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The Sources and Uses of U.S. Science Funding

Joseph V. Kennedy

The technological innovation that has driven much of the world's economic development since the Industrial Revolution would not have been possible without scientific knowledge. Americans have long recognized the importance of science and technology for our prosperity, health, and security, and have invested substantial amounts of money in supporting the scientific enterprise—both privately and through government.

The conventional political wisdom regarding public financing for science can be seen in the 2011 Economic Report of the President, in which President Barack Obama's economic advisors wrote that "basic scientific breakthroughs…underpin commercial innovation but provide little or no direct profit themselves, so basic scientific research relies heavily on public support." This sort of thinking has been influential in American politics since the end of the Second World War, when the engineer Vannevar Bush delivered to President Truman his report on how to pioneer the "new frontiers of the mind" opened by the natural sciences. In that report, titled *Science, The Endless Frontier* (1945), Bush argued for the importance of what he called "basic research," which he defined as scientific work that is "performed without thought of practical ends." Such research, Bush claimed, "creates the fund from which the practical applications of knowledge must be drawn" and "is the pacemaker of technological progress." But because it lacks any immediate application, and because the benefits of fundamental scientific breakthroughs may be difficult for companies to profit from directly, there is a strong case for public support for this kind of scientific work.

The wide acceptance of this conventional wisdom among both policymakers and the public at large means that fundamental questions about the funding of science generally go unasked. Is the money that

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Congress annually appropriates for scientific research wisely spent? Is government-funded research effective at achieving scientific breakthroughs, or at fostering technological innovation? How does the scientific work funded by the federal government compare to work funded by other sources, and how does the funding of science in America compare to other countries around the world?

Before we can attempt to answer those questions, however, we must first have a handle on the facts: how much money America invests in science, both currently and historically; the sources of that money; where it is spent; and how U.S. spending on science compares with other nations. A better understanding of these basic facts will put us in a position to think more clearly about the fundamental questions regarding the cost and direction of the scientific enterprise.

Defining and Studying R&D

A preliminary word is in order about the sources and limitations of the data used in the analysis that follows. Most of the data for the United States come from the National Science Foundation (NSF), which, in addition to financing basic research in a variety of fields, is responsible for assessing the state of the scientific enterprise in America. To this end, the NSF conducts surveys and studies and publishes them in reports, the most comprehensive of which is the biennial *Science and Engineering Indicators*, most recently released in 2012. These reports are a rich trove of information and statistics not only about the sources of funding for scientific research in America, but also about American science education, the public's attitudes toward science, the science and engineering labor force, and other important aspects of the scientific enterprise.

For the purposes of tracking spending on scientific work, the NSF divides science into three main categories or "characters of work." *Basic research*, the sort of research most encouraged under Vannevar Bush's model of government-sponsored science, is defined by the NSF as research that seeks to "gain more complete knowledge or understanding of the fundamental aspects of phenomena and of observable facts, without specific applications toward processes or products in mind." By contrast, *applied research* is aimed at knowledge "necessary for determining the means by which a recognized need may be met." And *development* is defined as the "systematic use of the knowledge or understanding gained from research, directed toward the production of useful materials, devices, systems, or methods, including design and development of prototypes and processes." These three forms of work in science and technology are often referred to collectively as "research and development" (R&D), and represent the different stages of the innovation pathway, from scientific breakthroughs to the creation of useful products.

While the NSF does a good job of keeping track of scientific funding in America, this topic is vast and complex, and there are a number of limitations and caveats to the data the agency publishes. Conducting surveys and compiling the biennial reports take time, and so the most recent data in the 2012 report are from 2009, or even 2008 for some areas. More recent data are available from the NSF in particular areas, however, including preliminary reports on federal research and development spending for 2010 and 2011; when available, these have been incorporated below. Another minor wrinkle arises from the fact that most data on federal spending are reported based on the federal fiscal year, which begins on October 1, while other data are generally reported on a calendar-year basis. In translating fiscal-year data into calendar-year data, the NSF often assumes that federal agencies spend their money evenly throughout the year. In the analysis that follows, calendar-year data are used unless specifically noted.

The NSF's survey data for corporate spending does not include companies with fewer than five employees, suggesting that much of the Do-It-Yourself (DIY) movement would not be reflected in the data. As Eric von Hippel argues in his book *Democratizing Innovation* (2005), experimentation by leading users is often a major source of new innovations, especially in the development stage, and such user-driven activity may become even more important as the Internet, cloud computing, increased affordability and precision of equipment, and better software improve the ability of individuals to access, extend, and distribute new technologies. The NSF has plans to address this omission with a forthcoming Microbusiness Innovation and Science and Technology Survey.

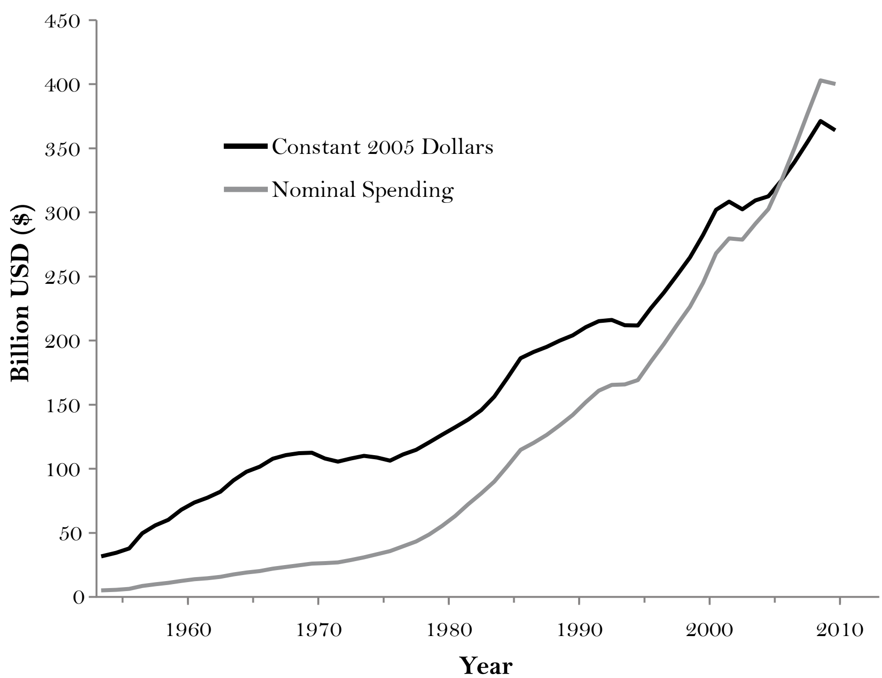
Until 2008, the statistics collected by NSF did not include spending on the social sciences, and even now spending in the humanities and other academic fields outside the sciences is not tracked by the NSF. For the purposes of understanding the relationship between scientific research and technological innovation, spending on the social sciences and humanities may not seem particularly important. However, many other countries do include spending on the humanities and social sciences in their reports on research and development funding, which can complicate some international comparisons.

Data relating to international R&D spending largely come from the Organization for Economic Co-operation and Development and the United Nations Educational, Scientific and Cultural Organization. The international data are usually presented in terms of purchasing power parity rather than current exchange rates, which sometimes has a significant effect on the figures.

Total R&D Expenditures and Trends

Ongoing, large-scale