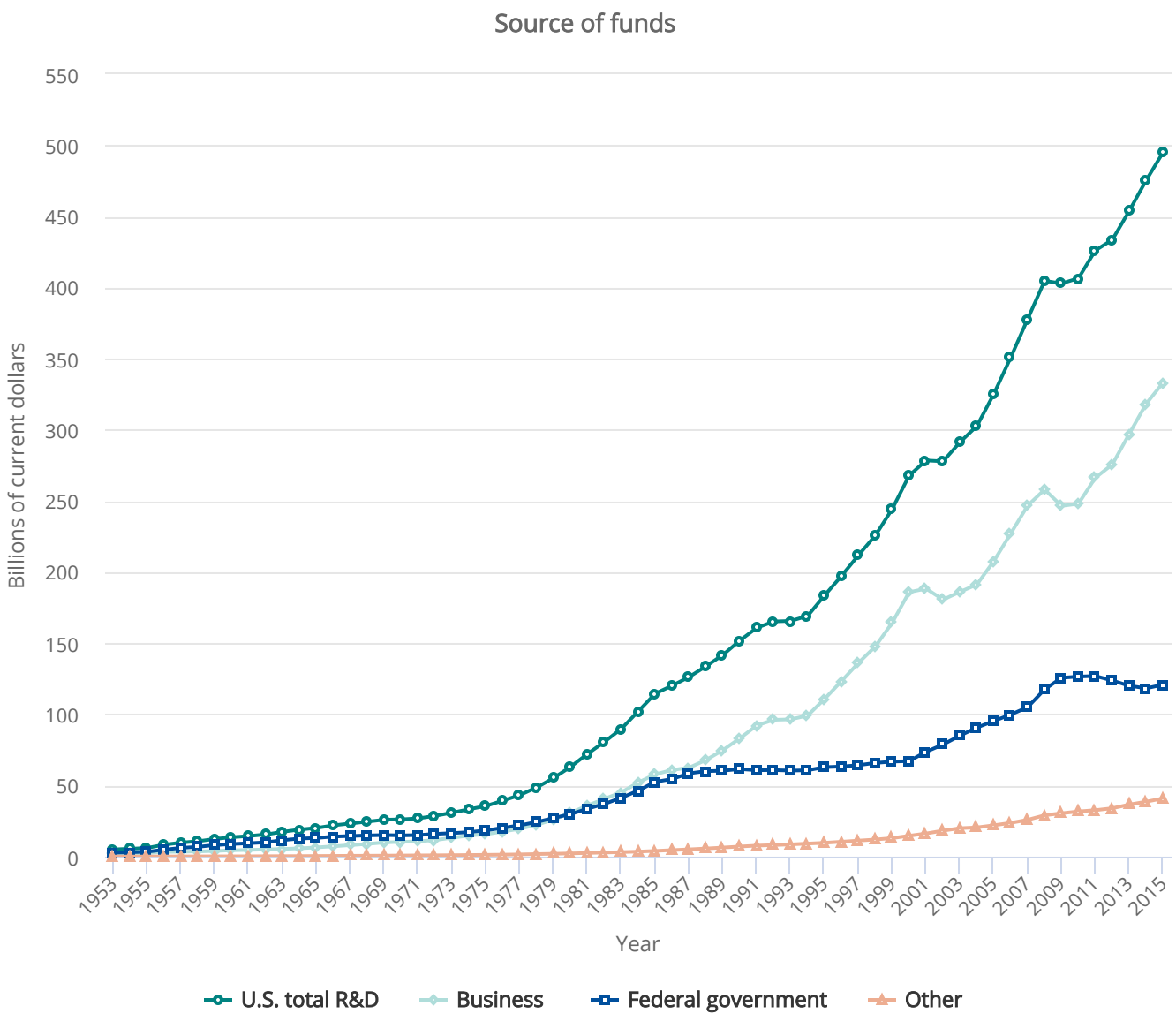
FIGURE 4-1

U.S. R&D, by performing sector and source of funds: 1953–2015





Note(s)

Some data for 2015 are preliminary and may later be revised. Some components of the R&D performed by other nonprofit organizations are projected and may later be revised. Federal performers of R&D include federal agencies and federally funded R&D centers. Performance by nonfederal government includes mainly state and local governments (data in this series are not available before 2006). Other funding includes support from higher education, nonfederal government, and nonprofit organizations.

Source(s)

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

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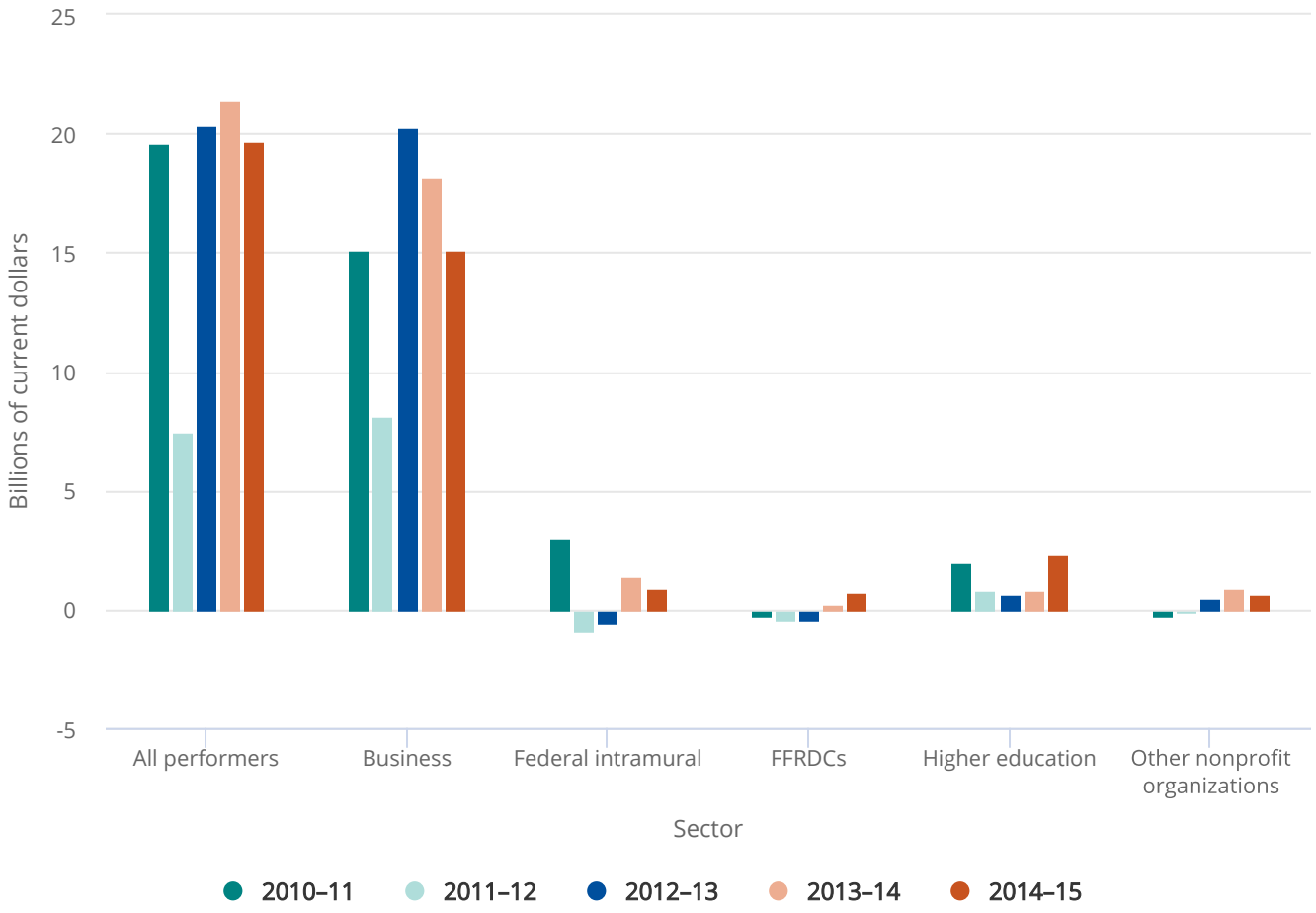
These data reflect increases of $21.5 billion in 2014 and $19.7 billion in 2015—year-over-year increases in the U.S. total from 2010 to 2015 averaged $17.7 billion. The 2014 and 2015 increases reflect mainly higher levels of business R&D

performance (Figure 4-2). Across the other main R&D-performing sectors, the annual changes were far smaller—and in some cases, were declines.

FIGURE 4-2

Year-to-year changes in U.S. R&D expenditures, by performing sector: 2010–15



FFRDC = federally funded research and development center.

Note(s)

Data are calculated from R&D expenditure data reported for performers in Table 4-1. Expenditures by nonfederal government performers are comparatively negligible, and specific bars for this sector are excluded.

Source(s)

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

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Adjusted for inflation, growth in U.S. total R&D averaged 1.4% annually over the 7-year period of 2008–15, marginally behind the 1.5% average pace of U.S. gross domestic product (GDP) (Table 4-2).[1] By comparison, the average annual rate of growth was notably higher in the prior 10-year period (1998–2008): 3.6% for total R&D and 2.2% for GDP. (As a comparative yardstick, a 7% average annual rate of growth yields a doubling of the quantity in 10 years.)

In part, the smaller average annual rate of growth for the 2008–15 period (by contrast to 1998–2008) partly reflects the inclusion of the Great Recession years (notably, 2009 and 2010) at the outset of this period. Considering just the 5-year period of 2010–15, the average annual pace of growth for U.S. R&D is 2.3%, compared to 2.2% for GDP (Table 4-2). The growth of business R&D over this same 5-year period is 3.3%, well ahead of GDP growth, but it is not strong enough to offset the slower average rates of growth (if not outright declines) in some of the other performing sectors.

TABLE 4-2

Annual rates of growth in U.S. R&D expenditures, total and by performing sectors: 1988–2015

(Percent)

Expenditures and gross domestic product	Longer-term trends			Most recent years						
	1988–98	1998–2008	2008–15	2008–09	2009–10	2010–11	2011–12	2012–13	2013–14	2014–15
Current $										
Total R&D, all performers	5.4	6.0	2.9	-0.5	0.9	4.8	1.8	4.7	4.7	4.1
Business	5.8	5.7	2.9	-2.9	-1.2	5.4	2.8	6.7	5.6	4.4
Federal government	1.8	5.9	2.5	4.2	6.8	5.4	-2.6	-2.0	3.1	3.1
Federal intramural[a]	1.9	5.6	2.6	2.4	4.6	9.3	-2.7	-1.8	4.1	2.6
FFRDCs	1.6	6.4	2.4	7.6	10.7	-1.4	-2.4	-2.5	1.3	4.2
Nonfederal government[b]	NA	NA	3.1	NA	14.1	0.4	-4.2	-6.8	-5.9	4.6
Higher education	6.0	7.4	3.1	5.5	5.8	3.5	1.3	1.1	1.3	3.7
Other nonprofit organizations[c]	8.5	8.2	3.1	9.8	3.3	-1.5	-0.6	3.0	4.9	3.5
Gross domestic product	5.6	4.9	3.0	-2.0	3.8	3.7	4.1	3.3	4.4	4.0
Constant 2009$										
Total R&D, all performers	2.9	3.6	1.4	-1.2	-0.3	2.7	-0.1	3.0	2.9	3.0
Business	3.3	3.3	1.4	-3.6	-2.4	3.3	0.9	5.0	3.8	3.3
Federal government	-0.6	3.4	1.0	3.4	5.5	3.2	-4.3	-3.6	1.3	2.0
Federal intramural[a]	-0.5	3.2	1.1	1.6	3.4	7.1	-4.4	-3.4	2.3	1.5
FFRDCs	-0.8	4.0	0.9	6.8	9.3	-3.3	-4.2	-4.0	-0.5	3.0
Nonfederal government[b]	NA	NA	1.6	NA	12.7	-1.6	-5.9	-8.3	-7.5	3.5
Higher education	3.5	4.9	1.6	4.7	4.5	1.4	-0.5	-0.5	-0.5	2.6
Other nonprofit organizations[c]	5.9	5.7	1.6	8.9	2.1	-3.5	-2.4	1.3	3.0	2.4
Gross domestic product	3.4	2.2	1.5	-2.8	2.5	1.6	2.2	1.7	2.6	2.9

NA = not available.

FFRDC = federally funded research and development center.

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

[b] Survey data on state internal R&D performance were not available prior to 2006.

[c] Some components of the R&D performed by other nonprofit organizations are projected and may later be revised.

Note(s)

Longer-term trend rates are calculated as compound annual growth rates. Data for 2015 are preliminary and may later be revised.

Source(s)

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

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Regarding the intensity of R&D in the national economy, the ratio of U.S. R&D expenditures to GDP was 2.73% in 2015 and also 2.73% in 2014 (Figure 4-3). In comparison, the ratio was 2.72% in 2013 and 2.68% in 2012. (The ratio of total national R&D expenditures to GDP is often reported as a measure of the intensity of a nation's overall R&D effort and is widely used as an international benchmark for comparing countries' R&D activities.)

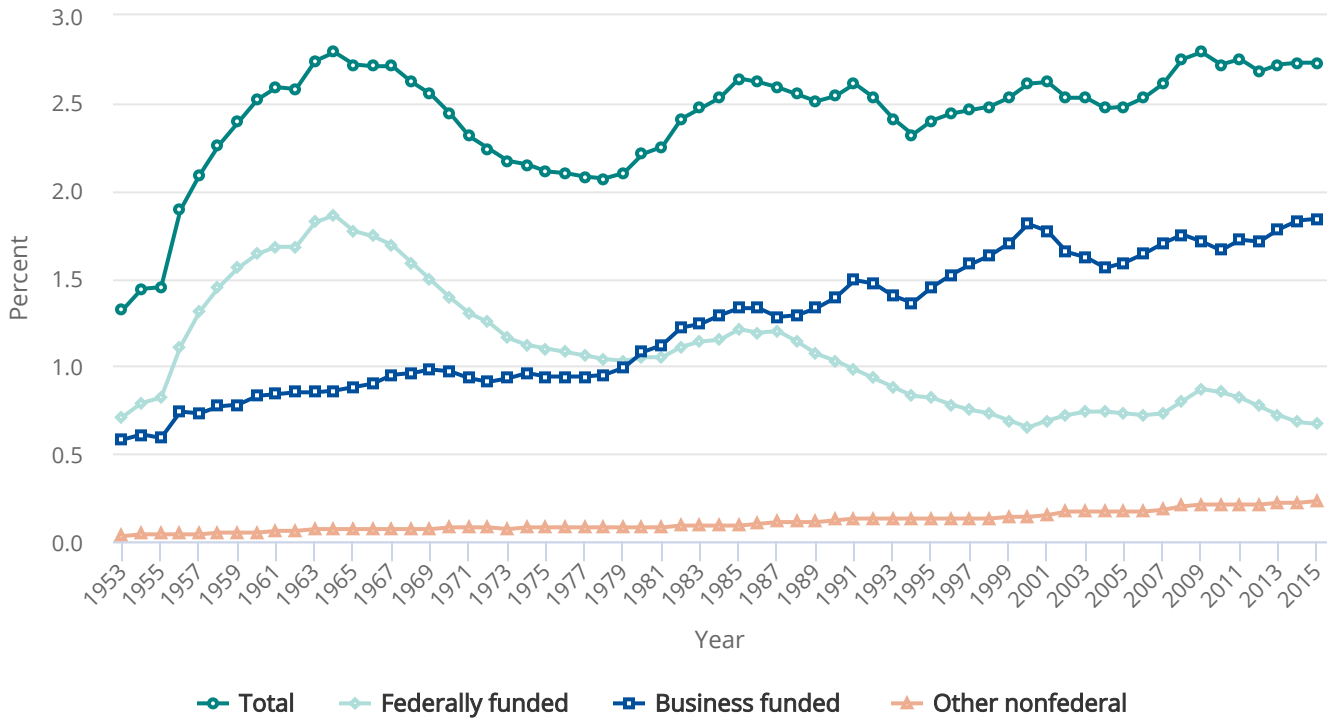
The U.S. R&D-to-GDP ratio stood at 2.79% in 2009—matching the ratio's highest level since the start of the time series in 1953 (it was also 2.79% in 1964). Over the 10-year period 2005–15, the ratio has fluctuated year to year, between a low of 2.48% in 2005 and the aforementioned high of 2.79% in 2009.

The broader trend since the late 1990s has been a rising R&D-to-GDP ratio, although with some periods of decline. Most of the rise of this ratio over the past several decades has been from the increase of nonfederal spending on R&D, particularly by the business sector. This arises from the growing role of business R&D in the national R&D system, which in turn reflects the unabated increase of R&D-dependent goods and services in the national and global economies.

By contrast, the ratio of federally funded R&D expenditures to GDP declined from the mid-1980s to the late 1990s, notably from cuts in defense-related R&D. There had been a gradual uptick in the ratio through 2009, the result of increased federal spending on biomedical and national security R&D and the one-time incremental funding for R&D provided by the American Recovery and Reinvestment Act of 2009 (ARRA). But the federally funded R&D-to-GDP ratio has returned to a path of decline since 2010 (Figure 4-3).

FIGURE 4-3

Ratio of U.S. R&D to gross domestic product, by roles of federal, business, and other nonfederal funding for R&D: 1953–2015



Note(s)

Some data for 2015 are preliminary and may later be revised. The federally funded data represent the federal government as a funder of R&D by all performers and similar for the business-funded data. The other nonfederal category includes R&D funded by all other sources—mainly, higher education, nonfederal government, and other nonprofit organizations. The gross domestic product data used reflect the U.S. Bureau of Economic Analysis's comprehensive revisions of the national income and product accounts of July 2017.

Source(s)

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

Science and Engineering Indicators 2018

Of note, the Department of Commerce's Bureau of Economic Analysis (BEA) introduced a comprehensive set of revisions to the U.S. national income and product accounts in July 2013, including explicitly recognizing R&D as investment in the measure of U.S. GDP. These changes resulted in modest revisions to the U.S. GDP time series back to 1929. The R&D-to-GDP ratio data reported here reflect BEA's revised GDP data series, both in the present and the past. For further information, see sidebar R&D in the U.S. National Income and Product Accounts.

SIDEBAR

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

Comprehensive revision of the U.S. gross domestic product (GDP) and related national income and product accounts (NIPA), released by the Bureau of Economic Analysis (BEA) in July 2013, included a change to treat R&D as a fixed investment with long-term benefits. R&D investment is now recognized in NIPA in a new asset category called "intellectual property products," or intangible assets, along with software and entertainment, literary, and artistic originals. Before this change, the NIPA considered R&D as an expense or intermediate input cost in the business sector and as consumption in the government and nonprofit sectors (BEA 2013). This update is one of several NIPA changes aimed at capturing the role of intangible assets in economic growth. (BEA's comprehensive updates occur about every 5 years—the most recent of which was the aforementioned July 2013 update. However, there have also been annual updates since July 2013, each of which has affected GDP and related data for the most recent years.) The National Center for Science and Engineering Statistics (NCSES) surveys of U.S. R&D expenditures serve as the primary data source for the R&D component of these revisions. (For a further discussion, see Moris et al. [2015].)

As a part of these July 2013 revisions, BEA provided a revised time series for GDP and its components going back to 1929. After these comprehensive revisions, GDP levels are somewhat higher in this revised time series than previously reported. An implication is that the R&D-to-GDP ratios reported in past editions of *Science and Engineering Indicators* and related publications on U.S. R&D are somewhat smaller because of this higher reported GDP. For example, the U.S. R&D-to-GDP ratio for 2000, previously reported as 2.70%, is now 2.61% under the revised NIPA, or what was 2.84% in 2011 under the previous methodology is revised to 2.75%. The U.S. R&D statistics reported throughout in this chapter fully reflect BEA's revised GDP data series from the July 2013 comprehensive update and subsequent annual updates.

Performers of R&D

NCSES tracks the R&D spending patterns of the major performers in the overall U.S. R&D system. Included are businesses, the intramural R&D activities of federal agencies, federally funded research and development centers (FFRDCs), nonfederal government organizations (mainly state government), higher education institutions, and other nonprofit organizations. (All amounts and calculations are in current dollars, unless otherwise noted.)

Business Sector

The business sector is by far the largest performer of U.S. R&D. In 2015, domestically performed business R&D accounted for $355.8 billion, or 72% of the $495.1 billion national total (Table 4-1 and Table 4-3). The business sector's predominance in the composition of national R&D performance has long been the case, with its annual share ranging between 69% and 75% over the 20-year period of 1995–2015 (Appendix Table 4-2). Business R&D performance increased by $15.1 billion in 2015, following gains of $8.2 billion in 2012, $20.3 billion in 2013, and $18.2 billion in 2014. These increases are in contrast to the essentially unchanged levels of business R&D performance in both 2009 and 2010.[2]

TABLE 4-3

U.S. R&D expenditures, by performing sector, source of funds, and type of work: 2015

(Millions of dollars)

Performing sector and type of work	Total	Business	Federal government	Nonfederal government	Higher education	Other nonprofit organizations	Distribution by performer (%)
R&D	495,144	333,207	120,933	4,280	17,334	19,390	100.0
Business	355,821	327,589	26,990	127	*	1115	71.9
Federal government	54,322	205	53,960	19	*	138	11.0
Federal intramural	35,673	0	35,673	0	0	0	7.2
FFRDCs	18,649	205	18,287	19	*	138	3.8
Nonfederal government	610	*	249	361	*	*	0.1
Higher education	64,653	3,842	33,546	3,772	17,334	6,159	13.1
Other nonprofit organizations	19,738	1,572	6,189	*	*	11,978	4.0
Percent distribution by funding source	100.0	67.3	24.4	0.9	3.5	3.9	-
Basic research	83,462	22,717	36,946	2,354	10,880	10,565	100.0
Business	21,792	19,621	2,038	14	*	120	26.1
Federal government	10,053	47	9,969	4	*	32	12.0
Federal intramural	5,926	0	5,926	0	0	0	7.1
FFRDCs	4,127	47	4,043	4	*	32	4.9
Nonfederal government	100.5	*	41.0	59.5	*	*	0.1
Higher education	40,983	2,176	21,888	2,277	10,880	3,763	49.1
Other nonprofit organizations	10,534	873	3,010	*	*	6,651	12.6
Percent distribution by funding source	100.0	27.2	44.3	2.8	13.0	12.7	-

Performing sector and type of work	Total	Business	Federal government	Nonfederal government	Higher education	Other nonprofit organizations	Distribution by performer (%)
Applied research	97,150	51,738	34,511	1,419	4,567	4,917	100.0
Business	56,472	50,137	6,102	24	*	209	58.1
Federal government	16,551	96	16,382	9	*	64	17.0
Federal intramural	9,200	0	9,200	0	0	0	9.5
FFRDCs	7,351	96	7,182	9	*	64	7.6
Nonfederal government	496.0	*	202.2	293.8	*	*	0.5
Higher education	17,466	1,107	9,094	1,092	4,567	1,608	18.0
Other nonprofit organizations	6,165	398	2,731	*	*	3,036	6.3
Percent distribution by funding source	100.0	53.3	35.5	1.5	4.7	5.1	-
Experimental development	314,532	258,753	49,476	507	1,888	3,908	100.0
Business	277,557	257,831	18,850	90	*	786	88.2
Federal government	27,718	62	27,609	6	*	42	8.8
Federal intramural	20,547	0	20,547	0	0	0	6.5
FFRDCs	7,171	62	7,062	6	*	42	2.3
Nonfederal government	13.6	*	5.5	8.0	*	*	0.0
Higher education	6,204	560	2,565	404	1,888	789	2.0
Other nonprofit organizations	3,040	301	447	*	*	2,292	1.0

Performing sector and type of work	Total	Business	Federal government	Nonfederal government	Higher education	Other nonprofit organizations	Distribution by performer (%)
Percent distribution by funding source	100.0	82.3	15.7	0.2	0.6	1.2	-

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

FFRDC = federally funded research and development center.

Note(s)

Data for 2015 include some estimates and may later be revised. Some components of R&D performance and funding by other nonprofit organizations are projected and may later be revised.

Source(s)

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

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Inflation-adjusted growth in business R&D averaged 1.4% annually over the 7-year period 2008–15, essentially at the 1.4% annual average for total R&D and just behind the 1.5% annual average for GDP (Table 4-2). Nonetheless, growth in business R&D substantially surpassed the growth rates for both total R&D and GDP in 4 of the 7 years spanning the full 2008–15 period (2011, 2013, 2014, and 2015).

Higher Education

The higher education sector is the second largest performer of U.S. R&D. Universities and colleges performed $64.7 billion, or 13%, of U.S. R&D in 2015 (Table 4-1 and Table 4-3).[3] Over the 20-year period 1995–2015, the higher education share of U.S. R&D has ranged between 11% and 14% (Appendix Table 4-2). Furthermore, the higher education sector is a special niche in the nation's overall R&D system: in recent years it has accounted for just under half of the nation's basic research, while training the nation's next generation of researchers. (For statistics, see section R&D, by Type of Work later in this chapter.)

Higher education R&D performance increased by $2 billion–$3 billion each year over 2009–11; however, the annual increases dropped below $1 billion in 2012–14 (Table 4-1). The data show a $2 billion increase in 2015. After adjusting for inflation, growth in this sector's R&D performance averaged 1.6% annually over 2008–15, somewhat ahead of that for U.S. total R&D (1.4%) and GDP (1.5%). However, when the year-by-year track is examined, the sector's growth was stronger in the first half of this period (2009, 2010, and 2011) (Table 4-2).

Federal Agencies and Federally Funded Research and Development Centers

The federal government conducted $54.3 billion, or 11%, of U.S. R&D in 2015 (Table 4-1 and Table 4-3). This included $35.7 billion (7% of the U.S. total) for intramural R&D performed by federal agencies in their own research facilities and $18.6 billion (4%) of R&D performed by the 41 FFRDCs.[4] (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.[5]) In 1995, the federal performance share of U.S R&D was about 14%, but it has gradually declined—although with some occasional increases—in the years since.

The federal performance total increased by $2 to $3 billion each year over 2009–11. But it decreased $1.4 billion in 2012 and $1.1 billion in 2013. In 2014, there was a $1.6 billion increase and about the same in 2015. These changes affected both federal intramural R&D and FFRDCs (Table 4-1). Adjusted for inflation, growth in this sector's R&D performance averaged 1.0% annually over 2008–15, behind that for U.S. total R&D (1.4%) and GDP (1.5%). The reversal in the 2012–15 period of the expansionary trend seen during 2009–11 reflects both the waning after 2010 of the incremental funding from ARRA and the more recent federal budget environment after 2011.

This volume of the federal government's R&D performance is small compared with that of the U.S. business sector. Even so, the $54.3 billion performance total in 2015 exceeded the total national R&D expenditures of every country except China, Japan, Germany, South Korea, and France.[6]

Other Nonprofit Organizations and Nonfederal Government

R&D performed in the United States by other nonprofit organizations (which excludes universities and FFRDCs) was $19.7 billion in 2015 (Table 4-1 and Table 4-3). This was 4% of U.S. total R&D in 2015, a share that has increased only slightly since the late 1990s.

NCSES started to track the annual intramural R&D performance of state agencies in 2006. The total for all 50 states and the District of Columbia in 2015 is estimated to be $610 million—a small share (about 0.1%) of the U.S. total (Table 4-1 and Table 4-3).

Geographic Location of R&D

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

SIDEBAR

Location of R&D Performance, by State

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

In 2015, the 10 states with the largest R&D expenditure levels accounted for about 65% of U.S. R&D expenditures that can be allocated to the states: California, Massachusetts, Texas, New York, Maryland, Michigan, Washington, Illinois, New Jersey, and Pennsylvania (Table 4-A; Appendix Table 4-10).* California alone accounted for 25% of the U.S. total, about four times as much as Massachusetts, the next highest state. The top 20 states accounted for 85% of the R&D total; the 20 lowest-ranking states accounted for around 4% (Appendix Table 4-11).

The states with the largest R&D expenditures are not necessarily those with the highest intensity of R&D. Among those with the greatest R&D-to-GDP ratios in 2015 were New Mexico, Massachusetts, Maryland, California, and Washington (Table 4-A). New Mexico is the location of several major government research facilities. Massachusetts benefits from both leading research universities and thriving high-technology industries. Maryland is the site of many government research facilities and growing research universities. California has relatively high R&D intensity and benefits from the presence of Silicon Valley, other high-technology industries, federal R&D, and leading research universities, but it is still fourth on this list. Washington State is home to government research facilities, leading research universities, and high-technology industries.

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, higher education, federal intramural R&D facilities, and federally funded R&D centers [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 2015, R&D performed by the business sector accounted for about 73% of the U.S. total R&D that could be allocated to specific states. Of the top 10 states in total R&D performance, 9 states are also in the top 10 in business R&D. Connecticut, 10th in business sector R&D, surpasses Maryland in the business R&D ranking.

Higher education-performed R&D accounts for 15% of the allocable U.S. total. The top 10 states for higher education R&D performance include 7 that are also top 10 in total R&D performance. But Connecticut, New Jersey, and Washington fall out and are replaced by Florida, Maryland, and North Carolina.

Federal R&D performance (including both intramural R&D facilities and FFRDCs)—about 10% of the U.S. total—is more concentrated geographically than other sectors. Only five jurisdictions—Maryland, California, New Mexico, Virginia, and the District of Columbia—account for 63% of all federal R&D performance.† This figure rises to 80% when the other 5 of the top 10 state locations for federal R&D performance—Massachusetts, Alabama, Tennessee, Washington, and Illinois—are included.

Federal R&D accounts for the bulk of total R&D in several states, including New Mexico (85%), which is home to the nation's two largest FFRDCs (Los Alamos and Sandia National Laboratories), and Tennessee (35%), which is home to Oak Ridge National Laboratory. The high figures for Maryland (55%), the District of Columbia (67%), and Virginia (41%) reflect the concentration of federal facilities and federal R&D administrative offices in the national capital area.

TABLE 4-A

Top 10 states in U.S. R&D performance, by sector and intensity: 2015

(Millions of current dollars, ranking, and R&D-to-GDP ratio)

Rank	All R&D[a]		Sector ranking			R&D intensity (R&D-to-GDP ratio)		
	State	Amount (current $millions)	Business	Higher education	Federal intramural and FFRDCs[b]	State	R&D/ GDP (%)	GDP (current $billions)
1	California	125,056	California	California	Maryland	New Mexico	6.52	93.2
2	Massachusetts	28,665	Massachusetts	New York	California	Massachusetts	5.87	488.1
3	Texas	23,668	Michigan	Texas	New Mexico	Maryland	5.57	366.2
4	New York	22,401	Texas	Maryland	Virginia	California	5.02	2,491.6
5	Maryland	20,385	Washington	Massachusetts	District of Columbia	Washington	4.49	446.4
6	Michigan	19,891	New York	Pennsylvania	Massachusetts	Michigan	4.23	470.6
7	Washington	20,038	New Jersey	North Carolina	Alabama	Delaware	4.19	68.9
8	Illinois	16,502	Illinois	Illinois	Tennessee	Connecticut	3.87	256.3
9	New Jersey	15,865	Pennsylvania	Florida	Illinois	Idaho	3.34	72.6
10	Pennsylvania	14,839	Connecticut	Michigan	Washington	Oregon	3.38	215.3

FFRDC = federally funded research and development center; GDP = gross domestic product.

[a] Includes in-state total R&D performance of the 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.

Note(s)

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.

Source(s)

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 Table 4-10.

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* The latest data available on the distribution of U.S. R&D performance by state are for 2015 (Appendix Table 4-10). Total U.S. R&D expenditures that year are estimated at $495.1 billion. Of this total, $468.9 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 several 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 (about $11 billion in 2015) 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 other performers, 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.

Sources of R&D Funding

Funds that support the conduct of R&D in the United States come from a variety of sources, including businesses, federal and nonfederal government agencies, higher education institutions, and other nonprofit organizations. For the most part, the mix of funding sources varies by performer. (All amounts and calculations are in current dollars, unless otherwise noted.)

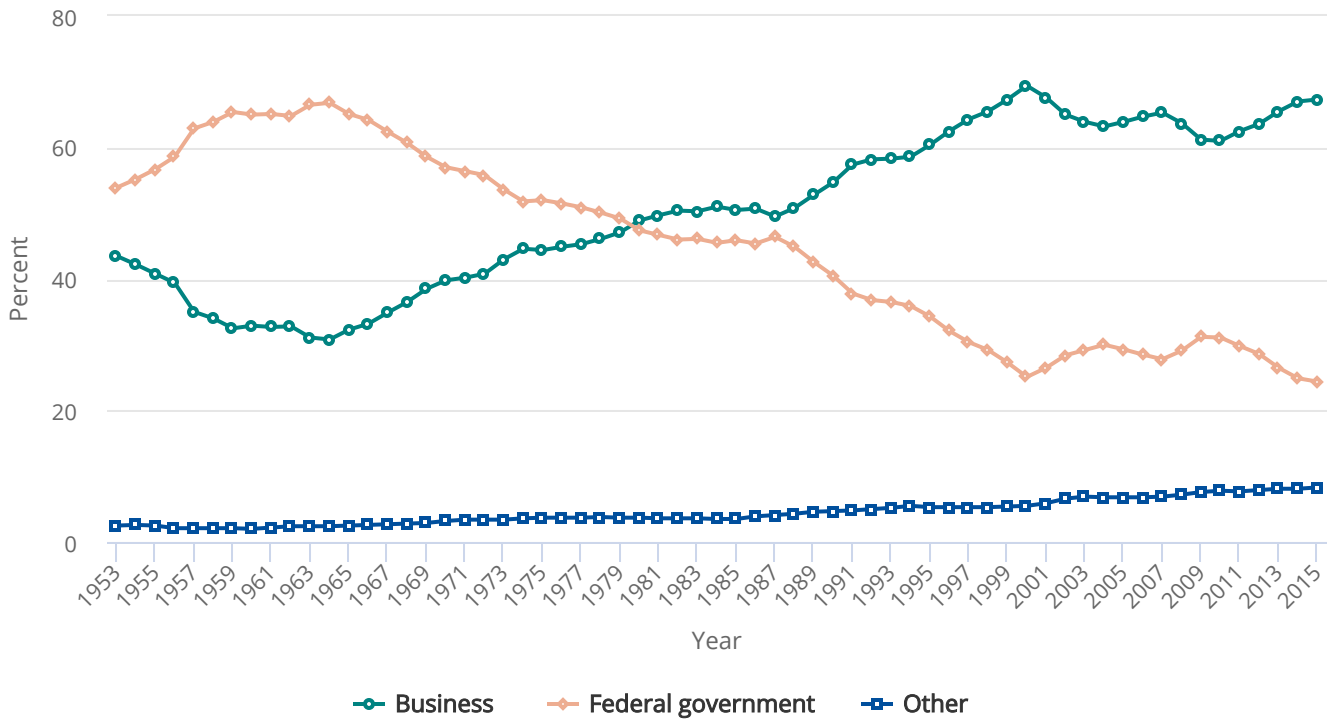
R&D Funding by Business

The business sector is the predominant source of funding for R&D performed in the United States. In 2015, business sector funding accounted for $333.2 billion, or 67%, of the $495.1 billion of total U.S. R&D performance (Table 4-1 and Table 4-3). Nearly all (98%) of the business sector's funding for R&D that year was directed at business R&D performance—even if funding provided by some businesses was performed by other businesses.[7] The small remainder went to R&D performers in higher education, other nonprofit organizations, and FFRDCs.

The business sector's large role in the nation's R&D funding began in the early 1980s, when the support it provided started to exceed 50% of all U.S. R&D funding (Figure 4-4). This business share moved up to 60% in 1995. It has been above that level throughout the years since, but fluctuating in the range of 60%–69% (Appendix Table 4-6).

FIGURE 4-4

U.S. total R&D expenditures, by source of funds: 1953–2015



Note(s)

Data for 2015 are preliminary and may later be revised. The other category includes nonfederal government, higher education, and other nonprofit organizations.

Source(s)

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

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R&D Funding by the Federal Government

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

Funds from the federal government accounted for $120.9 billion, or 24%, of U.S. total R&D in 2015 (Table 4-1 and Table 4-3). This federal funding was directed mainly to R&D performance by the federal government, business, and higher education.

Federal funding accounted for all of the $35.7 billion of federal intramural R&D performance in 2015 and most (98%) of the $18.6 billion of R&D performed by FFRDCs. Nonfederal support for FFRDC R&D has been around $0.4 billion or so in recent years, or 2% of FFRDCs' total support.

Federal funding to the business sector accounted for $27.0 billion of business R&D performance in 2015, or 8% of the sector's R&D total that year (Table 4-3). Federal funds to higher education supported $33.5 billion, or 52%, of the $64.7 billion spent on academic R&D in 2015. For the R&D performed by other nonprofit organizations, $6.2 billion (31%) of this sector's $19.7 billion of performance was supported by federal funds.

The federal government was once the leading sponsor of the nation's R&D, funding some 67% of all U.S. R&D in 1964 (Figure 4-4). The federal share decreased in subsequent years to 49% in 1979, 36% in 1994, down to a historical low of 25% in 2000. However, changing business conditions and expanded federal funding for health, defense, and counterterrorism R&D (including that from the ARRA) pushed the federal funding share to 31% in 2009 and 2010. But the federal share has declined somewhat in the subsequent years, falling to 24% in 2015, reflecting the waning after 2010 of the incremental funding from the ARRA and the more recent federal budget environment since 2011.

Through the early 1960s, the federal government had funded more than half of the nation's business-performed R&D. However, this share declined in subsequent years to around 9% in 2000, increasing again to 12%–14% from 2008 to 2010, but dropping back down to 8% by 2015 (Appendix Table 4-2).

R&D Funding from Other Sources

The remainder of R&D funding from other sources is a smaller component: $41.0 billion in 2015, or about 8% of all U.S. R&D performance (Table 4-3). Of this amount, $17.3 billion (4%) was from higher education's own institutional funds, all of which remain in the academic sector; $4.3 billion (1%) was from state and local governments, primarily supporting academic research; and $19.4 billion (4%) was from other nonprofit organizations, the majority of which funds this sector's own R&D. Of the nonprofit total, some funds ($6.2 billion) support R&D in higher education, and small amounts support business ($1.1 billion) and FFRDC ($0.1 billion) R&D performance.

R&D, by Type of Work

Basic research activities accounted for $83.5 billion, or 17% of the total of U.S. R&D expenditures in 2015 (Table 4-3 and Table 4-4). Applied research was $97.2 billion, or 20% of the total. Most of the R&D total—$314.5 billion, or 64%—went toward experimental development. (For definitions of these terms, see this chapter's Glossary. All amounts and calculations are in current dollars, unless otherwise noted.)

TABLE 4-4

U.S. R&D expenditures by type of work: Selected years, 1970–2015

(Billions of current and constant 2009 dollars; percent distribution)

Type of work	1970	1980	1990	2000	2010	2011	2012	2013	2014	2015[a]
Current $billions										
All R&D	26.3	63.2	152.0	267.9	406.6	426.2	433.6	454.0	475.4	495.1
Basic research	3.6	8.7	23.0	42.0	75.9	73.0	73.3	78.5	82.1	83.5
Applied research	5.8	13.7	34.9	56.5	79.3	82.1	87.1	88.3	91.9	97.2
Experimental development	16.9	40.7	94.1	169.4	251.4	271.0	273.3	287.1	301.5	314.5
Constant 2009 $billions										
All R&D	115.3	142.5	227.6	327.2	401.7	412.5	412.1	424.6	436.8	450.1
Basic research	15.8	19.7	34.5	51.3	75.0	70.7	69.7	73.4	75.4	75.9
Applied research	25.2	30.9	52.3	69.0	78.3	79.5	82.8	82.6	84.4	88.3
Experimental development	74.3	91.8	140.9	206.9	248.4	262.3	259.7	268.6	277.0	285.9
Percent distribution										
All R&D	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Basic research	13.7	13.8	15.2	15.7	18.7	17.1	16.9	17.3	17.3	16.9
Applied research	21.9	21.7	23.0	21.1	19.5	19.3	20.1	19.5	19.3	19.6
Experimental development	64.4	64.5	61.9	63.2	61.8	63.6	63.0	63.3	63.4	63.5

[a] Some data for 2015 are preliminary and may later be revised.

Note(s)

Detail may not add to total because of rounding. Data throughout the time series reported here are consistently based on the Organisation for Economic Co-operation and Development's Frascati Manual definitions for basic research, applied research, and experimental development. For 2010 and subsequent years, however, some changes have been introduced in the questionnaires of the sectoral expenditure surveys to improve the accuracy of respondents' classification of their R&D. Therefore, small percentage changes may not be meaningful when comparing data before 2010 with more recent data.

Source(s)

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

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R&D encompasses a wide range of activities, from research yielding fundamental knowledge in the physical, life, and social sciences, and research addressing national defense needs and such critical societal issues as global climate change, energy efficiency, and health care to the development of platform or general-purpose technologies that can enable the creation and commercial application of new and improved goods and services. The most widely applied classification of these activities characterizes R&D as "basic research," "applied research," or "experimental development" (NSF 2006; OECD 2015; OMB 2017). (For definitions of these terms, see Glossary.)

This longstanding trio of categories has been criticized over the years as reinforcing the idea that creating new knowledge, invention, and innovation are linear processes beginning with basic research, followed by applied research and then development, and ending with the production and diffusion of new technologies and eventually commercially significant innovations. Nonetheless, alternative classifications that provide measurable distinctions, capture major differences in types of R&D, and are widely accepted as superior have yet to be developed. Despite the recognized limitations of the basic research-applied research-development classification framework, it remains useful in providing indications of differences in the motivation, expected time horizons, outputs, and types of investments associated with R&D projects.

Basic Research

Higher education institutions continued to be the primary performers of U.S. basic research in 2015, accounting for just under half (49%) of the $83.5 billion of basic research performance that year (Table 4-3). The business sector was the second largest basic research performer, about 26%. The federal government (agency intramural laboratories and FFRDCs) performed 12%, and other nonprofit organizations performed 13%.

The federal government remains the largest source of funding for basic research, accounting for about 44% of the $83.5 billion funding total in 2015 (Table 4-3). The business sector was also a substantial funder, providing 27% of the total.

Applied Research

The business sector performed 58% of the $97.2 billion of applied research in 2015 (Table 4-3). Higher education accounted for 18%, the federal government (federal agency intramural laboratories and FFRDCs) accounted for 17%, and nonprofit organizations accounted for 6% of applied research.

The business sector provided 53% of the funding for applied research in 2015, with the majority remaining within the sector (Table 4-3). The federal government accounted for about 36%, spread broadly across the performers, with the largest amounts going to higher education and federal intramural laboratories and FFRDCs.

Experimental Development

The business sector predominates in experimental development, performing 88% of the $314.5 billion the United States devoted to this R&D category in 2015 (Table 4-3).[8] The federal government (agency intramural laboratories, FFRDCs) accounted for another 9%—much of it defense related, with the federal government being the main consumer. By contrast, higher education and other nonprofit organizations perform relatively little development (respectively, 2% and 1% of the total in 2015).

The business sector provided 82% of the funding for the $314.5 billion of U.S. development in 2015, most of which remained in the sector (Table 4-3). Federal funding accounted for about 16% of the development total—with the business sector (especially defense-related industries) and federal intramural laboratories being the largest recipients.

Trend in Shares, by Type of R&D

Data on the split of U.S. total R&D among the three types of R&D work in previous years appear in Table 4-4. Care is needed in drawing trend conclusions from these data, for reasons discussed in the notes for Table 4-4.[9] Nonetheless, the

table's data indicate that the shares of basic research, applied research, and development were largely the same between 2010 and 2015—and, furthermore, were also not dramatically different in the more distant past. Adjusted for inflation, U.S. overall performance of basic research is somewhat higher in 2015 ($75.9 billion) than in 2010 ($75.0 billion). More substantial increases are registered for applied research ($88.3 billion in 2015, compared to $78.3 billion in 2010) and experimental development ($285.9 billion in 2015, compared to $248.4 billion in 2010).

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[1] In this chapter, dollars adjusted for inflation (i.e., constant dollars) are based on the GDP implicit price deflator (currently in 2009 dollars) as published by the Department of Commerce, BEA (https://www.bea.gov/iTable/index_nipa.cfm). A 1953–2015 time series for this deflator appears in Appendix Table 4-1. Note that GDP deflators are calculated on an economy-wide scale and do not explicitly focus on R&D.

[2] Because of sample variability in the data for the business R&D component, the reported totals for 2009 and 2010 are not significantly different from one another at a 90% confidence level.

[3] The data for academic R&D reported in this chapter adjust the academic fiscal year basis of NSF's Higher Education Research and Development Survey data to calendar year and net out pass-throughs of research funds to remove double-counting in the national totals. Accordingly, the academic data reported in this chapter may differ from those cited in Chapter 5.

[4] Federal intramural R&D performance includes the spending for both agency laboratory R&D and for agency activities to plan and administer intramural and extramural R&D projects.

[5] NCSES maintains a current Master Government List of Federally Funded R&D Centers. For information on the current FFRDC count, along with its history, see https://www.nsf.gov/statistics/ffrdclist/. The R&D expenditure data cited here are for all the FFRDCs as an aggregate. For data on individual FFRDCs, see NCSES's annual FFRDC Research and Development Surveys at https://www.nsf.gov/statistics/srvyffrdc/.

[6] This figure does not include federal government investments in R&D infrastructure and equipment, which support the maintenance and operation of unique research facilities and the conduct of research activities that would be too costly or risky for a single company or academic institution to undertake.

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

[8] The Organisation for Economic Co-Operation and Development notes that in measuring R&D, one source of error is the difficulty of locating the dividing line between experimental development and the further downstream activities needed to realize an innovation (OECD 2015:51–52). Most definitions of R&D set the cutoff at the point when a particular product or process reaches "market readiness." At this point, the defining characteristics of the product or process are substantially set—at least for manufactured goods, if not also for services—and further work is primarily aimed at developing markets, engaging in preproduction planning, and streamlining the production or control system.

[9]The arithmetic is straightforward to calculate type-of-R&D shares for past years, based on the data in Appendix Table 4-2 through Appendix Table 4-5. Nonetheless, care must be taken in describing the trends for these shares over time. Although NCSES's sectoral surveys of R&D expenditures have consistently used the OECD Frascati Manual's type-of-R&D definitions, the survey instruments have occasionally been revised to improve the reliability of the responses received, most notably in the academic, business, and FFRDC R&D expenditure surveys. Accordingly, some differences observed in the shares directly

calculated from the appendix table time series data more nearly reflect the effects of these improvements in the type-of-R&D survey questions than changes in the type-of-R&D shares among R&D performers.

Cross-National Comparisons of R&D Performance

Data on R&D expenditures and intensity by country and region provide a broad picture of the global distribution of R&D capabilities and activities and changes under way. Data provided periodically by the Organisation for Economic Co-operation and Development (OECD) (covering its 35 member countries and 7 selected nonmembers) and by the United Nations Educational, Scientific, and Cultural Organization (UNESCO) Institute for Statistics (covering more than 100 other countries) are useful for this comparative task (OECD 2017; UNESCO 2017).

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

SIDEBAR

Comparing International R&D Expenditures

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

MERs represent the relative value of currencies for cross-border trade of goods and services but may not accurately reflect the cost of nontraded goods and services. They are also subject to currency speculation, political events, wars or boycotts, and official currency intervention. PPPs were developed to overcome these shortcomings (Ward 1985). They take into account the cost differences of buying a similar market basket of goods and services covering tradables and nontradables. The PPP basket is assumed to be representative of total GDP across countries. PPPs are the preferred international standard for calculating cross-country R&D comparisons and are used in all official R&D tabulations of the Organisation for Economic Co-Operation and Development (OECD).*

Because MERs tend to understate the domestic purchasing power of developing countries' currencies, PPPs can produce substantially larger R&D estimates than MERs for these countries. For example, China's R&D expenditures in 2013 (as reported to the OECD) were $334 billion in PPP terms but only $191 billion using MERs. However, PPPs for large developing countries such as China and India are often rough approximations and have 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.

* Some unresolved questions remain about the use of GDP PPPs for deflating R&D expenditures. In analyzing the manufacturing R&D inputs and outputs of six industrialized OECD countries, Dougherty et al. (2007:312) concluded that "the use of an R&D PPP will yield comparative costs and R&D intensities that vary substantially from the current practice of using GDP PPPs, likely increasing the real R&D performance of the comparison countries relative to the United States." The issue, and what if anything to do about it, remains unresolved.

Country and Regional Patterns in Total National R&D

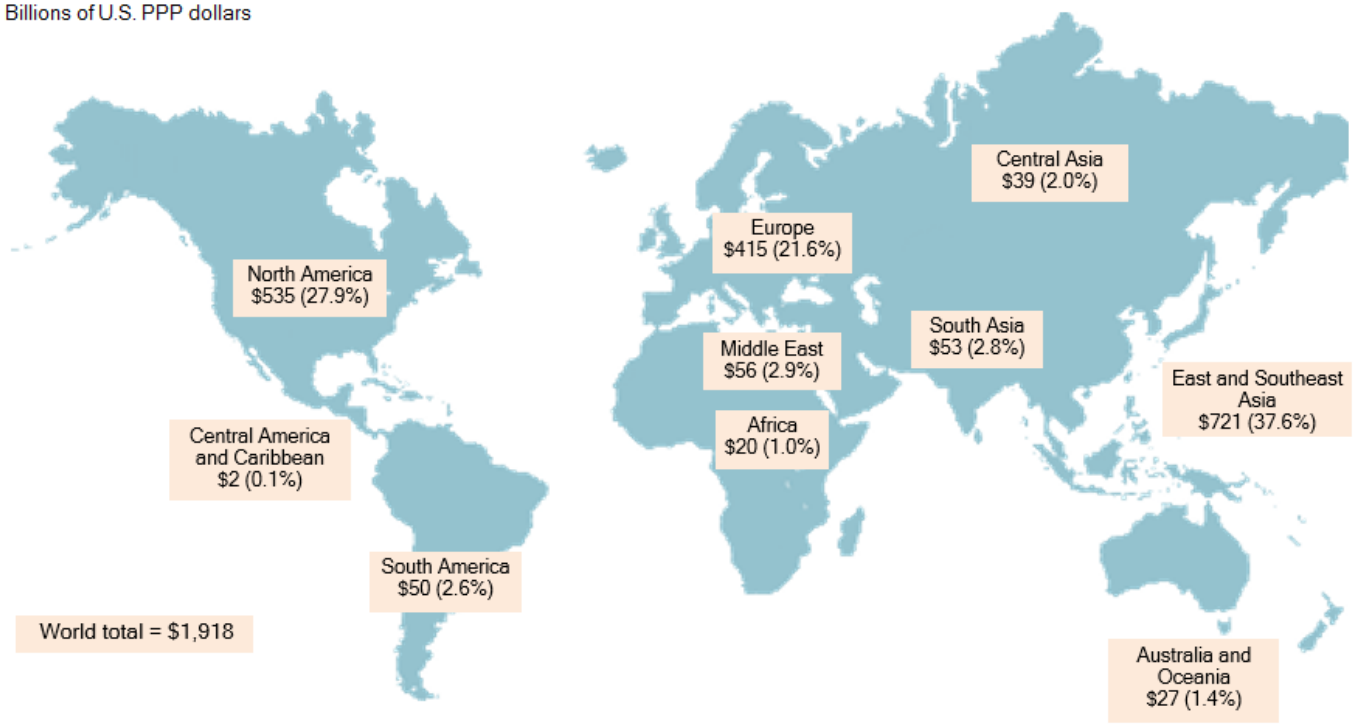
The global total of R&D expenditures continues to rise at a substantial pace. NCSES's latest estimate puts the worldwide total at $1.918 trillion (current PPP dollars) in 2015 (Figure 4-5).[1] The corresponding estimate for 5 years earlier in 2010 was $1.415 trillion. In 2000, it was $722 billion. By these figures, the annual increase in total global R&D averaged 6.3% over the 2010–15 period and 7.0% over 2000–10. (As a point of comparison, U.S. GDP totaled $18.121 trillion in 2015.)

Global R&D performance continues to remain concentrated in three geographic regions: North America, Europe, and the regions of East/Southeast and South Asia (Figure 4-5). North America (United States, Canada, Mexico) accounted for 28%

($535 billion) of worldwide R&D performance in 2015; Europe, including the European Union (EU) (see this chapter's Glossary for a list of the 28 EU member countries), accounted for 22% ($415 billion); the combination of the regions of East/Southeast and South Asia (including China, Japan, South Korea, India, and Taiwan) accounted for 40% ($773.5 billion). The remaining 10% of global R&D comes (in order) from the regions of the Middle East, South America, Central Asia, Australia and Oceania, Africa, and Central America and the Caribbean.

FIGURE 4-5

Global R&D expenditures, by region: 2015



PPP = purchasing power parity.

Note(s)

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

Source(s)

National Science Foundation, National Center for Science and Engineering Statistics estimates, October 2017. Based on data from the Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators* (2017/1), and the United Nations Educational, Scientific and Cultural Organization Institute for Statistics Data Centre, data.uis.unesco.org, accessed 13 October 2017.

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The geographic concentration of R&D is more sharply apparent when the profiles of specific countries or economies are considered (Table 4-5). The United States remains the largest R&D performer ($497 billion in 2015), accounting for 26% of

the global total. China was the second largest performer ($409 billion) in 2015, accounting for about 21% of the global total. Japan is third at 9% ($170 billion); Germany is fourth at 6% ($115 billion). South Korea ($74 billion), France ($61 billion), India ($50 billion), and the United Kingdom ($46 billion) make up a third tier of performers—each accounting for 2%–4% of the global R&D total. Brazil, Russia, Taiwan, and Italy make up a fourth tier, with annual R&D expenditures ranging from $30 billion to $38 billion, each accounting for 2% of the global total. Canada, Australia, and Spain are a next rung down, with annual R&D expenditures in the $20 billion–$27 billion range and each being about 1% of the global total. The United States and China together accounted for about 47% of the global R&D total in 2015, the top 8 countries accounted for 74%, and all 15 of the countries mentioned accounted for 85% of the global total.

TABLE 4-5

International comparisons of gross domestic expenditures on R&D and R&D share of gross domestic product, by region, country, or economy: 2015 or most recent year

(PPP millions of dollars and GERD-to-GDP ratio)

Region, country, or economy	GERD (PPP $millions)	GERD/GDP (%)
North America		
United States (2015)[a]	496,585.0	2.74
Canada (2015)	27,071.1	1.71
Mexico (2015)	11,563.4	0.53
Central America and Caribbean		
Cuba (2013)	1,113.5	0.47
Ecuador (2014)	805.5	0.44
South America		
Brazil (2014)	38,447.9	1.17
Argentina (2015)	5,577.1	0.63
Colombia (2015)	1,612.8	0.24
Chile (2015)	1,603.7	0.38
Europe		
Germany (2015)	114,778.1	2.93
France (2015)	60,818.7	2.22
United Kingdom (2015)	46,259.8	1.70
Italy (2015)	30,102.1	1.33
Spain (2015)	19,734.5	1.22
Switzerland (2015)	17,688.3	3.42
Netherlands (2015)	16,909.7	1.99
Sweden (2015)	15,371.7	3.28
Austria (2015)	13,321.2	3.12
Belgium (2015)	12,624.6	2.46
Poland (2015)	10,239.8	1.00

Region, country, or economy	GERD (PPP $millions)	GERD/GDP (%)
Denmark (2015)	8,236.2	2.96
Czech Republic (2015)	6,927.4	1.95
Finland (2015)	6,712.4	2.90
Norway (2015)	6,218.4	1.93
Portugal (2015)	3,921.5	1.28
Hungary (2015)	3,584.8	1.38
Ireland (2014)	3,638.7	1.54
Greece (2015)	2,765.9	0.97
Romania (2015)	2,136.6	0.49
Ukraine (2015)	2,100.9	0.62
Slovak Republic (2015)	1,911.6	1.18
Slovenia (2015)	1,458.9	2.21
Bulgaria (2015)	1,253.0	0.96
Lithuania (2015)	871.4	1.04
Belarus (2015)	870.2	0.52
Serbia (2015)	866.5	0.87
Croatia (2015)	808.1	0.85
Luxembourg (2015)	761.0	1.28
Estonia (2015)	569.3	1.50
Middle East		
Turkey (2015)	16,604.5	0.88
Israel (2015)	13,023.6	4.25
Saudi Arabia (2013)	12,513.3	0.82
United Arab Emirates (2015)	5,546.4	0.87
Iran (2012)	4,172.3	0.33
Africa		
Egypt (2015)	7,217.9	0.72

Region, country, or economy	GERD (PPP $millions)	GERD/GDP (%)
South Africa (2013)	4,975.0	0.73
Morocco (2010)	1,483.6	0.73
Nigeria (2007)	1,374.8	0.22
Tunisia (2015)	815.2	0.63
Kenya (2010)	788.2	0.79
Ethiopia (2013)	785.9	0.60
Tanzania (2013)	623.8	0.53
Central Asia		
Russian Federation (2015)	38,135.5	1.10
Khazakhstan (2015)	744.8	0.17
South Asia		
India (2015)	50,269.4	0.63
Pakistan (2015)	2,325.1	0.25
East and Southeast Asia		
China (2015)	408,829.0	2.07
Japan (2015)	170,003.0	3.29
South Korea (2015)	74,051.5	4.23
Taiwan (2015)	33,564.1	3.05
Singapore (2014)	10,102.5	2.18
Malaysia (2015)	10,637.6	1.30
Thailand (2015)	6,947.5	0.63
Indonesia (2013)	2,130.3	0.08
Viet Nam (2013)	1,777.4	0.37
Philippines (2013)	886.5	0.14
Australia and Oceania		
Australia (2013)	23,133.6	2.11
New Zealand (2015)	2,227.9	1.28

Region, country, or economy	GERD (PPP $millions)	GERD/GDP (%)
Selected country groups		
European Union (2015)	386,466.8	1.96
OECD (2015)	1,247,981.0	2.38
G-20 countries (2015)	1,766,356.4	1.92

G20 = Group of Twenty; GDP = gross domestic product; GERD = gross domestic expenditures on R&D; OECD = Organisation for Economic Co-operation and Development; PPP = purchasing power parity.

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

Note(s)

Year of data is listed in parentheses. Foreign currencies are converted to dollars through PPPs. Countries in this table have an annual GERD of $500 million or more. Countries are grouped according to the regions described by *The World Factbook*, https://www.cia.gov/library/publications/resources/the-world-factbook/index.html. Data for Israel are civilian R&D only. See sources below for GERD statistics on additional countries.

Source(s)

National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources (annual series); OECD, *Main Science and Technology Indicators* (2017/1); United Nations Educational, Scientific and Cultural Organization Institute for Statistics Data Centre, http://data.uis.unesco.org/, accessed 13 October 2017.

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The R&D total for the EU as a whole in 2015 was $386 billion—now noticeably behind China's $409 billion for the year. Among the EU countries, Germany, with $115 billion in 2015, is by far the largest R&D performer. France ($61 billion), the United Kingdom ($46 billion), and Italy ($30 billion) are next in order.

The generally vigorous pace at which total global R&D has increased, more than two and a half times over the 2000–15 period and continuing to grow, remains among the most prominent developments—a continued reflection of the escalating knowledge intensiveness of the economic competition among the world's nations (see Chapter 6 for a further discussion). Another major trend is the sustained, large increases in the levels of R&D performance in the regions of East/Southeast and South Asia compared with the other major R&D performing areas. R&D performed in the North American region accounted for 40% of the global total in 2000 but declined to 31% in 2010 and further down to 28% in 2015. Europe accounted for 27% in 2000, 23% in 2010, and then down to 22% in 2015. The regions of East/Southeast and South Asia comprised 25% of the global total in 2000 but rose to 35% in 2010 and even higher to 40% in 2015. Present regional growth trends in R&D performance suggest the ascendant primacy of these areas of Asia is unlikely to end soon.

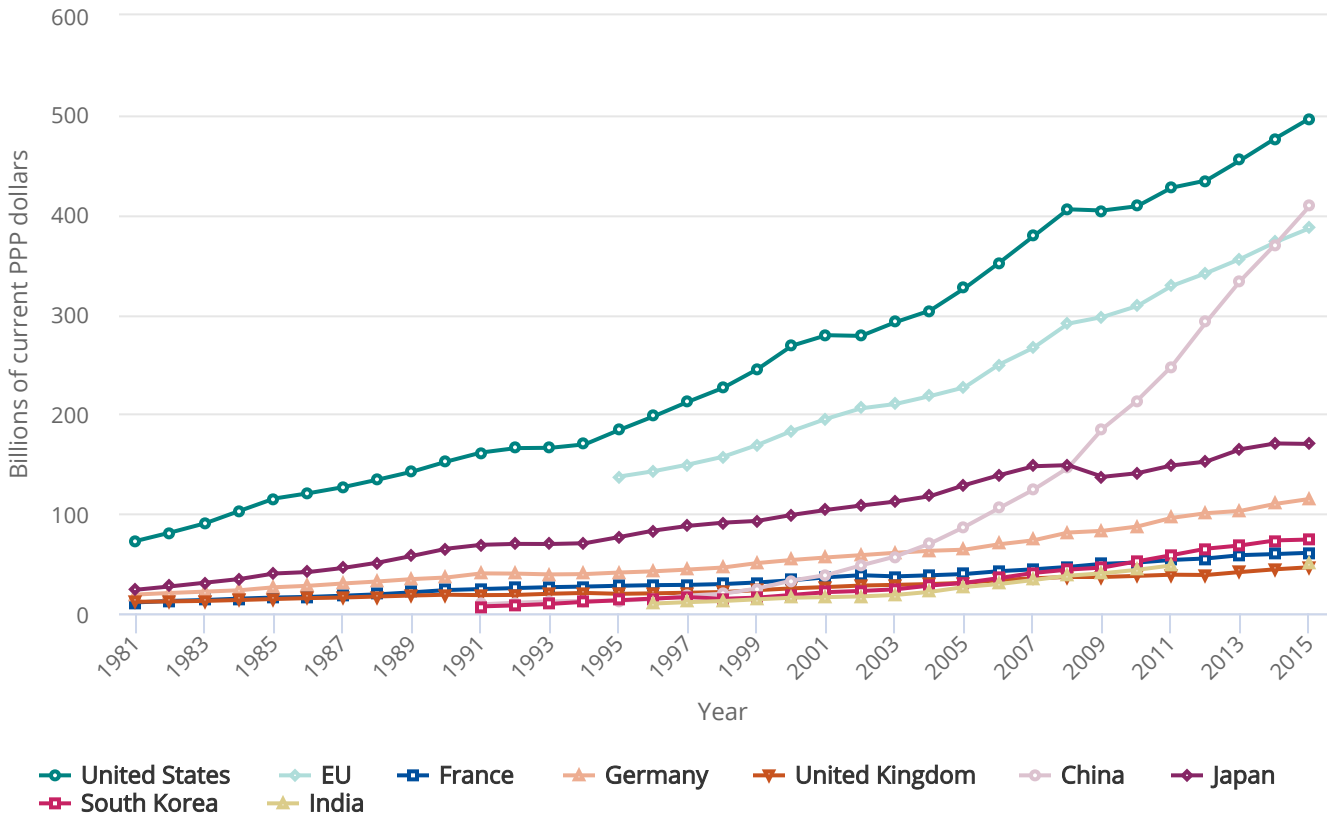
Total global R&D increased by some $1.196 trillion (current dollars) from 2000 to 2015—as noted earlier, the 2000 total was $723 billion, rising to $1.918 trillion in 2015. China alone accounted for 31% ($376 billion) of the global increase over this 15-year period. The United States accounted for 19% ($228 billion) of the global increase, and the EU accounted for 17% ($203 billion). The increases of several other major Asian R&D performers were also noticeable: Japan accounted for 6% of the increase ($71 billion), and South Korea accounted for 5% ($56 billion).

China continues to exhibit the world's most dramatic R&D growth pattern (Figure 4-6; Appendix Table 4-12). The pace of its increase in R&D performance has been exceptionally high over numerous years, averaging 20.5% annually over 2000–10 and 13.9% for 2010–15 (or 18.0% and 12.0%, respectively, when adjusted for inflation). The rate of growth in South Korea's R&D has also been quite high, averaging 10.9% annually over 2000–10 and 7.3% for 2010–15. Japan's corresponding rates of R&D growth have been slower, at 3.6% and 3.9%.

Although the United States remains well atop the list of the world's R&D-performing nations, its pace of growth in R&D performance has averaged 4.3% over 2000–10 and 4.0% for 2010–15, and its share of global R&D has declined from 37% in 2000 to 26% in 2015. Total R&D by EU nations has been growing at an annual average rate of 5.4% in 2000–10 and 4.6% in 2010–15—with Germany at 5.0% and 5.7%, France at 4.4% and 3.6%, and the United Kingdom at 4.1% and 4.2%. The EU countries accounted for 25% of total global R&D in 2000 but dropped to 20% in 2015.

FIGURE 4-6

Gross domestic expenditures on R&D, by the United States, the EU, and selected other countries: 1981–2015



EU = European Union; PPP = purchasing power parity.

Note(s)

Data are for the top eight R&D-performing countries and the EU. Data are not available for all countries for all years. Data for the United States in this figure reflect international standards for calculating gross expenditures on R&D, which vary slightly from the National Science Foundation's protocol for tallying U.S. total R&D. Data for Japan for 1996 onward may not be consistent with earlier data because of changes in methodology. Data for Germany for 1981–90 are for West Germany.

Source(s)

National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources (annual series); Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators* (2017/1); United Nations Educational, Scientific and Cultural Organization Institute for Statistics Data Centre, data.uis.unesco.org, accessed 13 October 2017. See Appendix Table 4-12.

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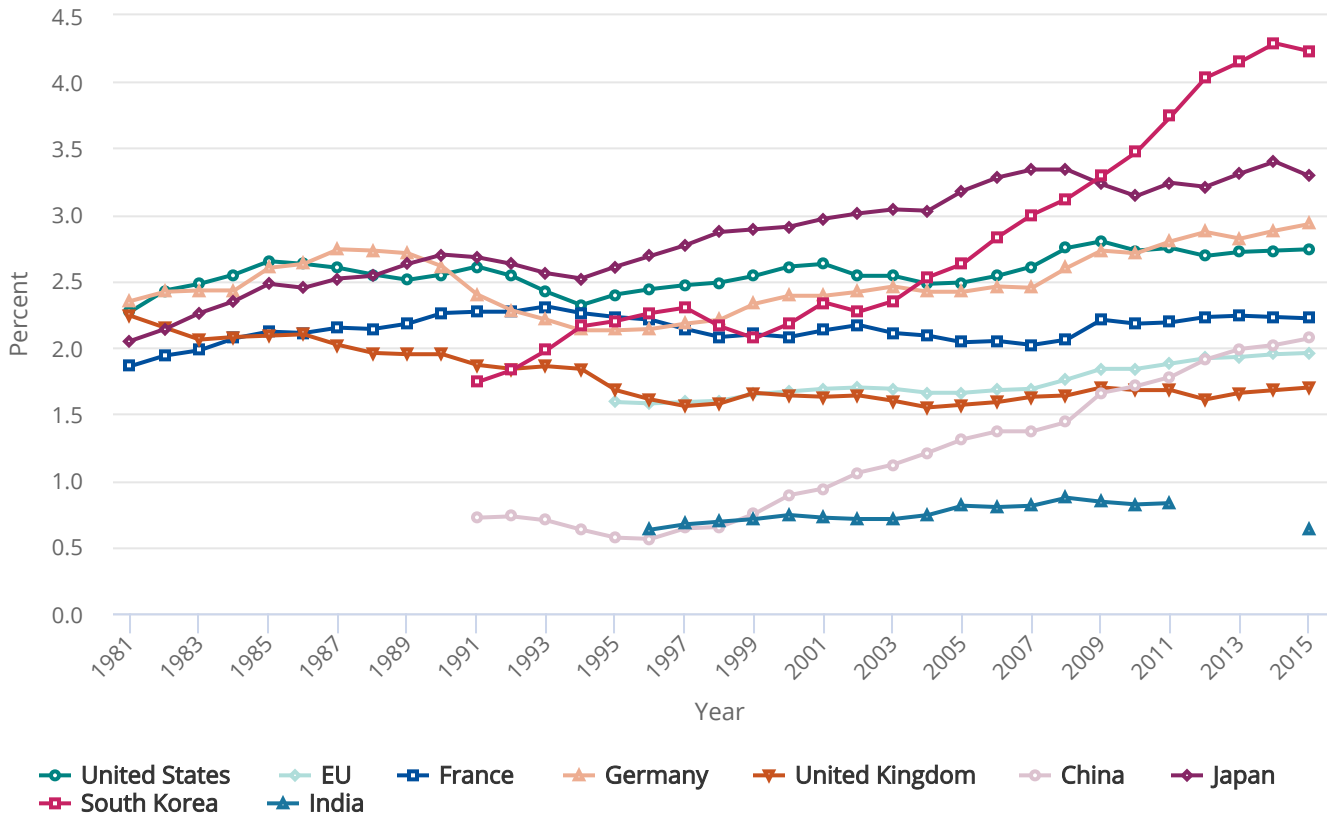
Country and Regional Patterns in National R&D Intensity

As discussed earlier in this chapter, the U.S. R&D-to-GDP ratio was 2.61% in 2000, peaked at 2.80% in 2009, dropped modestly over the next several years, but then moved upward again to 2.74% in 2015 (Figure 4-7).

At the 2015 level, the United States is 11th in R&D intensity among the economies tracked by OECD and UNESCO data. Israel and South Korea are essentially tied for the top spot, with ratios of 4.3% and 4.2%, respectively (although Israel's data exclude expenditures for defense R&D, while South Korea's data include them). Israel has long been at the top of the R&D-to-GDP ratio ranking (Table 4-5). But South Korea's upward movement has been particularly rapid since the late 1990s (Figure 4-7); furthermore, South Korea is one of the world's largest R&D performers, with annual R&D expenditures many times that of Israel. Switzerland is third, at 3.4%. Japan is fourth, at 3.3%. Several smaller countries or economies with comparatively high R&D-to-GDP ratios are Sweden (3.3%), Austria (3.1%), Taiwan (3.1%), Denmark (3.0%), Germany (2.9%), and Finland (also 2.9%). The other top 8 R&D performers include France at 2.2%, China at 2.1%, the United Kingdom at 1.7%, and India at 0.6%.

FIGURE 4-7

Gross domestic expenditures on R&D as a share of gross domestic product, by the United States, the EU, and selected other countries: 1981–2015



EU = European Union.

Note(s)

Data are for the top eight R&D-performing countries and the EU. Data are not available for all countries for all years. Data for the United States in this figure reflect international standards for calculating gross expenditures on R&D, which vary slightly from the National Science Foundation's protocol for tallying U.S. total R&D. Data for Japan for 1996 onward may not be consistent with earlier data because of changes in methodology. Data for Germany for 1981–90 are for West Germany.

Source(s)

National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources (annual series); Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators* (2017/1); United Nations Educational, Scientific and Cultural Organization Institute for Statistics Data Centre, data.uis.unesco.org, accessed 13 October 2017. See Appendix Table 4-12.

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The U.S. rank in this indicator has been slowly falling in recent years as other countries have expanded the range and scope of their R&D activities: 11th in 2013 (as reported in *Science and Engineering Indicators 2016*), 10th in 2011 (as reported

in *Science and Engineering Indicators 2014*), and 8th in 2009 (as reported in *Science and Engineering Indicators 2012*). The U.S. ranking has fallen despite the generally high U.S. R&D intensity levels (relative to historic levels) over these recent years.

The ratio has been rising gradually for the EU as a whole over the 2000–15 period, from about 1.7% in 2000 to nearly 2.0% in 2015 (Figure 4-7). For the largest R&D performers among the EU countries, the ratios for Germany, France, and the United Kingdom have gradually risen over 2000–15.

Among the large Asian R&D performers, Japan's R&D-to-GDP ratio has moved mainly upward in recent years, from 2.9% in 2000 to 3.3% in 2015. The high risers—across all the 8 countries considered here—have been China and South Korea. China's ratio doubled over the period, from just over 0.9% in 2000 to about 2.1% in 2015, suggesting that ample room remains for future increases (Appendix Table 4-12). South Korea's ratio increased from 2.2% in 2000 to 4.2% in 2015.

Comparisons of the Composition of Country R&D Performance

The business sector is the predominant R&D performer for nearly all the current top R&D-performing nations (Table 4-6). For the United States, the business sector accounted for 72% of gross expenditures on R&D in 2015. The shares were even higher in the leading Asian R&D performers: China, where the business sector accounted for 77% of the country's total R&D in 2015; Japan, where it accounted for 79%; and South Korea, where it accounted for 78%. The levels in Germany (69%), France (65%), and the United Kingdom (66%) were somewhat lower. The apparent exception is India, where the country's business sector accounted for a much smaller share of the national R&D total—44% in 2015.

TABLE 4-6

Gross expenditures on R&D for selected countries, by performing sector and source of funds: 2015 or most recent year

(PPP billions of dollars and percent share)

Country	GERD (PPP $billions)	R&D performance: Share of total (%)				R&D source of funds: Share of total (%)			
		Business	Government	Higher education	Private nonprofit	Business	Government	Other domestic	From abroad
United States (2015)[a]	496.6	71.7	11.3	13.0	4.0	62.4	25.5	7.1	5.0
China (2015)	408.8	76.8	16.2	7.0	na	74.7	21.3	NA	0.7
Japan (2015)	170.0	78.5	7.9	12.3	1.3	78.0	15.4	6.1	0.5
Germany (2015)	114.8	68.7	14.1	17.3	**	65.6	27.9	0.4	6.2
South Korea (2015)	74.1	77.5	11.7	9.1	1.6	74.5	23.7	1.0	0.8
France (2015)	60.8	65.1	13.1	20.3	1.6	55.7	34.6	2.0	7.8
India (2015)	50.3	43.6	52.5	3.9	na	NA	NA	NA	NA
United Kingdom (2015)	46.3	65.7	6.8	25.6	1.9	48.4	28.0	6.0	17.6

** = included in data for other performing sectors. na = not applicable; country does not recognize the category or does not report the data item. NA = not available.

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

[a] Data for the United States in this table reflect international standards for calculating GERD, which vary slightly from the National Science Foundation's protocol for tallying U.S. total R&D. The data for U.S. funding from abroad include funding for business R&D and academic R&D.

Note(s)

Top 8 R&D performing countries in 2015. Complete data for India are not currently available. Percentages may not add to 100 because of rounding. Year of data is listed in parentheses.

Source(s)

National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources (annual series); Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators* (2017/1); United Nations Educational, Scientific and Cultural Organization Institute for Statistics Data Centre, data.uis.unesco.org, accessed 13 October 2017.

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R&D performed by the government accounted for about 11% of the national total in the United States in 2015. This primarily includes activities by the federal government but also includes the small amount of R&D by nonfederal government (state) performers. The share ranged from 7% to 53% across the other countries. South Korea (12%) showed a similar share as the United States. The United Kingdom (7%) and Japan (8%) were both lower. The other countries arrayed around the United States include China (16%), Germany (14%), and France (13%). The government share in India was by far the highest, at 53%.

R&D performed by the higher education sector ranged from 4% to 26% of total national R&D across these countries. This sector's performance share for the United States was about 13% in 2015. China was at 7% that year; similarly, South Korea (9%) was also below the U.S level. Japan (12%) and Germany (17%) were near the U.S. level. France (20%) and the United Kingdom (26%) were both noticeably higher. India had by far the lowest level, at 4%.

Business sectors were the predominant source of R&D funding (Table 4-6). (Although comparable data on R&D funding sources are not available for India.) For the United States, the business sector (domestic) accounted for about 62% of all U.S. R&D in 2015. China, Japan, and South Korea had substantially higher percentages, at 75%, 78%, and 75%, respectively. Germany's share was higher than that of the United States, at 66%; the United Kingdom's was lower, at 48%.

Government was the second major source of R&D funding for these countries. For the United States, government (federal and nonfederal) accounted for 26% of the nation's R&D in 2015. Germany's (28%) and the United Kingdom's (28%) shares were somewhat higher than that of the United States. South Korea's was just under, at 24%, and China's was further below, at 21%. France's was considerably higher, at 35%.

Funding from abroad refers to funding from businesses, universities, governments, nonprofits, and other organizations located outside of the country. Among the top R&D-performing countries, the United Kingdom is the most notable in this category, with 18% of R&D funding coming from abroad in 2015. France is also comparatively high, at nearly 8%. Germany was at 6%, and the United States was around 5%. The rest are much lower. (For the United States, the funding from abroad reflects foreign funding for domestic R&D performance mainly by the business and higher education sectors.)

Another dimension for comparing the top R&D-performing countries is the levels and shares of overall national annual R&D performance devoted to basic research, applied research, and experimental development. (Type-of-R&D data are not available for some countries, including Germany, in Table 4-7.)

The portion of annual R&D that countries allocate to basic research ranges between 5% and 24% (Table 4-7). For the United States, this share is on the high side of the range: 17% of its overall R&D in 2015, which amounted to $83.9 billion of basic research performance that year. France often has a higher share; in 2015, it was 24%, but this amounted to $14.8 billion of basic research performance, which was well below the U.S. level. Among the top R&D-performing countries, China's basic research share is the lowest, at slightly more than 5% in 2015; however, this still amounted to about $21 billion of basic research performance that year.

TABLE 4-7

Gross expenditures on R&D for selected countries, by type of work: 2015 or most recent year

(PPP billions of dollars and percent share)

Country	GERD (PPP $billions)	Basic	Applied	Experimental development	Other nec
PPP $billions					
United States (2015)a	496.6	83.9	97.3	315.3	0.0
China (2015)	408.8	20.8	44.2	344.2	0.0
Japan (2015)	170.0	20.2	33.8	108.3	7.7
Germany (2015)	114.8	NA	NA	NA	NA
South Korea (2015)	74.1	12.7	15.4	45.9	0.0
France (2015)	60.8	14.8	22.9	21.1	2.0
India (2015)	50.3	8.0	11.2	11.8	19.3
United Kingdom (2015)	46.3	7.8	20.0	18.4	0.0
Share of total (%)					
United States (2015)[a]		16.9	19.6	63.5	0.0
China (2015)		5.1	10.8	84.2	0.0
Japan (2015)		11.9	19.9	63.7	4.5
Germany (2015)		NA	NA	NA	NA
South Korea (2015)		17.2	20.8	61.9	0.0
France (2014)		24.4	37.6	34.7	3.3
India (2009)		16.0	22.3	23.5	38.3
United Kingdom (2014)		16.9	43.3	39.8	0.0

NA = not available.

GERD = gross domestic expenditures on R&D; nec = not elsewhere classified; PPP = purchasing power parity.

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

Note(s)

Top 8 R&D performing countries in 2015. Year of data is listed in parentheses. Detail may not add to total because of rounding. Expenditure levels by type of R&D in top panel are based on type of R&D shares in bottom panel. In some cases, the data for type of R&D shares are not as recent as total R&D performance. Complete data are not presently available for Germany.

Source(s)

National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources (annual series); Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators* (2017/1); United Nations Educational, Scientific and Cultural Organization Institute for Statistics Data Centre, data.uis.unesco.org/, accessed 13 October 2017.

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The shares for applied research for these countries range from 11% (China) to 43% (United Kingdom), with the U.S. share nearly in the middle, at 20%. Nonetheless, in terms of overall volume, the United States dominates this category, with $97.3 billion of applied research spending in 2015. The overall volume of spending by the second and third ranked countries in this category are comparatively far behind: China, at $44.2 billion, and Japan, at $33.8 billion.

With regard to experimental development, China exhibits the highest share by far—84% of its R&D total in 2015, which was $344.2 billion of spending in this category that year. For the United States, the development share that year was 64%, totaling $315.3 billion of spending in this category. Japan and South Korea also exhibit comparatively high shares for development, respectively, 64% and 62% in 2015; however, the dollar amounts of those countries' performances were well below the levels for China and the United States.

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[1] The figures cited for total global R&D in 2000, 2010, and 2015 are NCSES estimates. R&D expenditures for all countries are denominated in U.S. dollars, based on PPPs. These estimates are based on data from the OECD's (2017) *Main Science and Technology Indicators* (Volume 2017/1) and from R&D statistics for additional countries assembled by UNESCO's Institute for Statistics (as of mid-October 2017). Presently, no database on R&D spending is comprehensive and consistent for all nations performing R&D. The OECD and UNESCO databases together provide R&D performance statistics for 158 countries, although the data are not current or complete for all. NCSES's estimate of total global R&D reflects 106 countries, with reported annual R&D expenditures of $50 million or more, which accounts for most of current global R&D.

U.S. Business R&D

Businesses have been the predominant performers of U.S. R&D dating back to the 1950s. In 2008, the business sector accounted for $290.7 billion (71.4%) of the $407.0 billion of U.S. total R&D (Table 4-8). In 2015, the business share was $355.84 billion (71.8%) of the $495.5 billion U.S. total. Year-to-year increases and declines in the level of business R&D performance greatly influence the U.S. R&D total. Indeed, the slowed growth and declines of U.S. R&D in the 2009–11 period owe much to the slowed growth and declines of the level of domestic business R&D in these years (Figure 4-2). (All amounts and calculations are in current dollars, unless otherwise noted.)

The business sectors of the U.S. economy are diverse, with wide differences in the goods and services provided across industries and in the various production inputs required, including roles for R&D. Historically, companies in manufacturing industries have accounted for two-thirds or more of U.S. business R&D, with the balance accounted for by companies in nonmanufacturing industries. As it turns out, however, the peaks in current U.S. business R&D stem from a relative handful of industries, classified in both the manufacturing and nonmanufacturing sectors.

TABLE 4-8

Funds spent for business R&D performed in the United States: 2008–15

(Millions of current dollars and percent share)

Sector	2008	2009	2010	2011	2012	2013	2014	2015
Current $millions								
U.S. total R&D	404,773	402,931	406,580	426,160	433,619	453,964	475,426	495,144
All business R&D[a]	290,680	282,393	278,977	294,093	302,250	322,528	340,728	355,821
Paid for by the company	232,505	224,920	221,706	238,768	247,280	264,913	282,570	296,677
From company-owned, U.S.-located units	225,848	221,104	218,187	235,426	242,674	259,908	277,272	289,892
From foreign subsidiaries	6,657	3,816	3,519	3,342	4,606	5,005	5,298	6,785
Paid for by others	58,176	57,473	57,271	55,324	54,970	57,615	58,158	59,144
Federal	36,360	39,573	34,199	31,309	30,621	29,362	26,554	26,990
Domestic companies	12,181	9,567	11,013	11,124	11,624	13,450	13,227	14,595
Foreign companies	8,876	7,648	11,015	12,007	12,093	13,791	17,246	16,317
Foreign parent[b]	NA	NA	7,102	7,438	8,486	10,445	13,407	12,579
Unaffiliated companies	NA	NA	3,913	4,569	3,607	3,346	3,839	3,738
All other organizations[c]	759	685	1,044	884	632	1,013	1,131	1,242
Source of funds as a percentage of all business R&D								
All business R&D[a]	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Paid for by the company	80.0	79.6	79.5	81.2	81.8	82.1	82.9	83.4
From company-owned, U.S.-located units	77.7	78.3	78.2	80.1	80.3	80.6	81.4	81.5
From foreign subsidiaries	2.3	1.4	1.3	1.1	1.5	1.6	1.6	1.9
Paid for by others	20.0	20.4	20.5	18.8	18.2	17.9	17.1	16.6
Federal	12.5	14.0	12.3	10.6	10.1	9.1	7.8	7.6
Domestic companies	4.2	3.4	3.9	3.8	3.8	4.2	3.9	4.1
Foreign companies	3.1	2.7	3.9	4.1	4.0	4.3	5.1	4.6
Foreign parent[b]	NA	NA	2.5	2.5	2.8	3.2	3.9	3.5
Unaffiliated companies	NA	NA	1.4	1.6	1.2	1.0	1.1	1.1

Sector	2008	2009	2010	2011	2012	2013	2014	2015
All other organizations[c]	0.3	0.2	0.4	0.3	0.2	0.3	0.3	0.3

NA = not available.

[a] Includes companies located in the United States that performed or funded R&D. Data in this table represent an aggregate of all industries in the North American Industry Classification System codes 21–33 and 42–81.

[b] Includes foreign parent companies of U.S. subsidiaries.

[c] Includes U.S. state government agencies and laboratories, foreign agencies and laboratories, and all other organizations located inside and outside the United States.

Note(s)

Detail may not add to total because of rounding. Industry classification was based on the dominant business code for domestic R&D performance, where available. For companies that did not report business codes, the classification used for sampling was assigned. This table excludes data for federally funded R&D centers.

Source(s)

National Science Foundation, National Center for Science and Engineering Statistics, Business R&D and Innovation Survey (annual series).

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Key Characteristics of Domestic Business R&D Performance

NCSES's annual Business R&D and Innovation Survey (BRDIS) provides data on all for-profit, nonfarm companies that are publicly or privately held and have five or more employees in the United States.[1] U.S. business R&D is the R&D performed by companies in the domestic United States, including that paid for by the company itself (from company-owned, U.S.-located units or from company subsidiaries located overseas) and that paid for by others (such as other companies, domestic or foreign, including foreign parents of U.S. subsidiaries; the federal government; nonfederal government, domestic or foreign; and nonprofit or other organizations, domestic or foreign).

Presently, most domestic R&D performance occurs in five business sectors: chemicals manufacturing (North American Industry Classification System [NAICS] 325, which includes the pharmaceuticals industry); computer and electronic products manufacturing (NAICS 334); transportation equipment manufacturing (NAICS 336, which includes the automobiles and aerospace industries); information (NAICS 51, which includes the software publishing industry); and professional, scientific, and technical (PST) services (NAICS 54, which includes the computer systems design and scientific R&D services industries) (Table 4-9).[2] Although a sector's R&D performance total is influenced by both its overall economic size and the intensity of its R&D need (usually measured as dollars of R&D performance divided by total product sales), these are all sectors and industries with R&D intensities higher than others in the national economy (Table 4-10).

TABLE 4-9

Funds spent for business R&D performed in the United States, by source of funds and selected industry: 2015

(Millions of dollars and percent share)

Industry and NAICS code	All R&D	Paid for by the company	Paid for by others				
			Total	Federal	Companies		All other organizations[b]
					Domestic	Foreign[a]	
	$millions						
All industries, 21–33, 42–81[c]	355,821	296,677	59,144	26,990	14,595 i	16,317	1,242
Manufacturing industries, 31–33	236,132	195,792	40,340	21,552 i	5,008	12,907	873
Chemicals, 325	68,196	58,769	9,427	410	1,546	7,413	58
Pharmaceuticals and medicines, 3254	58,675	50,242	8,432	138	1,465	6,772	57
Other 325	9,521	8,527	995	272	81	641	1
Machinery, 333	13,426	12,544	881 i	222	203 i	438 i	18 i
Computer and electronic products, 334	72,110	63,765	8,345	4,213	1,474	2,459	199
Electrical equipment, appliances, and components, 335	4,335	3,852	483 i	50 i	16 i	396 i	21 i
Transportation equipment, 336	49,274	29,224	20,050 i	16,515 i	1,304 i	1,690	541 i
Automobiles, trailers, and parts, 3361–63	19,078	16,636	2,441	200 i	547 i	1,602 i	92 i
Aerospace products and parts, 3364	27,464	11,138	16,326 i	15,064 i	738 i	76 i	448 i
Other 336	2,732	1,450	1,283 i	1,251 i	19 i	12 i	1 i
Manufacturing nec, other 31–33	28,791	27,638	1,154 i	142 i	465 i	511 i	36 i
Nonmanufacturing industries, 21–23, 42–81	119,690	100,885	18,804	5,438	9,587 i	3,411 i	368 i
Information, 51	65,513	64,578	935	51	s	s	s
Software publishers, 5112	33,248	32,500	747	22	s	s	s
Other 51	32,265	32,078	188	29	s	s	s
Finance and insurance, 52	5,366	5,329	38	0	6 i	0	32 i
Professional, scientific, and technical services, 54	38,626	21,915	16,710	5,323	9,074 i	2,048 i	265 i

Industry and NAICS code	All R&D	Paid for by the company	Paid for by others							
			Total		Federal		Companies		All other organizations[b]	
							Domestic	Foreign[a]		
Computer systems design and related services, 5415	14,333	12,418	1,915 i		605 i		1112 i	127 i	71 i	
Scientific R&D services, 5417	16,329	3,896	12,433		2,939		7,669 i	1,684 i	141 i	
Other 54	7,964	5,601	2,362 i		1,779 i		293 i	237 i	53 i	
Nonmanufacturing nec, other 21–23, 42–81	10,185	9,063	1,121		64		s	s	s	
	Percentage of sector or industry totals									
All industries, 21–33, 42–81[c]	100.0	83.4	16.6		7.6		4.1	4.6	0.3	
Manufacturing industries, 31–33	100.0	82.9	17.1		9.1		2.1	5.5	0.4	
Chemicals, 325	100.0	86.2	13.8		0.6		2.3	10.9	0.1	
Pharmaceuticals and medicines, 3254	100.0	85.6	14.4		0.2		2.5	11.5	0.1	
Other 325	100.0	89.6	10.5		2.9		0.9	6.7	0.0	
Machinery, 333	100.0	93.4	6.6		1.7		1.5	3.3	0.1	
Computer and electronic products, 334	100.0	88.4	11.6		5.8		2.0	3.4	0.3	
Electrical equipment, appliances, and components, 335	100.0	88.9	11.1		1.2		0.4	9.1	0.5	
Transportation equipment, 336	100.0	59.3	40.7		33.5		2.6	3.4	1.1	
Automobiles, trailers, and parts, 3361–63	100.0	87.2	12.8		1.0		2.9	8.4	0.5	
Aerospace products and parts, 3364	100.0	40.6	59.4		54.8		2.7	0.3	1.6	
Other 336	100.0	53.1	47.0		45.8		0.7	0.4	0.0	
Manufacturing nec, other 31–33	100.0	96.0	4.0		0.5		1.6	1.8	0.1	
Nonmanufacturing industries, 21–23, 42–81	100.0	84.3	15.7		4.5		8.0	2.8	0.3	
Information, 51	100.0	98.6	1.4		0.1		s	s	s	
Software publishers, 5112	100.0	97.8	2.2		0.1		s	s	s	
Other 51	100.0	99.4	0.6		0.1		s	s	s	
Finance and insurance, 52	100.0	99.3	0.7		0.0		s	0.0	s	

Industry and NAICS code	All R&D	Paid for by the company	Paid for by others				
			Total	Federal	Companies		All other organizations[b]
					Domestic	Foreign[a]	
Professional, scientific, and technical services, 54	100.0	56.7	43.3	13.8	23.5	5.3	0.7
Computer systems design and related services, 5415	100.0	86.6	13.4	4.2	7.8	0.9	0.5
Scientific R&D services, 5417	100.0	23.9	76.1	18.0	47.0	10.3	0.9
Other 54	100.0	70.3	29.7	22.3	3.7	3.0	0.7
Nonmanufacturing nec, other 21–23, 42–81	100.0	89.0	11.0	0.6	s	s	s

i = more than 50% of value imputed; s = suppressed for reasons of confidentiality and/or reliability.

NAICS = North American Industry Classification System; nec = not elsewhere classified.

[a] Includes unaffiliated foreign companies and foreign parent companies of U.S. subsidiaries.

[b] Includes U.S. state government agencies and laboratories, foreign agencies and laboratories, and all other organizations located inside and outside the United States.

[c] R&D performed by companies in the United States.

Note(s)

Detail may not add to total because of rounding. Industry classification was based on the dominant business code for domestic R&D performance.

Source(s)

National Science Foundation, National Center for Science and Engineering Statistics, Business R&D and Innovation Survey, 2015.

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TABLE 4-10

Sales and R&D intensity for companies that performed or funded R&D, by selected industry: 2015

(Millions of U.S. dollars, percent, and thousands of domestic employees)

Industry and NAICS code	Domestic net sales (US$millions)[a]	R&D intensity (%)[b]	Domestic employment (thousands)[c]	
			Total	R&D[d]
All industries, 21–33, 42–81	9,049,901	3.9	18,915	1,543
Manufacturing industries, 31–33	5,358,542	4.4	10,151	916
Chemicals, 325	1,023,512	6.7	1,373	167
Pharmaceuticals and medicines, 3254	456,424	12.9	553	120
Other 325	567,088	1.7	820	47
Machinery, 333	360,719	3.7	989	82
Computer and electronic products, 334	734,610	9.8	1,355	263
Electrical equipment, appliances, and components, 335	150,020	2.9	330	28
Transportation equipment, 336	1,187,996	4.1	1,754	185
Automobiles, trailers, and parts, 3361–63	795,662	2.4	899	101
Aerospace products and parts, 3364	324,873	8.5	671	70
Other 336	67,461	4.0	184	14
Manufacturing nec, other 31–33	1,901,685	1.5	4,350	191
Nonmanufacturing industries, 21–23, 42–81	3,691,358	3.2	8,764	627
Information, 51	1,105,520	5.9	1,972	279
Software publishers, 5112	403,153	8.2	634	145
Other 51	702,367	4.6	1,338	134
Finance and insurance, 52	709,990	0.8	1,246	32
Professional, scientific, and technical services, 54	421,966	9.2	1,592	246
Computer systems design and related services, 5415	151,626	9.5	587	92
Scientific R&D services, 5417	60,922	26.8	264	82
Other 54	209,418	3.8	741	72

Industry and NAICS code	Domestic net sales (US$millions)[a]	R&D intensity (%)[b]	Domestic employment (thousands)[c]	
			Total	R&D[d]
Nonmanufacturing nec, other 21–23, 42–81	1,453,882	0.7	3,954	70

NAICS = North American Industry Classification System; nec = not elsewhere classified.

[a] Includes domestic net sales of companies that perform or fund R&D, transfers to foreign subsidiaries, and export sales to foreign companies; excludes intracompany transfers and sales by foreign subsidiaries.

[b] R&D intensity is domestic R&D paid for by the company and others and performed by the company divided by domestic net sales.

[c] Data recorded on 12 March represent employment figures for the year.

[d] Includes researchers, R&D managers, technicians, clerical staff, and others assigned to R&D groups.

Note(s)

Detail may not add to total because of rounding. Sales, R&D intensity, and total domestic employment statistics are representative of companies located in the United States that performed or funded R&D; R&D employment statistics are representative of companies located in the United States that performed R&D. Industry classification was based on dominant business code for domestic R&D performance, where available. For companies that did not report business codes, the classification used for sampling was assigned. Excludes data for federally funded R&D centers. The Business R&D and Innovation Survey does not include companies with fewer than five employees.

Source(s)

National Science Foundation, National Center for Science and Engineering Statistics, Business R&D and Innovation Survey (BRDIS), 2015.

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In 2015, these five business sectors accounted for $296.7 billion (83%) of the $355.8 billion business R&D performance total that year (Table 4-9). Corresponding data for earlier years are much the same. In 2008, the five sectors accounted for $244.9 billion (84%) of the $290.6 billion business R&D performance total (Appendix Table 4-13). Computer and electronic products accounted for about 20% of the business R&D performance total in 2015. From 2014 back to 2008, its share was in the 20%–22% range. Chemicals accounted for 19% of the business R&D total in 2015—most of which arose in the pharmaceuticals and medicines industry. Chemicals' share ranged from 19% to 21% in the previous years. The information sector accounted for about 18% of the business R&D performance total in 2015—nearly two-thirds of which was in software publishing. The information sector represented only 13% of the business R&D total in 2008, but its share has been rising since then. Transportation equipment (mainly the automobiles and aerospace industries) accounted for 14% in 2015 but had a higher share, at 17%, in 2008. Finally, the PST sector represented nearly 11% of the business R&D total in 2015—somewhat more than two-fifths is from the scientific R&D services industry, but R&D is also sizable in the computer systems design and related services industry. The PST sector's share of the total was 13% in 2008 and has been gradually declining.

For U.S. business R&D as a whole, performance is funded mainly by companies' own funds: 83% in 2015—the vast majority of which came from companies' units owned and located in the United States (81%), but a small amount (nearly 2%) came from companies' foreign subsidiaries (Table 4-8). The 17% remainder came from R&D performed by the company but paid for by others. Here, the federal government is the largest of these "paid for by" sources—about 8% of the business R&D

performance total in 2015. Domestic companies other than the performer accounted for 4% of the 2015 total; foreign companies (including foreign parents) accounted for 5%. The "all other organizations" category spans a diverse group: state government agencies and laboratories, foreign agencies and laboratories, and any other domestic and foreign funding organizations. But this grouping accounts for a nearly negligible share—0.3% in 2015. Looking back to 2008, the most notable change in the relative shares compared with 2015 is the declining role of federal funding—13%–14% in 2008–09, down to 8% in 2014–15 (Table 4-8).

Nonetheless, there are some noteworthy differences when more narrowly defined sectors and industries are considered, particularly for the five top R&D-performing sectors (and their main industries) previously discussed (Table 4-9). R&D performance funded through a company's own funds was highest (in 2015) in the information sector, where the share was nearly 99%. By contrast, the own-funds share was 59% in the transportation equipment sector and 57% in the PST sector. Even lower shares are found in specific industries: 24% in scientific R&D services and 41% in aerospace products and parts are own-funds.

The federal funding share is greatest in the transportation equipment sector (34%), particularly in the aerospace products and parts industry (55%). The share is also markedly higher in the PST sector (14%) than the all-industries average (8%). The next highest share is in the computer and electronic products sector, at 6%.

Funding provided by other domestic companies, for most of the sectors and industries, is at or below the 4% aggregate average. The exceptions are in PST, where such funding is 24% for the sector, and in scientific R&D services, where it is at an even higher 47%. Funding provided by foreign companies was about the 5% aggregate average for the PST sector and was somewhat below for the computer and electronic products and transportation equipment sectors. Foreign funding was well below the all-industry average in the information sector (less than 1%) and well above in the chemicals sector (11%).

Apart from direct funding for R&D in the form of contracts and grants to businesses, the U.S. government offers indirect R&D support via fiscal incentives such as tax credits. For recent statistics, see sidebar Federal Research and Experimentation Tax Credit and Appendix Table 4-14.

Finally, regarding domestic business R&D performance and company size (as measured by the number of employees), Table 4-11 provides statistics for 2008–15. In 2015, the largest companies (i.e., those with 25,000 or more domestic employees) performed 36% of U.S. business R&D. On the other side, micro companies (5–9 employees) and small companies (10–49 employees) accounted together for 5%. The other 59% was spread among the size classifications between these extremes. As is apparent from the table, the distribution of all business R&D by company size has not greatly changed since 2008.

TABLE 4-11

Funds spent for business R&D performed in the United States, by size of company: Selected years, 2008–15

(Millions of dollars and percent share)

Size of company (number of domestic employees)	Millions of dollars										Percentage of all business R&D				
	2008	2010	2012		2014		2015		2008	2010	2012	2014	2015
All business domestic R&D[a]	290,680	278,977	302,250		340,728		355,821		100.0	100.0	100.0	100.0	100.0
Micro companies[b]													
5–9	NA	3,851	2,926	i	3,295	i	2,988	i	NA	1.4	1.0	1.0	0.8
Small companies													
10–24[c]	14,280	8,722	6,915	i	7,177	i	NA		4.9	3.1	2.3	2.1	NA
25–49	9,626	8,624	7,195	i	8,428	i	NA		3.3	3.1	2.4	2.5	NA
10–19[d]	NA	NA	NA		NA		5,680	i	NA	NA	NA	NA	1.6
20–49[d]	NA	NA	NA		NA		10,249	i	NA	NA	NA	NA	2.9
Medium companies													
50–99	9,351	8,855	9,182	i	10,178	i	11,509		3.2	3.2	3.0	3.0	3.2
100–249	14,662	11,866	12,480		13,492		13,602		5.0	4.3	4.1	4.0	3.8
Large companies													
250–499	10,219	10,283	11,264		12,203		13,553		3.5	3.7	3.7	3.6	3.8
500–999	11,886	10,117	11,484		13,262		15,217		4.1	3.6	3.8	3.9	4.3
1,000–4,999	46,336	48,228	50,691		57,551		58,094		15.9	17.3	16.8	16.9	16.3
5,000–9,999	24,764	27,463	30,483		38,202		38,838		8.5	9.8	10.1	11.2	10.9
10,000–24,999	48,737	41,835	49,493		54,445		59,328		16.8	15.0	16.4	16.0	16.7
25,000 or more	100,820	99,133	110,138		122,495		126,763		34.7	35.5	36.4	36.0	35.6

i = more than 50% of value imputed; NA = not available.

[a] R&D performed by companies in the domestic United States. Includes industries in NAICS 21–33, 42–81.

[b] Business R&D and Innovation Survey does not include companies with fewer than five employees.

[c] Data for 2008 include the 5–9 employees category.

[d] Employee size categories have been revised to match international classifications starting in 2015.

Note(s)

Detail may not add to total because of rounding. This table excludes data for federally funded R&D centers.

Source(s)

National Science Foundation, National Center for Science and Engineering Statistics, Business R&D and Innovation Survey (BRDIS) (annual series).

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SIDEBAR

Federal Research and Experimentation Tax Credit

The United States and other Organisation for Economic Co-Operation and Development (OECD) countries offer fiscal incentives for business R&D at the national and subnational levels (OECD 2017).* For businesses, tax credits reduce the after-tax costs of R&D activities. For governments, tax credits are forgone revenue, known as tax expenditures. Such incentives are generally justified by the inability of private performers to capture the full benefits of R&D, given the intangible nature and abundant spillover effects of new knowledge and information.

The U.S. research and experimentation (R&E) tax credit was originally established by the Economic Recovery Tax Act of 1981 on a temporary basis. The credit was extended on a temporary basis 16 times through 2015. It was made permanent as part of the Protecting Americans from Tax Hikes Act of 2015 (P.L. 114-113, 18 December 2015). The R&E credit is incremental, with the credit amount calculated as an applicable credit rate times the amount of qualified research expense above a base amount; under the law, taxpayers may select one of several methods to calculate the credit.** (For further details and a discussion of data on the use of the credit, see U.S. Department of the Treasury [2016]).

Based on estimates from the Internal Revenue Service (IRS) Statistics of Income, R&E tax credit claims fell to $7.8 billion in 2009 from $8.3 billion in 2008 but rebounded in subsequent years, totaling $11.3 billion in 2013 (most recent data; Appendix Table 4-14). Likewise, the number of corporate returns claiming the credit dropped in 2009 compared with 2008 but resumed an upward trend in subsequent years. R&E credit claims relative to company-funded domestic R&D have fluctuated fairly narrowly between 3.0% and 4.4% since 2001 (3.6% in 2008, 3.5% in 2009, and increasing gradually to 4.4% in 2012 and 2013).

* For general information on US and other OECD countries tax relief for business R&D see http://www.oecd.org/sti/rd-tax-stats.htm

** See Internal Revenue Code (IRC) Section 41, as amended. See also IRS Form 6765 at https://www.irs.gov/pub/irs-pdf/i6765.pdf.

Cross-National Comparisons of Business R&D

The industries currently predominant in performing business R&D in the United States are generally also the same in the other largest R&D-performing countries. Table 4-12 provides cross-national comparisons for the United States, France, Germany, the United Kingdom, China, Japan, and South Korea (corresponding statistics for India and Russia are not presently available). These data come from the OECD's Analytical Business Enterprise R&D (ANBERD) database.[3] Note that the classification of industries in this table reflects the International Standard Industrial Classification of All Economic Activities (ISIC), Revision 4 for all countries (including the United States), which differs somewhat from NAICS, which is used to report U.S. data earlier in this section of the chapter.[4] The coverage in Table 4-12 is also truncated, in that only those industries with comparatively higher levels of annual R&D performance are included—for a more complete listing of industries, see the OECD ANBERD database (as cited in Table 4-12). (All amounts and calculations are in current purchasing power parity or PPP dollars, unless otherwise noted.)

TABLE 4-12

Business expenditures for R&D, by selected countries and top R&D-performing industries: 2014 or most recent year

(PPP millions of current dollars and percent share)

Industry	ISIC Rev.4		United States (2014)	France (2013)	Germany (2014)	United Kingdom (2014)	China (2014)	Japan (2014)	South Korea (2014)
	Section	Division							
PPP current $millions									
Total business enterprise	A–U	1–99	340,728	35,956	72,425	28,151	275,257	129,062	58,156
Manufacturing	C	10–33	232,815	18,255	62,877	10,993	242,975	111,666	51,709
Chemicals and chemical products		20	9,688	1,106	4,611	517	22,477	7,157	2,771
Pharmaceuticals, medicinal chemical, and botanical products		21	56,612	943	5,127	565	10,679	14,205	1,309
Computer, electronic, and optical products		26	73,891	4,296	9,539	1,421	42,724	27,427	30,920
Motor vehicles, trailers, and semi-trailers		29	18,404	2,233	24,992	2,848	21,537	32,485	6,855
Other transport equipment		30	28,342	3,969	2,628	2,246	11,659	852	887
Air and spacecraft and related machinery		303	26,181	3,651	2,289	2,108	NA	468	88
Total services	G–U	45–99	102,039	16,630	9,008	16,580	NA	15,956	4,803
Information and communication	J	58–63	74,792	4,256	4,103	4,145	NA	6,539	2,499
Publishing activities		58	36,140	1,094	NA	117	NA	9	1,615
Software publishing		582	36,052	1,076	NA	51	NA	NA	1,600
Computer programming, consultancy, and related activities		62	11,019	1,984	3,459	2,309	NA	2,629	227

Industry	ISIC Rev.4		United States (2014)	France (2013)	Germany (2014)	United Kingdom (2014)	China (2014)	Japan (2014)	South Korea (2014)
	Section	Division							
Professional, scientific, and technical activities	M	69–75	19,956	9,785	3,982	9,837	NA	8,152	1,228
Scientific R&D		72	12,807	4,213	2,215	7,025	NA	7,442	348
Percentage of total business enterprise									
Total business enterprise	A–U	1–99	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Manufacturing	C	10–33	68.3	50.8	86.8	39.0	88.3	86.5	88.9
Chemicals and chemical products		20	2.8	3.1	6.4	1.8	8.2	5.5	4.8
Pharmaceuticals, medicinal chemical, and botanical products		21	16.6	2.6	7.1	2.0	3.9	11.0	2.3
Computer, electronic, and optical products		26	21.7	11.9	13.2	5.0	15.5	21.3	53.2
Motor vehicles, trailers, and semi-trailers		29	5.4	6.2	34.5	10.1	7.8	25.2	11.8
Other transport equipment		30	8.3	11.0	3.6	8.0	4.2	0.7	1.5
Air and spacecraft and related machinery		303	7.7	10.2	3.2	7.5	NA	0.4	0.2
Total services	G–U	45–99	29.9	46.3	12.4	58.9	NA	12.4	8.3
Information and communication	J	58-63	22.0	11.8	5.7	14.7	NA	5.1	4.3
Publishing activities		58	10.6	3.0	NA	0.4	NA	0.0	2.8
Software publishing		582	10.6	3.0	NA	0.2	NA	NA	2.8
Computer programming, consultancy, and related activities		62	3.2	5.5	4.8	8.2	NA	2.0	0.4
Professional, scientific, and technical activities	M	69–75	5.9	27.2	5.5	34.9	NA	6.3	2.1
Scientific R&D		72	3.8	11.7	3.1	25.0	NA	5.8	0.6

NA = not available.

ISIC Rev.4 = International Standard Industrial Classification of All Economic Activities, Revision 4; PPP = purchasing power parity.

Note(s)

Detail may not add to total because of rounding. Industry classifications for all countries are based on main activity. The U.S. business R&D data are from the U.S. Business R&D and Innovation Survey 2014 (cross-walked to the ISIC Rev. 4 classifications). In general, the table includes industries with annual R&D expenditures of $10 billion or more (i.e., each country's largest R&D performers). See the Organisation for Economic Co-operation and Development's (OECD's) ANalytic Business Enterprise Research and Development (ANBERD) database for a more detailed set of industries by country (source as below).

Source(s)

OECD, ANBERD database, Statistical Analysis Database, R&D Expenditures in Industry, https://stats.oecd.org/Index.aspx?DataSetCode=ANBERD_REV4, accessed 25 January 2016.

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Based on ISIC, the manufacturing section (ISIC 10–33) accounted for about 68% of the $340.7 billion of overall business R&D performance in the United States in 2014. As apparent in Table 4-12, this stemmed in large part from the relatively high levels of R&D performed in the computer, electronic, and optical products division (ISIC 26; $73.9 billion, or 22% of all business-performed R&D in the United States in 2014); the pharmaceuticals, medicinal chemical, and botanical products division (ISIC 21; $56.6 billion, 17%); and the air and spacecraft and related machinery industry (ISIC 303; $26.2 billion, 8%). (The shares reported here are not materially different from those reported earlier in this section based on the NAICS categories.)

Outside of manufacturing, a comprehensive group encompassing all services divisions (ISIC 45–99) accounted for most of the rest of U.S. business R&D in 2014 ($102.0 billion, or 30%) (Table 4-12). The information and communication section (ISIC 58–63) itself accounted for 22%, including software publishing (ISIC 582, 11%). The PST activities section (ISIC 69–75) represented 6%, including scientific research and development (ISIC 72, 4%).

For Germany, Japan, South Korea, and China, the manufacturing sector accounts for a substantially higher share of overall business R&D—87%–89%, depending on the country (Table 4-12). With Germany, the motor vehicles, trailers, and semi-trailers division (ISIC 29) accounted for 35% of the $72.4 billion of business R&D in 2014. The next largest share was computer, electronic, and optical products (ISIC 26) at 13%. For Japan, with $129.1 billion of business R&D in 2014, the R&D emphases were 25% in motor vehicles, trailers, and semi-trailers (ISIC 29); 21% in computer, electronic, and optical products (ISIC 26); and 11% in pharmaceuticals, medicinal chemical, and botanical products (ISIC 21). For South Korea, 53% of its $58.2 billion of business R&D in 2014 was in computer, electronic, and optical products (ISIC 26); the next highest share was 12% in motor vehicles, trailers, and semi-trailers (ISIC 29). China's business R&D, $275.3 billion in 2014, although conducted mainly in manufacturing, is more diverse: 16% in computer, electronic, and optical products (ISIC 26); 8% in chemicals and chemical products (ISIC 20); and 8% in motor vehicles, trailers, and semi-trailers (ISIC 29), with the rest widely spread.

France and the United Kingdom are exceptions to the manufacturing emphasis, given the quite large shares of R&D that occur in services industries (Table 4-12). For France, 51% of its $36.0 billion of business R&D in 2013 was in manufacturing, with peaks in computer, electronic, and optical products (12%) and in air and spacecraft and related machinery (10%). But 46% of France's business R&D total came from services, with 27% in the PST activities section (ISIC 69–75) and 12% in the information and communication section (ISIC 58–63). Somewhat similarly, for the United Kingdom, with $28.2 billion of

business R&D in 2014, 39% is in manufacturing, with modest emphases in motor vehicles, trailers, and semi-trailers (10%) and air and spacecraft and related machinery (8%). But 59% is in services—35% in PST activities (ISIC 69–75) and 15% in information and communication (ISIC 58–63).

R&D by Multinational Enterprises

The extent and geographic spread of R&D by multinational enterprises (MNEs) are useful markers of the increasingly global character of supply chains for production and innovation in R&D-intensive sectors. These business activities reflect a mix of international economic trends, including the increased complexity of global supply chains, the deepening arrays of scientific or technological capabilities and resources around the globe, and the need to economically and strategically strengthen internal technological capabilities (Moncada-Paternò-Castello, Vivarelli, and Voigt 2011; OECD 2008).

This section is based on MNE operations data collected in annual foreign direct investment surveys conducted by the U.S. Bureau of Economic Analysis (BEA). These data cover majority-owned affiliates (those owned more than 50% by their parent companies) of foreign MNEs located in the United States (Survey of Foreign Direct Investment in the United States) and U.S. MNEs and their majority-owned foreign affiliates (Survey of U.S. Direct Investment Abroad).[5] (All amounts and calculations are in current dollars, unless otherwise noted.)

R&D Performed in the United States by Affiliates of Foreign Multinational Enterprises

Affiliates of foreign MNEs located in the United States (hereafter, U.S. affiliates) performed $56.9 billion of R&D in the United States in 2014 (Table 4-13). This was equivalent to 17% of the $340.7 billion of business R&D performed in the United States in 2014 (comparing data in Table 4-1 and Table 4-13). Both the level of U.S. affiliate R&D and its share of the total of U.S. business R&D have generally increased since the late 1990s. In 1997, U.S. affiliate R&D was $17.2 billion, or equivalent to 11% of the U.S. business total; in 2007, it was $41.0 billion, or equivalent to 15% of the U.S. business R&D total (Appendix Table 4-2 and Appendix Table 4-15).

About more than two-thirds of U.S. affiliate R&D in 2014 was performed by firms owned by parent companies based in five countries: Switzerland (19%), Japan (14%), the United Kingdom (13%), France (12%), and Germany (12%) (Table 4-13). Although the relative rankings have shifted somewhat from year to year, these have been the predominant countries throughout the last 5 years.

TABLE 4-13

R&D performed by majority-owned affiliates of foreign companies in the United States, by selected industry of affiliate and investor country: 2014

(Millions of current U.S. dollars)

Country	All industries	Manufacturing						Nonmanufacturing		
		Total	Chemicals	Machinery	Computer and electronic products	Electrical equipment, appliances, and components	Transportation equipment	Wholesale trade	Information	Professional, scientific, and technical services
All countries	56,904	41,124	22,407	2,835	5,000	1,070	6,295	8,407	1,235	4,905
Canada	509	346	1	s	s	0	212	14	75	58
Europe	42,068	34,579	19,791	2,491	3,363	997	5,225	2,790	726	3,289
France	6,749	6,242	s	s	1,625	s	s	s	287	57
Germany	7,080	5,791	2,058	s	171	19	s	238	s	s
Netherlands	2,362	1,672	252	s	s	0	s	505	3	s
Switzerland	10,551	8,539	s	45	s	s	s	s	5	1,564
United Kingdom	7,269	6,754	5,033	76	298	s	641	118	198	179
Other	8,058	5,581	1,149	229	134	s	s	1,522	s	s
Asia and Pacific	10,539	3,636	1,391	s	515	73	852	4,963	s	s
Japan	7,865	2,920	1,297	195	440	69	574	3,550	165	1,109
Other	2,674	716	94	s	75	4	279	1,412	s	s
Other	3,788	2,563	1,224	s	s	0	6	640	s	s

s = suppressed for reasons of confidentiality and/or reliability.

Note(s)

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

Source(s)

Bureau of Economic Analysis, Survey of Foreign Direct Investment in the United States (annual series), https://www.bea.gov/iTable/Index_MNC.cfm, accessed 26 April 2017.

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U.S. affiliates classified in manufacturing accounted for 72% of the U.S. affiliate R&D total in 2014 (Table 4-14). This manufacturing share has generally been 70% or more since 2007 (Appendix Table 4-16). The chemicals subsector share was 39%, and the pharmaceuticals share (a component of chemicals) was 36%. Other manufacturing subsectors with appreciable shares in 2014 included transportation equipment (11%), computer and electronic products (9%), and machinery (5%) (Appendix Table 4-16). For nonmanufacturing, the most notable sectors in 2014 were wholesale trade (15%) and PST services (9%). (Affiliates are classified in the industries in which they have the most sales; many affiliates classified in wholesale trade have manufacturing operations as well.)

TABLE 4-14

R&D performed abroad by majority-owned foreign affiliates of U.S. parent companies, by selected industry of affiliate and host region, country, or economy: 2014

(Millions of current U.S. dollars)

Region, country, or economy	All industries	Manufacturing						Nonmanufacturing		
		Total	Chemicals	Machinery	Computer and electronic products	Electrical equipment, appliances, and components	Transportation equipment	Wholesale trade	Information	Professional, scientific, and technical services
All countries	52,174	32,128	8,511	2,852	8,376	527	7,723	4,976	3,952	10,338
Canada	3,418	2,046	330	42	695	65	674	206	445	641
Europe	30,774	19,822	5,509	2,000	4,305	240	5,083	3,933	1,937	4,523
Austria	314	124	18	s	9	4	5	48.0	0	142
Belgium	1,151	818	609.0	19	96	1	s	71	s	230
Denmark	483	385	s	s	108	0	0	s	s	2
Finland	389	331	4	s	s	1	0	18	*	40
France	2,395	1,899	438	224	440	19	370	192	127	169
Germany	8,344	6,926	700	656	2,016	108	2,798	556	119	649
Ireland	2,415	1,472	893	*	349	s	3	s	533	295
Italy	800	637	186	240	59	9	68	28	5	128
Luxembourg	311	s	5.0	*	*	*	0	4	9	s
Netherlands	1,226	936	404	58	83	11	s	65	54	108

Region, country, or economy	All industries	Manufacturing						Nonmanufacturing		
		Total	Chemicals	Machinery	Computer and electronic products	Electrical equipment, appliances, and components	Transportation equipment	Wholesale trade	Information	Professional, scientific, and technical services
Norway	296	112	s	1.0	47	s	0	7	s	s
Poland	241	155	32	2	s	*	55	7	2	77
Russia	195	50	6	s	5	0	0	s	s	115
Spain	406	230	129.0	4	s	6	50.0	67	s	63
Sweden	711	550	82	12.0	82	5	203	21.0	70	67
Switzerland	4,140	1,525	665	s	199	s	7.0	1,927	s	s
United Kingdom	6,306	3,193	943	230	444	34	1,227	700	530	1,589
Latin America and OWH	2,333	1,724	512	163	166	s	613	109	59	343
Argentina	133	63	39	*	1	0	s	1	s	s
Brazil	1,221	1,067	315	s	38	*	531	16	36	73
Mexico	472	332	83	s	4	s	67	s	2	s
Africa	102	28	10	s	2	0	4	s	s	s
South Africa	58	24	7	s	2	0	4.0	s	*	s
Middle East	2,906	1,182	225	s	639	s	1	s	s	s
Israel	2,695	s	s	172	639	s	1	s	s	1,341

Region, country, or economy	All industries	Manufacturing						Nonmanufacturing		
		Total	Chemicals	Machinery	Computer and electronic products	Electrical equipment, appliances, and components	Transportation equipment	Wholesale trade	Information	Professional, scientific, and technical services
Asia and Pacific	12,639	7,325	1,925	467	2,569	205	1,348	568	1,265	3,453
Australia	1,185	851	142	25	32	9	s	52	128	148
China	3,036	1,494	399	92	469	121	174	89.0	s	1,053
India	2,906	909	314	158	355	s	57	s	s	1,331
Japan	2,521	1,740	937	123	460	s	s	s	148	559
Malaysia	440	430	2	1	419	0	0	3.0	2	6
Singapore	767	550	28	s	379	s	s	119	35	58
South Korea	946	825	47	19	151	0	s	17	29	75
Taiwan	387	215	20	2	165	7	5	6	31	136

* = ≤ $500,000; s = suppressed for reasons of confidentiality and/or reliability.

OWH = other Western Hemisphere.

Note(s)

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

Source(s)

Bureau of Economic Analysis, Direct Investment and Multinational Enterprises (annual series), https://www.bea.gov/iTable/index_MNC.cfm, accessed 27 January 2017.

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U.S. Multinational Enterprise Parent Companies and Their Foreign Affiliates

R&D performed outside the United States by majority-owned foreign affiliates of U.S. MNEs totaled $52.2 billion in 2014 (Table 4-14). The parent companies of these U.S. MNEs performed $268.8 billion of R&D in the United States (Appendix Table 4-19), which was equivalent to about 79% of the total business R&D conducted in the United States that year. In 1997, foreign affiliates' R&D performance abroad was $14.6 billion; in 2007, it was $34.4 billion (Appendix Table 4-17).

European countries hosted $30.8 billion (59%) of this foreign affiliate R&D in 2014 (Table 4-14). The largest R&D expenditures by U.S.-owned affiliates in this region were in Germany ($8.3 billion, 16%) and the United Kingdom ($6.3 billion, 12%). Other notable locations included Switzerland ($4.1 billion, 8%), Ireland ($2.4 billion, 5%), France ($2.4 billion, 5%), the Netherlands ($1.2 billion, 2%), and Belgium ($1.2 billion, 2%). The European share overall was 66% in 2007 and 69% in 1997 (Appendix Table 4-17). Germany and the United Kingdom were the predominant host countries over this 15-year period, although the two countries had more evenly matched shares before 2008.

Canada hosted $3.4 billion (7%) of U.S. MNE foreign affiliate R&D in 2014, a sizable amount in comparison with most other countries. Although Canada has seen increased levels of U.S. foreign affiliates' R&D performance since 1997 (albeit with some year-over-year volatility), its share has been gradually declining since then (Appendix Table 4-17).

Countries in the Asia and Pacific regions hosted $12.6 billion (24%) of U.S. foreign affiliate R&D in 2014 (Table 4-14). Majority-owned affiliates of U.S. MNEs in China ($3.0 billion, 6%), India ($2.9 billion, 6%), and Japan ($2.5 billion, 5%) had the largest R&D expenditures in this region. As in other cross-national comparative indicators for R&D, the Asia/Pacific region continues to gain an increasing share as a host for U.S. parent companies' foreign affiliate R&D. The region accounted for only 13% of the total in 1997. Whereas Japan's share has remained sizable across the 1997–2014 period, though declining somewhat since the early 2000s, the growth areas for foreign affiliate R&D have been India and China, each of which accounted for a negligible share in the late 1990s but grew to exceed that of Japan by 2014 (Appendix Table 4-17).

Latin America and other Western Hemisphere countries—mostly Brazil—accounted for $2.3 billion (4%) in R&D expenditures by U.S.-owned affiliates in 2014. U.S.-owned affiliates in the Middle East—nearly all in Israel—accounted for $2.9 billion (6%) in 2014.

With respect to economic sectors, foreign affiliate R&D of U.S. MNEs was concentrated in four industries in 2014: PST services ($10.3 billion, 20%), chemicals particularly pharmaceuticals ($8.5 billion, 16%), computer and electronic products ($8.4 billion, 16%), and transportation equipment ($7.7 billion, 15%) (Table 4-14). Other notable industries include wholesale trade ($5.0 billion), information ($4.0 billion), and machinery ($2.9 billion). These industries have been similarly prominent over the last several years (Appendix Table 4-18).

As noted, Europe (as a whole) and Japan remain top R&D hosts for U.S. MNEs in major industries, reflecting both strengths of the host countries in certain technologies and the large, longstanding investments by U.S. MNEs in these locations (Appendix Table 4-17). In transportation equipment, Germany is by far the largest location of U.S.-owned affiliates' R&D—$2.8 billion of the $7.7 billion total R&D in 2014 performed by majority-owned foreign affiliates of U.S. MNEs is classified in this industry (Table 4-14). Similarly, for computers and electronic products manufacturing, Germany was the leading host location, with $2.0 billion in R&D expenditures out of the $8.4 billion total R&D performed by majority-owned foreign affiliates of U.S. MNEs classified in this industry. In chemicals manufacturing, the United Kingdom, Japan, and Ireland were the top locations of U.S.-owned affiliates' R&D in 2014—each accounting for $0.9 billion, of the $8.5 billion in total U.S.-owned affiliates' R&D in this industry.

For R&D performed by U.S. MNE foreign affiliates classified in PST services, the host country roles reflect both older trends and the rise of Asia as a host of U.S.-owned R&D (Table 4-14). The United Kingdom hosted the largest amount of R&D

performed in this industry in 2014 ($1.6 billion of the $10.3 billion total of U.S.-owned affiliates' R&D outside the United States). The second, third, fourth, and fifth largest were, respectively, Israel ($1.3 billion), India ($1.3 billion), China ($1.1 billion), and Germany ($0.6 billion).

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[1] The Business R&D and Innovation Survey does not collect data for companies with fewer than five employees. See sidebar Measured and Unmeasured R&D.

[2] The industry-level data presented in this section are obtained by classifying a company's total R&D into a single industry, even if R&D activities occur in multiple lines of business. For example, if a company has $100 million in R&D expenses—$80 million in pharmaceuticals and $20 million in medical devices—the total R&D expense of $100 million is assigned to the pharmaceuticals industry because it is the largest component of the company's total R&D expense (Shackelford 2012). However, most companies performed R&D in only one business activity area. In 2010, 86% of companies reported domestic R&D performed by and paid for by the company related to only one business activity. See Shackelford (2012) for an in-depth analysis of the relationship between business codes and industry codes.

[3] For a description of the OECD's ANBERD methodology and data, see https://www.oecd.org/innovation/inno/anberdanalyticalbusinessenterpriseresearchanddevelopmentdatabase.htm.

[4] ISIC Revision 4 was released by the United Nations Statistics Division in August 2008. For an overview of the classification structure, comparisons with earlier editions, and background, see https://unstats.un.org/unsd/cr/registry/regcst.asp?Cl=27.

[5] For further information on the BEA surveys, see https://www.bea.gov/international.

Recent Trends in Federal Support for U.S. R&D

One of the federal government's most significant roles in supporting the U.S. R&D system is the regular stream of funding it has provided for R&D activities conducted by both federal entities (agency intramural laboratories/facilities and FFRDCs) and external, nonfederal organizations such as businesses and academic institutions. Fifteen federal departments and a dozen other agencies engage in and/or provide funding for R&D in the United States (Table 4-15). Historically, the majority of the yearly federal funding total is accounted for by the R&D activities of a relatively small group of departments and agencies: Department of Defense (DOD); Department of Health and Human Services (HHS, primarily the National Institutes of Health [NIH]); Department of Energy (DOE); National Aeronautics and Space Administration (NASA); National Science Foundation (NSF); Department of Agriculture (USDA); and Department of Commerce (DOC).

TABLE 4-15

Federal obligations for R&D and R&D plant, by agency: FYs 2007–16

(Millions of dollars)

Agency	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016[a]
All agencies	129,431.2	129,049.5	144,758.1	146,967.8	139,661.5	140,629.1	127,291.1	132,496.3	131,398.2	142,555.0
Department of Defense	72,290.5	71,996.6	75,973.7	73,623.9	75,327.6	73,973.6	63,654.7	65,128.6	61,683.0	69,076.4
Department of Health and Human Services	29,556.1	29,700.7	35,735.9	37,616.9	30,928.0	31,335.8	29,512.8	30,799.1	30,425.5	32,047.4
Department of Energy	8,629.8	8,990.3	11,562.2	11,644.9	10,680.4	10,635.2	10,397.1	11,296.3	12,343.0	13,303.7
National Aeronautics and Space Administration	6,205.8	5,847.1	5,957.6	8,691.3	8,429.0	10,758.3	10,494.3	10,880.6	11,413.1	12,313.5
National Science Foundation	4,406.9	4,506.4	6,924.8	6,073.4	5,536.6	5,705.4	5,328.5	5,800.2	5,989.7	6,116.7
Department of Agriculture	2,372.3	2,246.0	2,344.7	2,615.4	2,376.9	2,187.6	2,031.2	2,269.0	2,352.0	2,491.2
Department of Homeland Security	1,106.4	1,056.8	983.6	1,131.8	1,127.5	832.2	718.8	943.8	1,645.2	886.4
Department of Commerce	1,145.4	1,196.4	1,533.4	1,683.2	1,308.9	1,230.7	1,293.9	1,567.8	1,519.4	1,933.0
Department of Transportation	811.0	825.2	846.2	929.2	861.8	936.1	875.8	847.7	884.5	1,095.0
Department of the Interior	624.7	645.3	738.8	728.0	716.5	742.7	717.3	762.4	808.7	850.2
Department of Veterans Affairs	446.5	480.0	510.0	563.0	612.9	614.8	639.0	588.8	661.6	673.4
Environmental Protection Agency	576.0	532.0	552.8	572.3	581.7	581.1	529.7	538.0	520.7	513.3
Department of Education	333.1	328.1	322.4	362.8	346.1	338.0	309.9	322.0	251.3	254.5
Smithsonian Institution	186.0	188.0	226.7	213.0	248.7	246.2	240.3	230.9	229.0	232.6
Agency for International Development	234.5	123.8	160.1	84.3	119.2	77.4	125.5	59.9	212.2	212.2

Agency	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016[a]
Department of Justice	184.4	114.5	103.4	125.4	102.3	85.0	118.7	160.5	149.7	151.5
All other agencies	321.8	272.3	281.8	309.0	357.4	349.0	303.6	300.7	309.6	404.0

[a] FY 2016 data are preliminary and may later be revised.

Note(s)

This table lists all agencies with R&D and R&D plant obligations greater than $100 million in FY 2015. All other agencies include Department of Housing and Urban Development, Department of Labor, Department of State, Department of the Treasury, Appalachian Regional Commission, Consumer Product Safety Commission, Federal Communications Commission, Federal Trade Commission, Library of Congress, National Archives and Records Administration, Nuclear Regulatory Commission, and Social Security Administration.

Source(s)

National Science Foundation, National Center for Science and Engineering Statistics, Survey of Federal Funds for Research and Development.

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The sections immediately following address several topics that illuminate the key recent trends in the important federal role: (1) the ups and downs of overall federal funding for R&D over the last 10 years in particular; (2) how this federal financial support has been distributed across the various federal departments and agencies and by types of performers; (3) which fields of S&E predominate, when looking at federal funding just for research (i.e., basic plus applied research); and, finally, (4) how the U.S. priorities for federal R&D funding compare with those of the world's other large, R&D-performing countries. (All amounts and calculations are in current dollars, unless otherwise noted.)

Of note, the corresponding data for federal funding of U.S. R&D cited in Table 4-1 earlier in this chapter are lower. The Table 4-1 numbers 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 20 years and reflects various technical issues in the measurement of R&D performance and funding (Appendix Table 4-20). For a discussion, see sidebar Tracking R&D Expenditures: Disparities in the Data Reported by Performers and Sources of Funding.

SIDEBAR

Tracking R&D Expenditures: Disparities in the Data Reported by Performers and Sources of Funding

The data on government funding of R&D as reported by the government often differ from those reported by performers of R&D. Consistent with international guidelines, most countries report their national R&D expenditures based chiefly on data from R&D performers (OECD 2015). In the United States, over the last several decades, a sizable gap has opened between what the federal government and R&D performers separately report as the level of federally funded R&D (Figure 4-A; Appendix Table 4-20).

In the mid- to late 1980s, the total of federally funded R&D reported by all U.S. performers exceeded by $3–$4 billion (i.e., 6%–9% of the federally reported total) what the federal government said it funded (top panel of Figure 4-A). In 1989–91, however, the pattern reversed, with the performer-reported total of federal funding less than the federally reported total by $1–$2 billion annually. From the early 1990s through the mid-2000s, this federal report excess grew larger. In 2007, the federal report indicated $127 billion of federal funding for R&D, compared with R&D performers' report of $107 billion—a difference of almost $21 billion, or 16% of the federally reported total. As implied by Figure 4-A's bottom panel (which focuses on only business R&D performers), much of the disparity arose from differences in the federal and performer reports regarding business R&D.

FIGURE 4-A

Difference in federal R&D support, as reported by performers and federal agencies: 1985–2015

Note(s)

Difference is defined as performer-reported R&D minus federally reported R&D funding. A negative discrepancy indicates that agency-reported R&D funding exceeds performer-reported R&D.

Source(s)

National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources (annual series), and Survey of Federal Funds for Research and Development. See Appendix Table 4-20.

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More recently, the all-performer gap has narrowed, although only to a degree. In 2015, the federal report showed federal funding for all R&D performers exceeding the performer-reported total by $15 billion (12% of the federal report). Furthermore, the federal report excess for only the business R&D performers in these most recent years has remained quite sizable (see Figure 4-A). The appearance is that the federal report now includes lower estimates of the level of federally funded R&D by performers (notably in higher education and the federally funded R&D centers) other than the business sector, which then offset the federal report's higher estimates of funding for business R&D.

Federal R&D funding data are normally reported as obligations on a fiscal year basis; performers typically report R&D expenditures on a calendar year basis. Some of the observed discrepancies reflect this difference in reporting calendars. Nevertheless, adjusting these two data series to a common calendar does not substantially remove the observed gaps.

Several investigations into the possible causes for these data disparities have produced insights but no conclusive explanation. A General Accounting Office investigation made the following assessment:

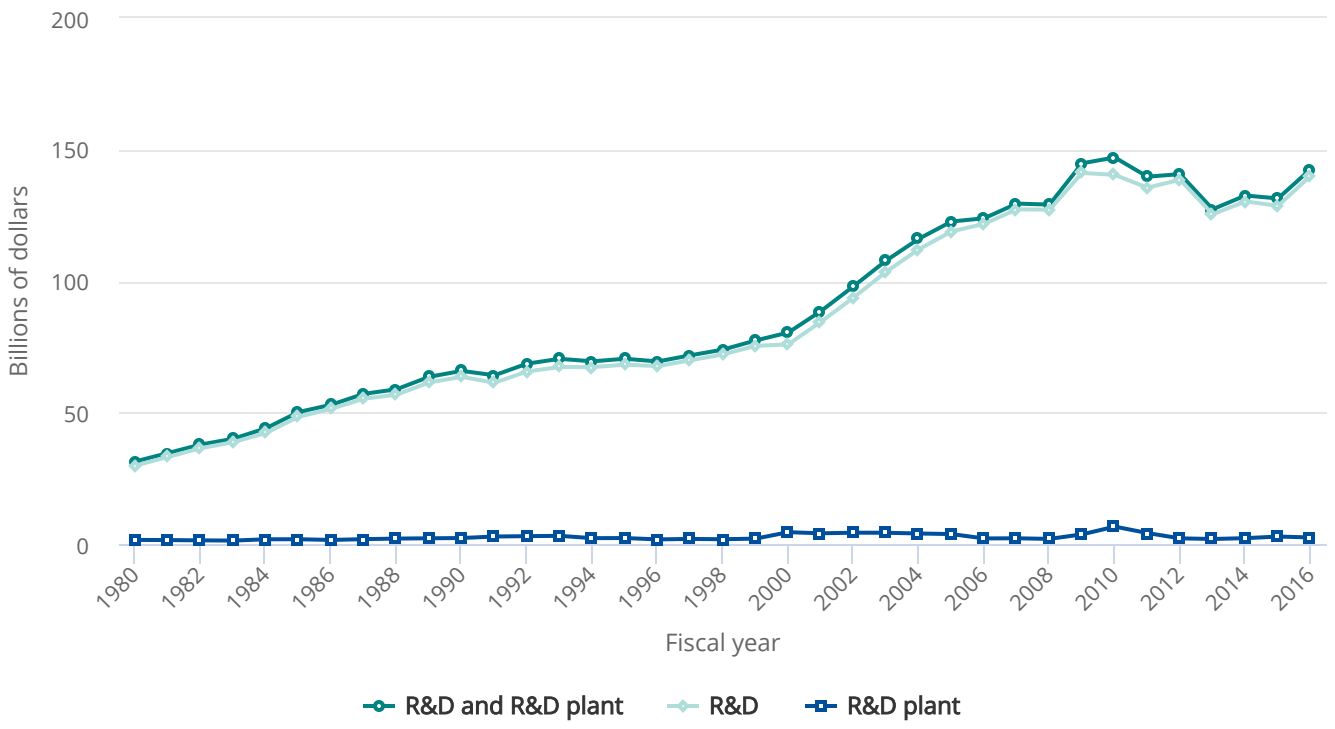
Because the gap is the result of comparing two dissimilar types of financial data (federal obligations and performer expenditures), it does not necessarily reflect poor quality data, nor does it reflect whether performers are receiving or spending all the federal R&D funds obligated to them. Thus, even if the data collection and reporting issues were addressed, a gap would still exist (GAO 2001:2).

Total of Federal Funding for R&D and for Major Agencies

The level of overall federal support for R&D (including for both R&D conduct and R&D plant) has generally increased year to year since the early 1950s (Figure 4-8; Appendix Table 4-21 and Appendix Table 4-22).[1] What was $2–$5 billion in the mid-1950s increased to well above $100 billion in FY 2003 and to just under $130 billion in FYs 2007 and 2008. The level moved higher still in FYs 2009 and 2010, largely a result of the $18.7 billion of incremental funding for R&D authorized by ARRA. In fact, the FYs 2009 and 2010 levels were the highest since the early 1950s, whether considered in current or constant dollar terms (Figure 4-9). Annual growth in federal funding averaged 6.2% in current dollars over FYs 2000–10, or 4.0% when adjusted for inflation.

FIGURE 4-8

Federal obligations for R&D and R&D plant: FYs 1980–2016



Note(s)

FY 2016 data are preliminary and may later be revised. Data for FYs 2009 and 2010 include obligations from the additional federal R&D funding appropriated by the American Recovery and Reinvestment Act of 2009.

Source(s)

National Science Foundation, National Center for Science and Engineering Statistics, Survey of Federal Funds for Research and Development.

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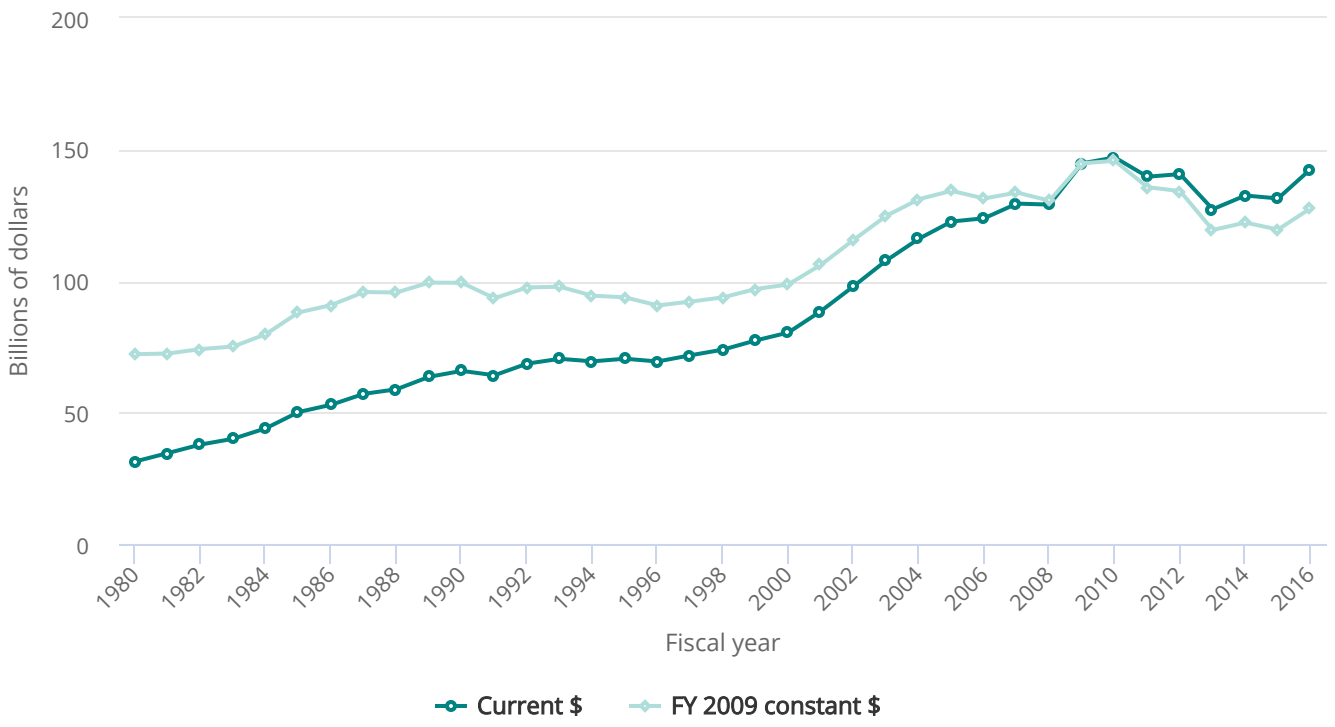
However, a notably different trend has prevailed in the years since then, as federal R&D funding has been buffeted by the more challenging policymaking circumstances for the federal budget that prevailed over the last several years. The $147.0 billion in FY 2010 had dropped to $131.4 billion in FY 2015—with the track of the annual total over the intervening years a mix of several large declines (FYs 2011 and 2013), a modest gain (FY 2014), and several small changes (FYs 2012 and 2015) (Figure 4-9). The obligations total for FY 2016, which is not yet final, indicates a large increase over the FY 2015 level, to $142.6 billion. Nevertheless, when adjusted for inflation, the FY 2015 level is 18% below the FY 2010 level, and the FY 2016 level is still 12% below (Figure 4-9).

FIGURE 4-9

Federal obligations for R&D and R&D plant, current versus constant dollars: FYs 1980–2016



Note(s)

FY 2016 data are preliminary and may later be revised. Data for FYs 2009 and 2010 include obligations from the additional federal R&D funding appropriated by the American Recovery and Reinvestment Act of 2009.

Source(s)

National Science Foundation, National Center for Science and Engineering Statistics, Survey of Federal Funds for Research and Development.

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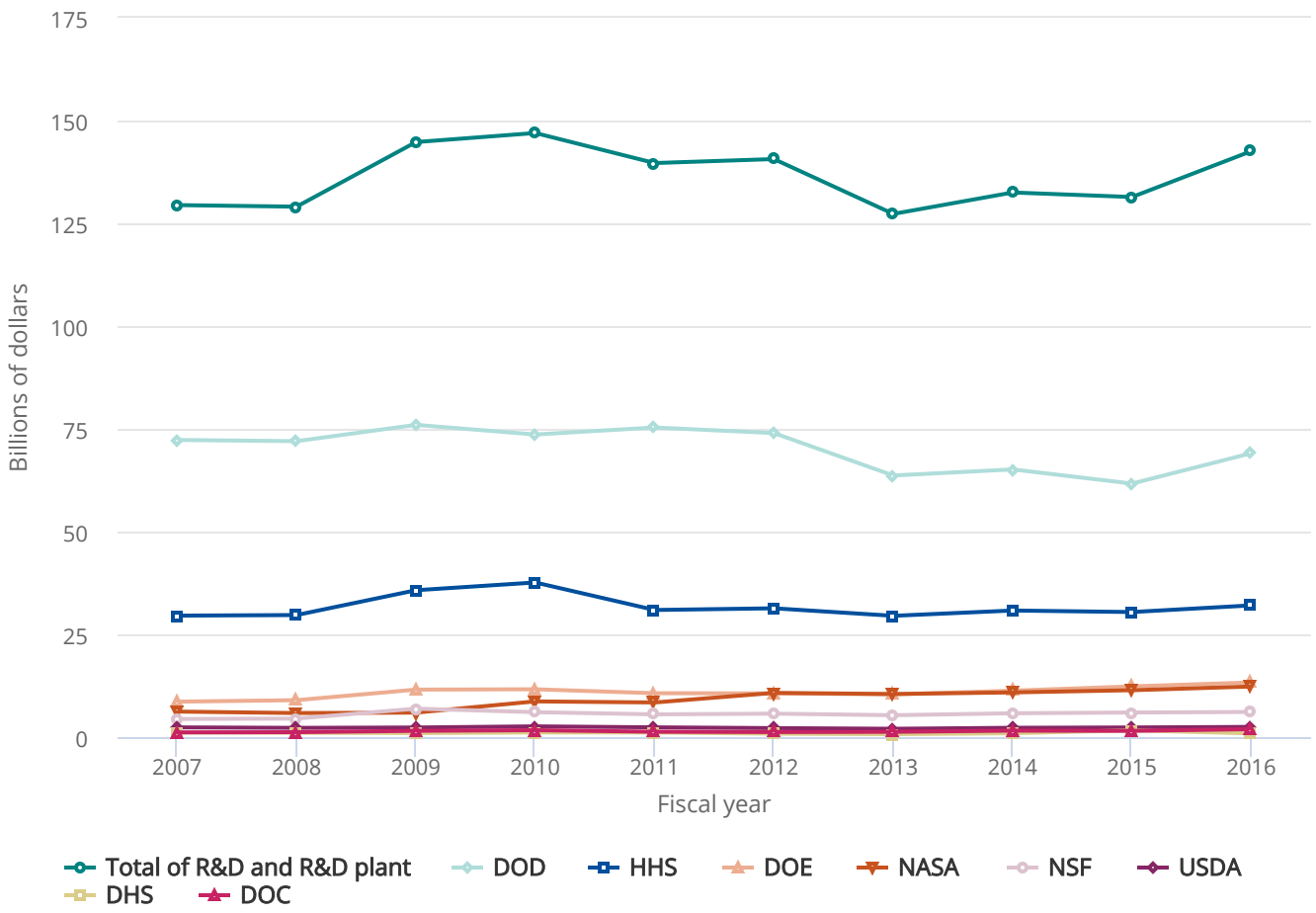
Some of this post–FY 2010 drop in federal R&D funding reflects the waning of the incremental funding provided by ARRA, which showed up as R&D obligations mainly in FYs 2009 and 2010. Even so, the still-sluggish U.S. economy and the more recent federal budget environment since 2011 have taken a toll—with federal funding for R&D affected as part of this larger picture.[2]

In FY 2015, eight agencies each obligated more than $1 billion (current dollars) annually: DOD, HHS, NASA, DOE, NSF, USDA, DHS, and DOC (Table 4-15). Taken together, these eight agencies accounted for about 97% of the federal R&D and R&D plant total that year. Another four agencies obligated funding in the $500 million to $900 million range: Department of Transportation, Department of the Interior, Department of Veterans Affairs, and the Environmental Protection Agency.

Figure 4-10 charts the annual total federal funding for R&D and R&D plant together and that for each of the eight agencies from FY 2007 to FY 2016. With only preliminary data for FY 2016 available at this point, one noticeable trend in the chart is the substantial drop in the federal funding total (current dollars) that occurred from the FY 2010 peak through FY 2015. The figure also shows the funding drop has been borne most heavily by DOD ($11.9 billion of the $15.6 billion cumulative decline from FY 2010 to FY 2015) and HHS ($7.2 billion of the $15.6 decline). NASA had a gain of $2.7 billion over the period; DOE and DHS had gains of, respectively, $0.6 billion and $0.5 billion. The other agencies sustained substantially smaller losses or gains.

FIGURE 4-10

Federal obligations for R&D and R&D plant, by selected agencies: FYs 2007–16



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; NSF = National Science Foundation; USDA = Department of Agriculture.

Note(s)

The departments and agencies included in this figure each had annual R&D obligations of $1 billion or more and together account for the vast majority of the R&D and R&D plant total. Data for FYs 2009 and 2010 include obligations from the additional federal R&D funding appropriated by the American Recovery and Reinvestment Act of 2009.

Source(s)

National Science Foundation, National Center for Science and Engineering Statistics, Survey of Federal Funds for Research and Development (annual series).

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Distribution of Federal Funding of R&D, by Performer and Type of Work

Table 4-16 and Table 4-17 provide breakdowns, by agency, of the $131.4 billion of federal dollars obligated for R&D and R&D plant in FY 2015 according to purpose (R&D conduct, R&D plant), performers funded (intramural, extramural), and type of work (basic research, applied research, development).

The majority of federal dollars obligated for R&D ($128.6 billion) was for R&D conduct, whether performed by the intramural R&D facilities of the agencies themselves, agency-affiliated FFRDCs, or by one or more of various other extramural performers receiving federal R&D funding private businesses, universities and colleges, state and local governments, other nonprofit organizations, or foreign performers) (Table 4-16). Barely 2% of the annual total ($2.8 billion) funded R&D plant, with most of the obligations in this category coming from a few agencies.

For the $128.6 billion of obligations for R&D in FY 2015, 25% was for basic research, 25% for applied research, and 50% for development (Table 4-17). These proportions vary widely, however, across the differing departments/agencies.

TABLE 4-16

Federal obligations for R&D and R&D plant, by agency and performer: FY 2015

(Millions of dollars)

Agency	Total	R&D	R&D plant	Total by performers			
				Intramural and FFRDCs	Percentage of total	Extramural performers	Percentage of total
All agencies	131,398.2	128,573.2	2,825.1	48,149.9	36.6	83,248.4	63.4
Department of Defense	61,683.0	61,513.5	169.5	22,241.4	36.1	39,441.6	63.9
Department of Health and Human Services	30,425.5	30,272.1	153.4	7,258.0	23.9	23,167.5	76.1
Department of Energy	12,343.0	11,391.0	952.0	8,640.4	70.0	3,702.6	30.0
National Aeronautics and Space Administration	11,413.1	11,360.7	52.4	3,229.8	28.3	8,183.3	71.7
National Science Foundation	5,989.7	5,669.7	320.0	341.5	5.7	5,648.2	94.3
Department of Agriculture	2,352.0	2,341.0	10.9	1,517.7	64.5	834.3	35.5
Department of Homeland Security	1,645.2	742.2	902.9	1,367.2	83.1	277.9	16.9
Department of Commerce	1,519.4	1,331.3	188.1	1,141.1	75.1	378.3	24.9
Department of Transportation	884.5	855.6	28.9	298.4	33.7	586.0	66.3
Department of the Interior	808.7	800.1	8.6	692.2	85.6	116.4	14.4
Department of Veterans Affairs	661.6	661.6	0.0	661.6	100.0	0.0	0.0
Environmental Protection Agency	520.7	515.6	5.1	261.8	50.3	258.9	49.7
Department of Education	251.3	251.3	0.0	10.7	4.2	240.7	95.8
Smithsonian Institution	229.0	195.7	33.2	229.0	100.0	0.0	0.0
Agency for International Development	212.2	212.2	0.0	10.9	5.1	201.3	94.8
Department of Justice	149.7	149.7	0.0	20.4	13.7	129.3	86.3
All other agencies	309.6	309.6	0.0	227.8	73.6	81.9	26.5

FFRDC = federally funded research and development center.

Note(s)

This table lists all agencies with R&D obligations greater than $100 million in FY 2015. Detail may not add to total because of rounding. R&D is basic research, applied research, and development and does not include R&D plant. Intramural activities include actual intramural R&D performance and costs associated with planning and administering both intramural and extramural programs by federal personnel. Extramural performers include federally funded R&D performed in the United States and U.S. territories by businesses, universities and colleges, other nonprofit institutions, state and local governments, and foreign organizations. All other agencies include Department of Housing and Urban Development, Department of Labor, Department of State, Department of the Treasury, Appalachian Regional Commission, Consumer Product Safety Commission, Federal Communications Commission, Federal Trade Commission, Library of Congress, National Archives and Records Administration, Nuclear Regulatory Commission, and Social Security Administration.

Source(s)

National Science Foundation, National Center for Science and Engineering Statistics, Survey of Federal Funds for Research and Development, FY 2015–17.

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TABLE 4-17

Federal obligations for R&D, by agency and type of work: FY 2015

(Millions of current dollars)

Agency	Total R&D	Basic research	Applied research	Development	Percentage of total R&D		
					Basic research	Applied research	Development
All agencies	128,573.2	31,527.1	32,118.2	64,927.8	24.5	25.0	50.5
Department of Defense	61,513.5	2,133.4	4,558.1	54,822.1	3.5	7.4	89.1
Department of Health and Human Services	30,272.1	15,076.9	15,119.9	75.4	49.8	49.9	0.2
Department of Energy	11,391.0	4,460.4	4,181.1	2,749.5	39.2	36.7	24.1
National Aeronautics and Space Administration	11,360.7	3,209.7	2,329.7	5,821.3	28.3	20.5	51.2
National Science Foundation	5,669.7	4,973.9	695.8	0.0	87.7	12.3	0.0
Department of Agriculture	2,341.0	924.5	1,203.9	212.7	39.5	51.4	9.1
Department of Homeland Security	742.2	11.7	205.1	525.4	1.6	27.6	70.8
Department of Commerce	1,331.3	232.4	921.5	177.4	17.5	69.2	13.3
Department of Transportation	855.6	0.0	662.6	192.9	0.0	77.5	22.5
Department of the Interior	800.1	53.3	627.0	119.7	6.7	78.4	15.0
Department of Veterans Affairs	661.6	227.2	416.3	18.1	34.3	62.9	2.7
Environmental Protection Agency	515.6	0.0	440.4	75.2	0.0	85.4	14.6
Department of Education	251.3	22.4	137.4	91.6	8.9	54.7	36.4
Smithsonian Institution	195.7	195.7	0.0	0.0	100.0	0.0	0.0
Agency for International Development	212.2	0.0	212.2	0.0	0.0	100.0	0.0
Department of Justice	149.7	5.3	123.0	21.3	3.6	82.2	14.3
All other agencies	309.6	0.2	284.2	25.3	0.1	91.8	8.2

Note(s)

This table lists all agencies with R&D obligations greater than $100 million in FY 2015. Detail may not add to total because of rounding. All other agencies include Department of Housing and Urban Development, Department of Labor, Department of State, Department of the Treasury, Appalachian Regional Commission, Consumer Product Safety Commission, Federal Communications Commission, Federal Trade Commission, Library of Congress, National Archives and Records Administration, Nuclear Regulatory Commission, and Social Security Administration.

Source(s)

National Science Foundation, National Center for Science and Engineering Statistics, Survey of Federal Funds for Research and Development, 2015–17.

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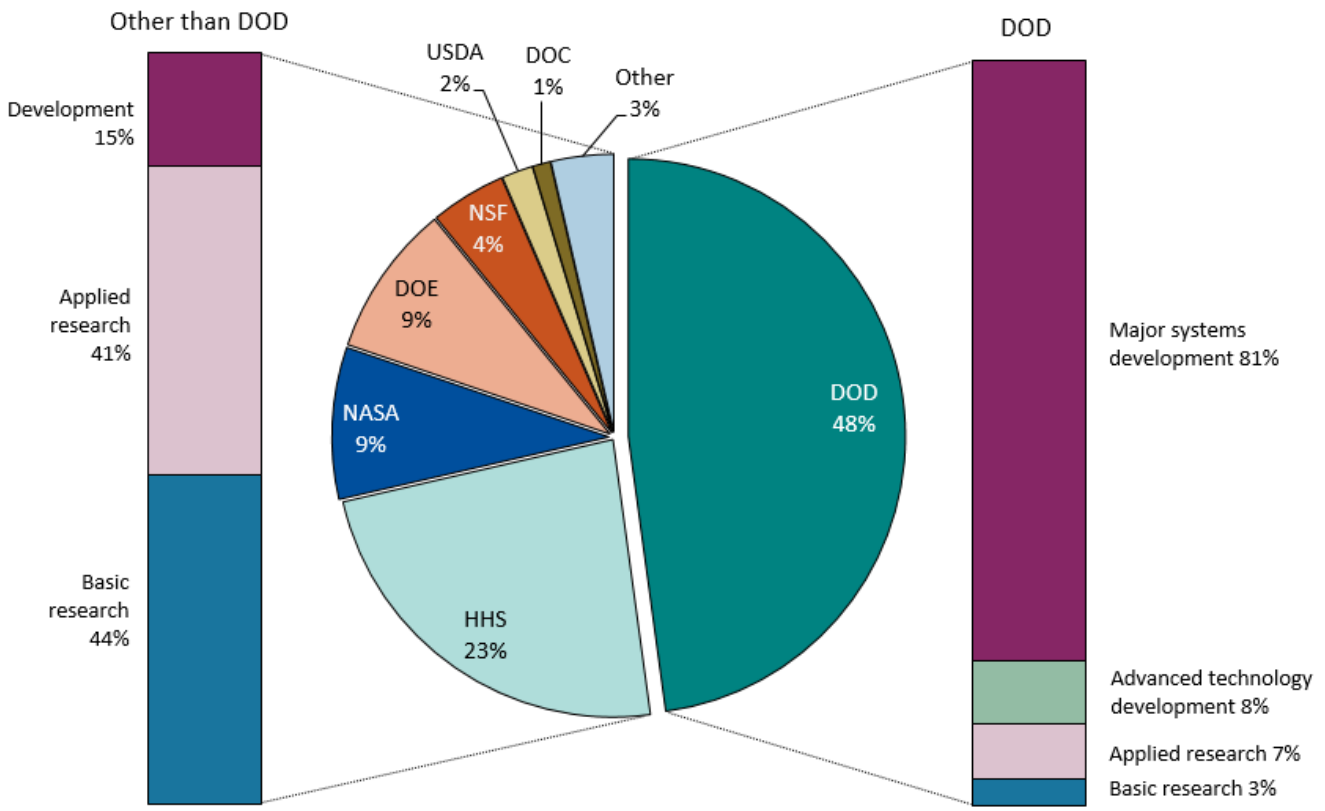
Department of Defense

In FY 2015, DOD obligated a total of $61.7 billion for R&D and R&D plant (Table 4-16), about 47% of all federal R&D and R&D plant spending that year. Almost all of the DOD total was R&D spending ($61.5 billion), with the remainder spent on R&D plant. Of the total, 36% ($22.2 billion) was spending by the department's intramural laboratories, related agency R&D program activities, and FFRDCs (Table 4-16). Extramural performers accounted for 64% ($39.4 billion) of the obligations, with the bulk going to business firms ($35.8 billion) (Appendix Table 4-23).

Considering just the R&D, relatively small amounts were spent on basic research ($2.1 billion, 3%) and applied research ($4.6 billion, 7%) in FY 2015 (Table 4-17). The majority of the obligations, $54.9 billion (89%), went to development. Furthermore, the bulk of this DOD development ($49.6 billion) was allocated for major systems development, which includes the main activities in developing, testing, and evaluating combat systems (Figure 4-11). The remaining DOD development ($5.2 billion) was allocated for advanced technology development, which is more similar to other agencies' development obligations.

FIGURE 4-11

Federal obligations for R&D, by agency and type of work: FY 2015



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; NSF = National Science Foundation; USDA = Department of Agriculture.

Note(s)

Detail may not add to total because of rounding.

Source(s)

National Science Foundation, National Center for Science and Engineering Statistics, Survey of Federal Funds for Research and Development.

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Department of Health and Human Services

HHS is the main federal source of funds for health-related R&D. In FY 2015, the department obligated $30.4 billion for R&D and R&D plant, or 23% of the total of federal obligations that year. Nearly all the funding was for R&D ($30.3 billion). Furthermore, the majority, $29.0 billion, was for the R&D activities of NIH.

For the department as a whole, R&D and R&D plant obligations for agency intramural activities and FFRDCs accounted for 24% ($7.3 billion) of the total. Extramural performers accounted for 76% ($23.3 billion). Universities and colleges ($16.9 billion) and other nonprofit organizations ($4.3 billion) were the most sizable of these extramural activities (Appendix Table 4-23). Nearly all HHS R&D funding was allocated to research—50% for basic research and 50% for applied research. Only a tiny fraction, 0.2%, was for development.

Department of Energy

DOE obligated $12.3 billion for R&D and R&D plant in FY 2015, or about 9% of the total of federal obligations that year. Of this amount, $11.4 billion was for R&D, and $1.0 billion was for R&D plant.

The department's intramural laboratories and FFRDCs accounted for 70% of the obligations total, a substantially higher percentage than most other agencies. Many of DOE's research activities require specialized equipment and facilities available only at its intramural laboratories and FFRDCs, which are used by scientists and engineers from other agencies and sectors as well as by DOE researchers. The remaining 30% of obligations went to extramural performers, chiefly to businesses and to universities and colleges.

Basic research accounted for 39% of the $11.4 billion obligated to R&D, applied research accounted for 37%, and development accounted for 24%.

DOE R&D activities are distributed among domestic energy systems, defense (much of it funded by the department's National Nuclear Security Administration), and general science (much of which is funded by the department's Office of Science).

National Aeronautics and Space Administration

NASA obligated $11.4 billion to R&D in FY 2015, or around 9% of the federal total. Nearly all of it ($11.4 billion) was for R&D. Of these obligations, 72% were for extramural R&D, which was conducted chiefly by business performers. Agency intramural R&D and that done by FFRDCs represented 28% of the total NASA obligations. By type of R&D, 51% of the NASA R&D obligations funded development activities, 28% funded basic research, and 21% funded applied research.

National Science Foundation

In FY 2015, NSF obligated $6.0 billion for R&D and R&D plant, or 5% of the federal total that year—$5.7 billion for R&D and $0.3 billion for R&D plant. Extramural performers, chiefly universities and colleges, accounted for 94% ($5.6 billion). Basic research was about 88% of the R&D component. NSF is a primary source of federal government funding for academic basic S&E research; it is the second largest federal source (after HHS) of R&D funds for universities and colleges.

Department of Agriculture

USDA obligated $2.4 billion for R&D and R&D plant in FY 2015 (2% of the federal total), focusing mainly 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 2015, about 65% ($1.5 billion) funded R&D by agency intramural performers, chiefly the Agricultural Research Service. Basic research accounts for about 39% of the federal total, applied research accounts for 51%, and development accounts for 9%.

Department of Homeland Security

DHS obligated $1.6 billion for R&D in FY 2015 (1% of the federal total), nearly all of which was for R&D ($0.7 billion) and R&D plant ($0.9 billion) spending of the department's Science and Technology Directorate. Of the total, 83% was for agency intramural R&D; 17% went to extramural performers, primarily businesses and universities and colleges. For the R&D component, 2% was for basic research, 28% was for applied research, and 71% was for development.

Department of Commerce

DOC obligated $1.5 billion for R&D in FY 2015 (about 1% of the federal total), most of which represented R&D ($1.3 billion) and R&D plant ($0.2 billion) spending of the National Oceanic and Atmospheric Administration and the National Institute of Standards and Technology. Of this total, 75% was for agency intramural R&D; 25% went to extramural performers, primarily universities and colleges. For the R&D component, 17% was for basic research, 69% was for applied research, and 13% was for development.

Other Agencies

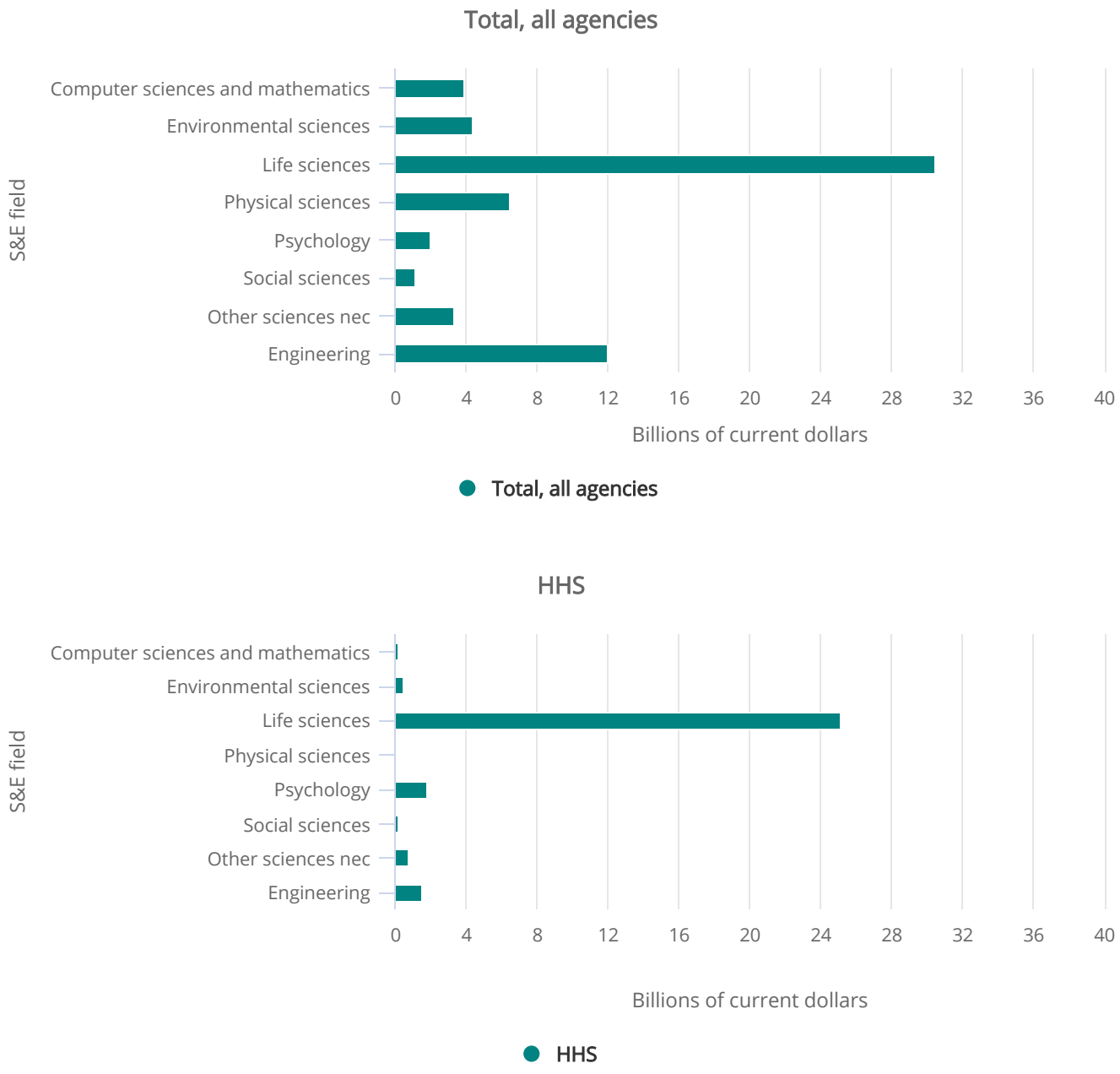
The eight agencies already discussed accounted for 97% of the total R&D and R&D plant obligations ($131.4 billion) in FY 2015. The other agencies shown in Table 4-16 and Table 4-17 play significant roles in the overall U.S. R&D system, but individually they account for comparatively small to very small levels of federal resources annually. Furthermore, as the data in the tables show, these agencies continue to vary considerably with respect to the type of research and the roles of intramural, FFRDC, and extramural performers.

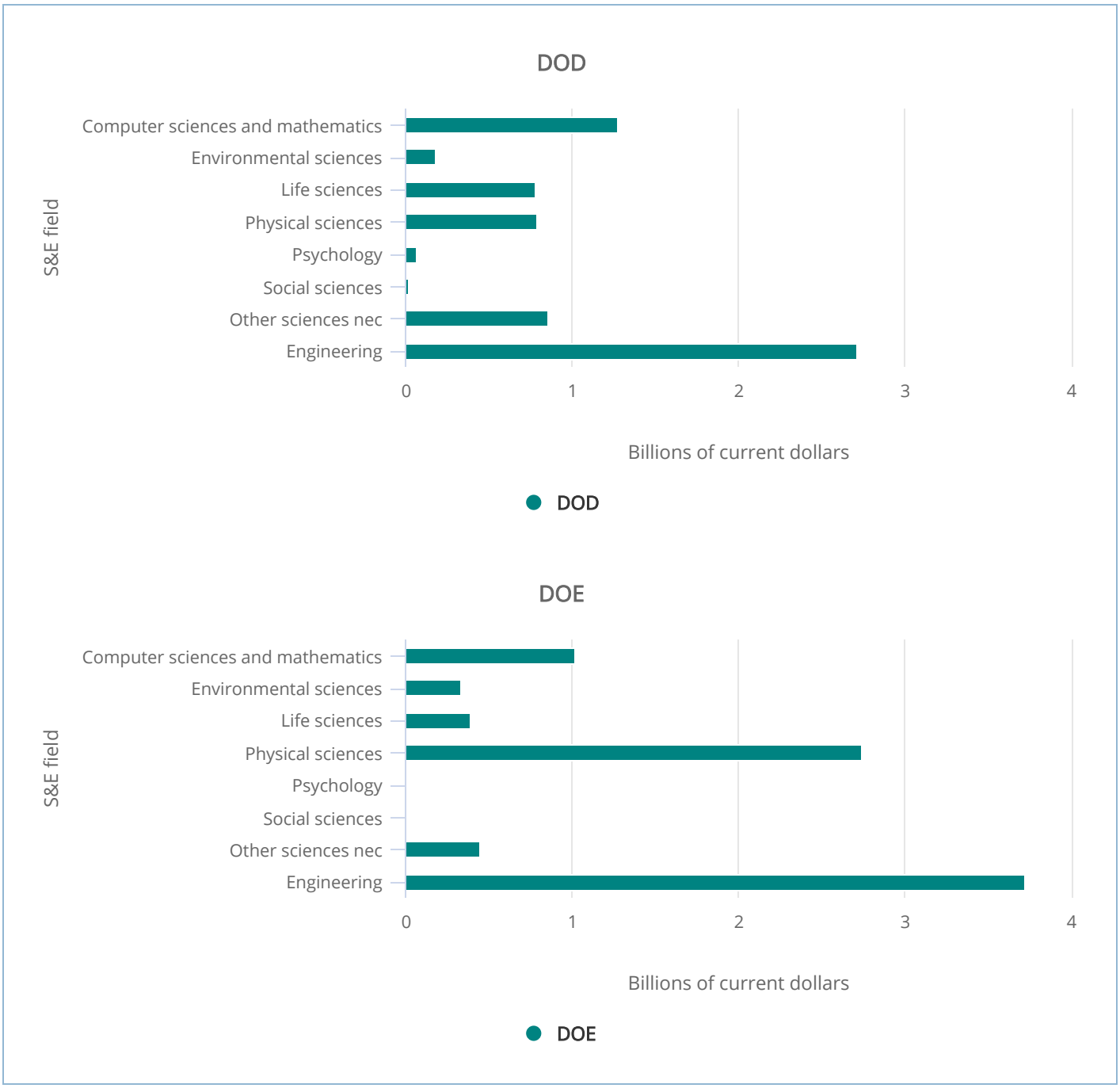
Distribution of Federal Funding for Research, by S&E Fields

Development work cannot easily be classified by S&E field, but research—basic and applied—can be. The research conducted and/or funded by the federal government spans a full range of S&E fields (computer sciences and mathematics, environmental sciences, life sciences, physical sciences, psychology, social sciences, engineering, and other S&E fields). Analysis of the source, nature, and field support patterns provides insights into the federal government's research priorities (Figure 4-12; Appendix Table 4-24 and Appendix Table 4-25).

FIGURE 4-12

Federal obligations for research, by agency and major S&E field: FY 2015




DOD
Computer sciences and mathematics
Environmental sciences
Life sciences
Physical sciences
Psychology
Social sciences
Other sciences nec
Engineering
S&E field
0
1
2
3
4
Billions of current dollars
DOD
DOE
Computer sciences and mathematics
Environmental sciences
Life sciences
Physical sciences
Psychology
Social sciences
Other sciences nec
Engineering
S&E field
0
1
2
3
4
Billions of current dollars
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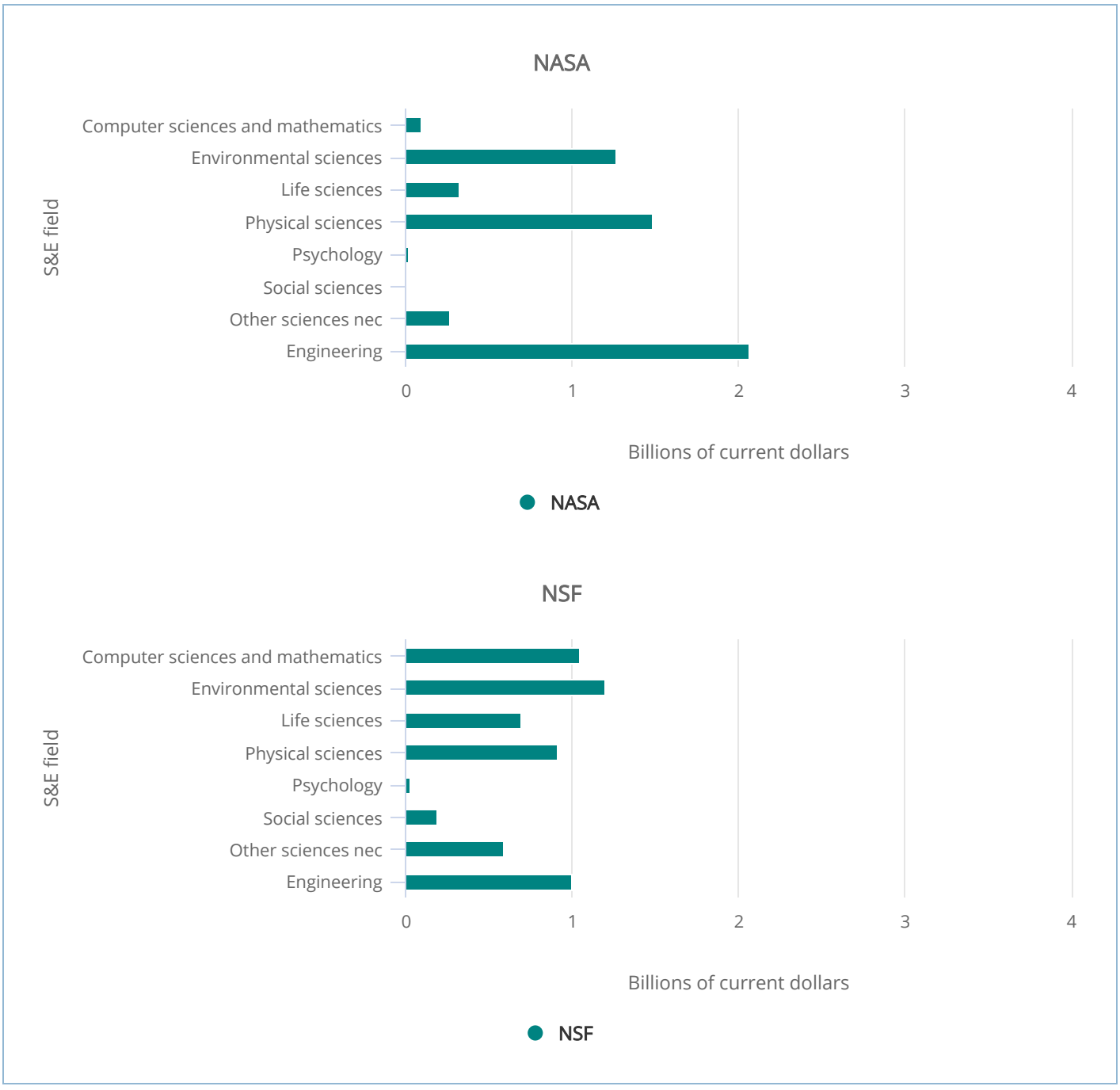
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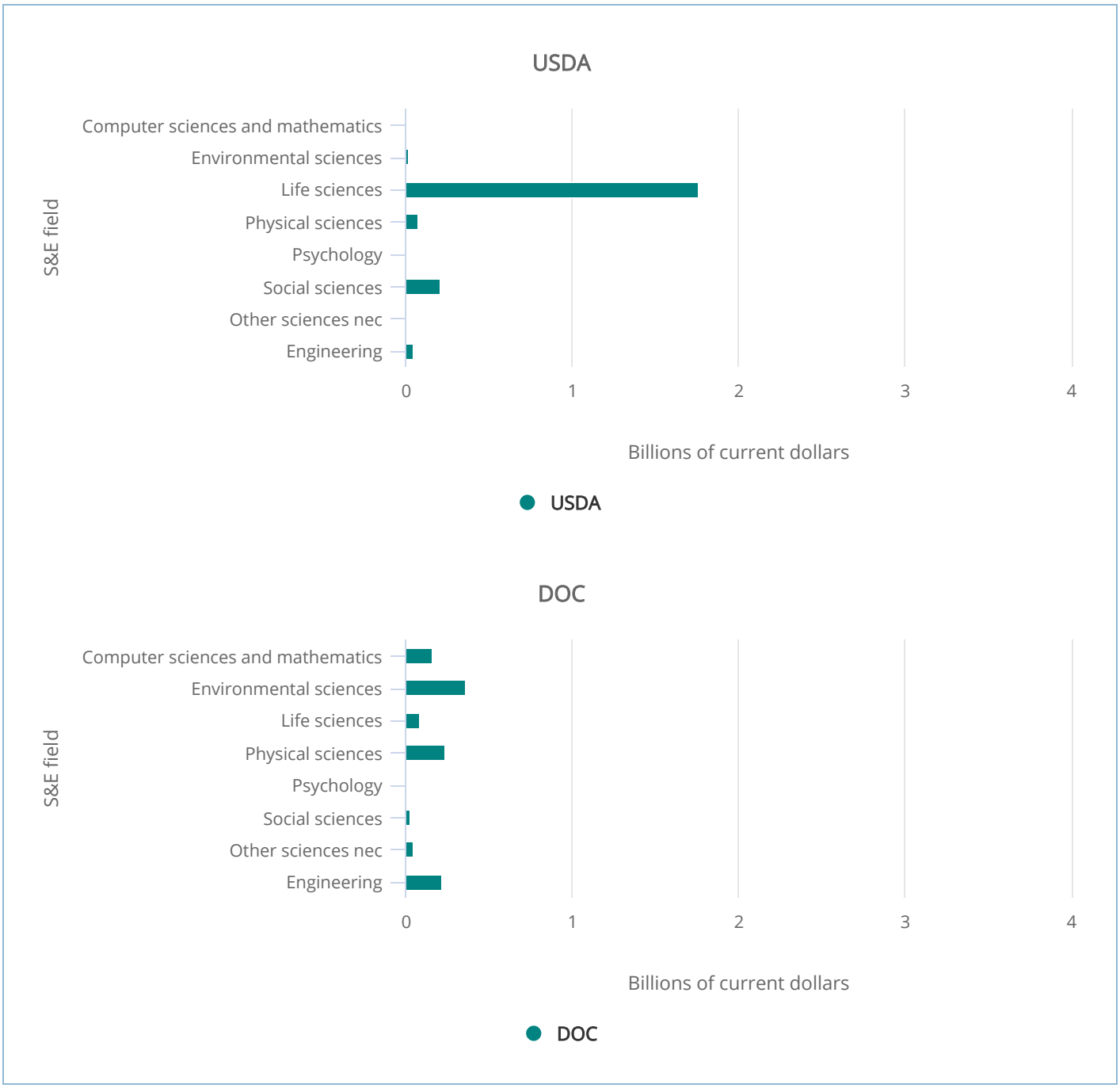
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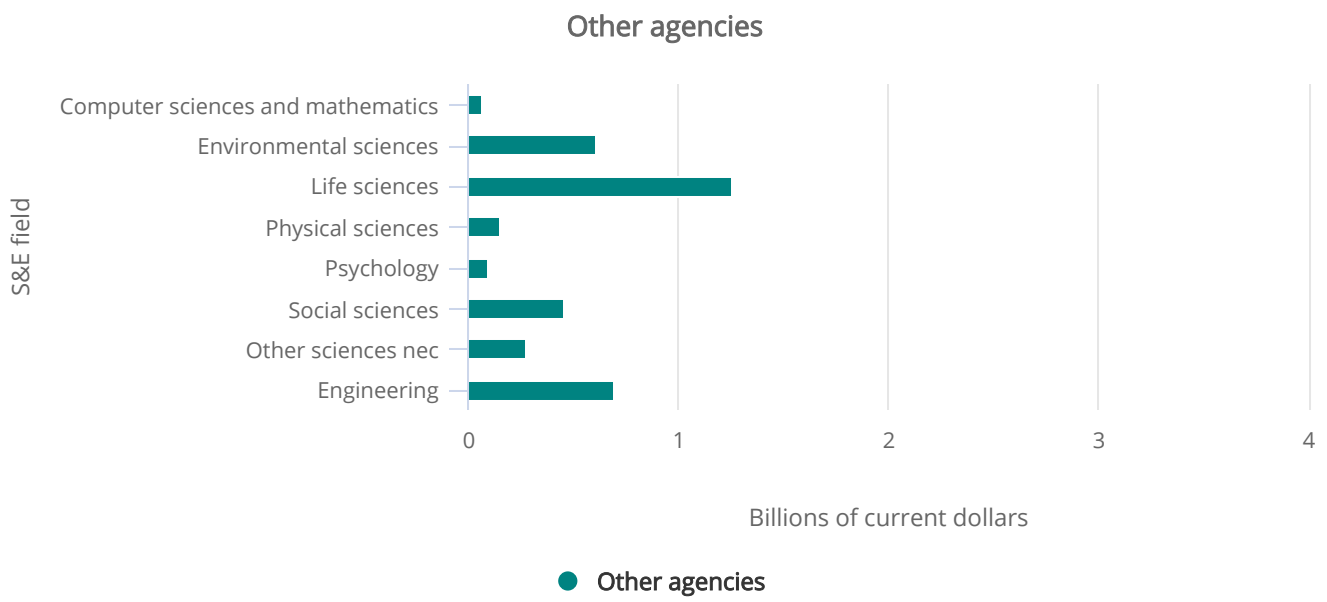

DOC = Department of Commerce; DOD = Department of Defense; DOE = Department of Energy; HHS = Department of Health and Human Services; NASA = National Aeronautics and Space Administration; nec = not elsewhere classified; NSF = National Science Foundation; USDA = Department of Agriculture.

Note(s)

The scales differ for total, all agencies, and HHS compared with the scales for the other agencies listed. Research includes basic and applied research.

Source(s)

National Science Foundation, National Center for Science and Engineering Statistics, Survey of Federal Funds for Research and Development, FYs 2015–17 . See Appendix Table 4-24.

Science and Engineering Indicators 2018

In FY 2015, funding for basic and applied research combined accounted for half ($63.6 billion) of the $128.6 billion total of federal obligations for R&D (Table 4-17). About half of this amount, $30.5 billion, supported research in the life sciences (Appendix Table 4-24). The fields with the next largest amounts were engineering ($12.0 billion, 19%) and physical sciences ($6.5 billion, 10%), followed by environmental sciences ($4.4 billion, 7%) and computer sciences and mathematics ($3.7 billion, 6%). The balance of federal obligations for research in FY 2015 supported psychology, social sciences, and all other sciences ($6.4 billion overall, or 10% of the total for research).

The allocation of federal research funds across agencies and fields reflect the differing agency missions. HHS accounted for the largest share (47%) of federal obligations for research in FY 2015 (Appendix Table 4-24). Most of this amount funded research in life sciences, primarily through NIH. The six next largest federal agencies for research funding that year were DOE (14%), DOD (11%), NSF (9%), NASA (9%), USDA (3%), and DOC (2%).

DOE's $8.6 billion in research obligations provided funding for research primarily in engineering ($3.7 billion), physical sciences ($2.7 billion), and computer sciences and mathematics ($1.0 billion). DOD's $6.7 billion of research funding emphasized engineering ($2.7 billion) but also included computer sciences and mathematics ($1.2 billion), physical sciences ($0.8 billion), and life sciences ($0.8 billion). NSF is charged with "promoting the health of science." As such, it had a

comparatively diverse $5.7 billion research portfolio that allocated about $0.7 billion to $1.2 billion in each of the following fields: environmental sciences, life sciences, computer sciences and mathematics, physical sciences, and engineering. Lesser amounts were allocated to psychology, social sciences, and other sciences. NASA's $5.5 billion for research emphasized engineering ($2.1 billion), followed by physical sciences ($1.5 billion) and environmental sciences ($1.3 billion). USDA's $2.1 billion was directed primarily at life (agricultural) sciences ($1.8 billion). DOC's $1.1 billion was distributed mainly in the fields of environmental sciences, physical sciences, engineering, and computer sciences and mathematics.

Viewed over the longer time span of 1990 to 2015, the total of federal funds obligated for research across all S&E fields increased on average by 5.9% annually over 1990–2000 and by 5.2% over 2000–10 (Appendix Table 4-25). Adjusted for inflation, these average annual growth rates were, respectively, 3.8% and 3.0%. More recently, however, the research obligations total has been declining—essentially a zero average annual rate of growth for the period of FYs 2010–15, or -1.7% when adjusted for inflation (Appendix Table 4-25).

A more complex mix of trends is evident when narrowly defined S&E fields are considered. Federally funded research in the environmental sciences increased by an inflation-adjusted average annual rate of 3.9% in FYs 2010–15, reversing a sizable constant dollar decline in FYs 2000–10 (Appendix Table 4-25). In contrast, federally funded research in life sciences showed a constant dollar, average annual decline of 3.8% over the same period, reversing what were high positive rates of growth through the decade of the 1990s and 2000–10. Federally funded research in computer sciences and mathematics averaged 0.8% in FYs 2010–15, well ahead of the decline that prevailed for all S&E fields together, but the rate was well below those for the 1990s and 2000–10. The rate for physical sciences also was above zero for FYs 2010–15, reversing lower rates in the earlier periods. Engineering showed a declining average annual rate for FYs 2010–15, reversing what were notably positive growth rates in the earlier periods. Other fields (e.g., psychology, social sciences) showed constant dollar declines in the FY 2010–15 period, worse than that for the all-fields total.

Cross-National Comparisons of Government R&D Priorities

Government R&D funding statistics compiled annually by the OECD provide insights into how national government priorities for R&D differ across countries. Known technically as government budget allocations for R&D (GBARD), this indicator provides data on how a country's overall government funding for R&D splits among a set of socioeconomic categories (e.g., defense, health, space, general research).[3] GBARD statistics are available for the United States and most of the other top R&D-performing countries discussed earlier in Table 4-18 (corresponding GBARD data for China and India are not currently available). (All amounts and calculations are in current purchasing power parity or PPP dollars, unless otherwise noted.)

Defense is an objective for government funding of R&D for all the top R&D-performing countries, but the shares vary considerably (Table 4-18). Defense accounted for 51% of U.S. federal R&D support in 2015 but was markedly lower elsewhere—a smaller but still sizable 16% in the United Kingdom, 14% in South Korea, 7% in France, and 3%–4% in Germany and Japan.

TABLE 4-18

Government R&D support by major socioeconomic objectives, by selected countries or regions and years: Selected years, 2000–15

(Millions of U.S. dollars and percent)

Region or country	Year	GBARD (current PPP US$millions)	Percentage of GBARD		Percentage of nondefense					
			Defense	Nondefense	Economic development programs	Health and environment	Education and society	Civil space	Non-oriented research	General university funds
United States	2000	83,612.5	51.6	48.4	13.4	49.9	1.8	20.9	13.8	na
	2010	148,962.0	57.3	42.7	12.5	56.1	1.6	12.9	16.9	na
	2015	138,544.0	51.4	48.6	11.7	52.6	3.0	16.2	16.5	na
EU	2000	76,650.9	12.6	87.4	23.3	11.6	3.4	6.0	17.8	35.0
	2010	117,880.8	6.4	93.6	22.2	14.1	6.5	5.3	18.2	33.1
	2015	125,477.4	4.4	95.6	20.5	14.8	5.5	5.2	18.7	35.4
France	2000	14,868.7	21.4	78.5	17.7	9.7	1.1	13.2	27.4	28.5
	2010	19,178.6	14.7	85.3	21.1	12.6	5.3	12.7	19.6	27.0
	2015	17,721.1	7.2	92.8	17.8	12.5	5.9	11.3	22.8	27.6
Germany	2000	17,228.7	7.8	92.2	21.6	9.4	3.9	5.1	17.5	42.4
	2010	28,642.4	5.0	95.0	24.4	9.2	4.4	5.0	17.0	40.6
	2015	34,301.9	3.1	96.9	21.8	10.2	4.7	5.2	18.0	41.7
United Kingdom	2000	9,484.9	35.6	64.4	14.2	27.7	6.3	3.4	18.3	29.7

Region or country	Year	GBARD (current PPP US$millions)	Percentage of GBARD		Percentage of nondefense					
			Defense	Nondefense	Economic development programs	Health and environment	Education and society	Civil space	Non-oriented research	General university funds
	2010	13,341.6	18.2	81.8	8.5	32.3	5.0	2.1	22.0	30.1
	2015	14,696.1	16.4	83.6	15.8	35.1	5.1	4.0	13.8	26.2
Japan	2000	21,193.4	4.1	95.9	33.4	6.6	1.0	5.8	14.6	37.0
	2010	32,149.0	4.8	95.2	27.6	7.4	0.9	7.1	21.0	35.9
	2015	33,907.4	4.4	95.6	24.7	6.9	0.7	6.5	23.0	38.2
South Korea	2000	5,017.9	20.5	79.5	53.4	14.8	3.8	3.1	24.9	**
	2010	16,300.1	13.3	86.7	52.1	13.7	2.4	2.7	29.1	**
	2015	21,207.5	13.5	86.5	50.3	14.7	7.8	3.1	24.1	**

** = included in other categories. na = not applicable; country or region does not use this funding mechanism.

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

Note(s)

Foreign currencies are converted to dollars through PPPs. The GBARD statistics reported for the United States are federal budget authority data. GBARD data are not yet available for China or India. The socioeconomic objective categories are aggregates of the 14 categories identified by Eurostat's 2007 Nomenclature for the Analysis and Comparison of Scientific Programmes and Budgets. The data are as reported by the Organisation for Economic Co-operation and Development (OECD).

Source(s)

OECD, *Main Science and Technology Indicators* (2017/1).

Science and Engineering Indicators 2018

Defense has received 50% or more of the federal R&D budget in the United States for many years. The defense share was 63% in 1990 as the Cold War period waned but then dropped in subsequent years. It rose again in the first decade of the 2000s—in large part, reflecting post-9/11 security concerns—but it has been declining again over the last several years. For the other countries, the defense share of government R&D funding has generally declined or remained at a stable, low level.

The health and environment objective accounted for almost 53% of nondefense federal R&D budget support in the United States in FY 2015 and 35% in the United Kingdom. For both countries, the share has expanded markedly over the share prevailing several decades ago. The health and environment share of nondefense government R&D is currently 15% in South Korea and 13% or less in France, Germany, and Japan.

The economic development objective encompasses agriculture, energy, fisheries and forestry, industry, transportation, telecommunications, and other infrastructure. In the United States, government R&D funding in this category was 13% of all nondefense federal support for R&D in 2000 and had dropped to just below 12% in 2015, substantially lower than most other major nations (Table 4-18).[4] In the United Kingdom, government R&D funding for economic development was at 14% in 2000, declining from 2000 to 2010 but rising to 16% in 2015. France was at 18% in 2000, rising to 21% by 2010, but declining back to 18% by 2015. Japan was at 33% in 2000 but generally declined in the years after to 25% in 2015. Germany was at 22% in 2000, rising somewhat by 2010, but dropping back to 22% in 2015. South Korea, at 52% in 2010 and 50% in 2015, has consistently exhibited the largest share for this category among the top R&D-performing countries.

The civil space objective accounted for about 16% of nondefense federal R&D funding in the United States in 2015 (Table 4-18). The share was 21% in 2000 and declined to 13% by 2010 but has experienced increases more recently. The share in France was about 11% for 2015, down from 13% in both 2000 and 2010. The space share has been well below 10% for the rest of the top R&D-performing countries.

Both the nonoriented research funding and general university fund (GUF) objectives reflect government support 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 represents by far the largest part of nondefense GBARD: in 2015, Japan (61%), Germany (60%), France (50%), the United Kingdom (40%), and South Korea (24%). The corresponding 2015 share for the United States (17%), although appearing substantially smaller, requires interpretive caution. Cross-national comparisons of these particular indicators can be difficult because some countries (notably the United States) do not use the GUF mechanism to fund R&D for general advancement of knowledge, do not separately account for GUF (e.g., South Korea), and/or more typically direct R&D funding to project-specific grants or contracts, which are then assigned to the more specific socioeconomic objectives (see sidebar Government Funding Mechanisms for Academic Research).

SIDEBAR

Government Funding Mechanisms for Academic Research

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

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

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

Finally, the education and society objective represents a comparatively small component of nondefense government R&D funding for all the top R&D-performing countries—3% of nondefense GBARD in the United States in 2015. However, the share was notably higher in South Korea (8%), France (6%), Germany (5%), and the United Kingdom (5%). Japan (1%) was well below the United States.

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

[2] For a further account of this recent federal budget history, see Boroush (2015, 2016). Notable among the various interconnected developments over these years were the federal-wide spending reductions imposed by the enacted FY 2011 federal budget: the Budget Control Act of 2011, intended to address the then-ongoing national debt ceiling crisis, which commanded a 10-year schedule of budget caps and spending cuts; the budget sequestration provision, which ultimately took hold in the FY 2013 federal budget; and the Bipartisan Budget Act of 2013, which provided some subsequent relief from the deepening sequestration requirements, but only for the FY 2014 and FY 2015 budgets.

[3] GBARD classifies total government funding on R&D into the 14 socioeconomic categories specified by the EU's 2007 edition of the Nomenclature for the Analysis and Comparison of Scientific Programmes and Budgets (NABS). These categories are exploration and exploitation of the earth; environment; exploration and exploitation of space; transport, telecommunications, and other infrastructures; energy; industrial production and technology; health; agriculture; education; culture, recreation, religion, and mass media; political and social systems, structures, and processes; general advancement of knowledge: R&D financed from general university funds; general advancement of knowledge: R&D financed from sources other than general university funds; and defense. GBARD statistics published by the OECD in the *Main Science and Technology Indicators* series report on clusters of these 14 NABS categories. (Prior to the fall of 2015, GBARD was referred to as GBAORD, or government budget authority or outlays for R&D. Earlier data may continue to use the GBAORD terminology.)

[4] Some analysts argue that the relatively low nondefense GBARD 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 then classified in these other socioeconomic objectives.

Conclusion

Globally, R&D performance has increased at a relatively high rate over the past decade and a half, averaging 6.7% annually. Worldwide R&D performance (measured as expenditures) totaled an estimated $1.918 trillion (current PPP dollars) in 2015, the latest global total available. The comparable figure for 2010 was $1.415 trillion, and $722 billion in 2000.

U.S. R&D increased to $495.1 billion in 2015 (Table 4-1; Appendix Table 4-1), which represented 26% of the global total that year. The comparable U.S. figure for 2010 was $406.6 billion and $268.0 billion in 2000. The United States remains the world's largest R&D performer. Nonetheless, investments in R&D by other countries—particularly those in Asia—continue to increase, further eroding the longstanding U.S. lead. China ($408.8 billion of R&D in 2015) has now moved well ahead of Japan ($170.0 billion) as the second largest R&D-performing nation (Table 4-5). Countries or economies of the East/Southeast and South Asian regions accounted for 25% of the global total in 2000 but rose to a striking 40% in 2015. EU countries accounted for 25% of the global total in 2000 but dropped to 20% in 2015.

In 2008, just ahead of the onset of the main economic effects of the national/international financial crisis and the Great Recession, U.S. R&D totaled $404.8 billion. The total was an estimated $495.1 billion at the end of 2015. Adjusted for inflation, the annual expansion of R&D over the 2008–15 period averaged 1.4%, compared with GDP at 1.5% over the same period (Table 4-2). Further, removing the deepest of the Great Recession years (2009 and 2010), the annual growth of R&D averaged 2.3%, compared to 2.2% for GDP. On these numbers, the period since 2008 remains an uncharacteristically slow pattern of R&D expansion -- compared with 3.6% for R&D versus 2.2% for GDP over the decade immediately prior (1998–2008).

Glossary

Definitions

European Union (EU): The EU comprises 28 member nations: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, and the United Kingdom. Unless otherwise noted, data on the EU include all 28 nations.

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

Gross domestic product (GDP): The market value of goods and services produced within a country. It is one of the main measures in a country's national income and product accounts, which record the value and composition of national output and the distribution of the incomes generated in this production (BEA 2015).

Multinational enterprise (MNE): A parent company and its foreign affiliates. An affiliate is a company or business enterprise (incorporated or unincorporated) located in one country but owned or controlled (10% or more of voting securities or the equivalent) by a parent company in another country. A majority-owned affiliate is a company owned or controlled by more than 50% of the voting securities (or equivalent) by its parent company.

Organisation for Economic Co-operation and Development (OECD): An international organization of 35 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, Latvia, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, Slovakia, Slovenia, South Korea, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States. Among its many activities, the OECD compiles social, economic, and science and technology statistics for all member and selected nonmember countries.

R&D: Research and experimental development comprise creative and systematic work undertaken in order to increase the stock of knowledge—including knowledge of humankind, culture, and society—and its use to devise new applications of available knowledge.

> **Basic research:** Experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any particular application or use in view.
>
> **Applied research:** Original investigation undertaken in order to acquire new knowledge; directed primarily, however, toward a specific, practical aim or objective.
>
> **Experimental development:** Systematic work, drawing on knowledge gained from research and practical experience and producing additional knowledge, which is directed to producing new products or processes or to improving existing products or processes (OECD 2015).

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

Key to Acronyms and Abbreviations

ANBERD: Analytical Business Enterprise R&D

ARRA: American Recovery and Reinvestment Act

BEA: Bureau of Economic Analysis

BRDIS: Business R&D and Innovation Survey

CAGR: compound average annual growth rate

DOC: Department of Commerce

DOD: Department of Defense

DOE: Department of Energy

EU: European Union

FFRDC: federally funded research and development center

FY: fiscal year

G20: Group of Twenty

GBARD: government budget appropriations for R&D

GDP: gross domestic product

GERD: gross domestic expenditures on R&D

GUF: general university fund

HE: higher education

HERD: Higher Education Research and Development Survey

HHS: Department of Health and Human Services

IRC: Internal Revenue Code

IRS: Internal Revenue Service

ISIC: International Standard Industrial Classification of All Economic Activities

MER: market exchange rate

MNE: multinational enterprise

NAICS: North American Industry Classification System

NASA: National Aeronautics and Space Administration

NCSES: National Center for Science and Engineering Statistics

nec: not elsewhere classified

NIH: National Institutes of Health

NIPA: national income and product accounts

NSF: National Science Foundation

OECD: Organisation for Economic Co-operation and Development

ONP: other nonprofit organization

OPEC: Organization of the Petroleum Exporting Countries

OWH: other Western Hemisphere

PPP: purchasing power parity

PST: professional, scientific, and technical

R&D: research and development

R&E: research and experimentation

S&E: science and engineering

UK: United Kingdom

UNESCO: United Nations Educational, Scientific and Cultural Organization

USDA: Department of Agriculture

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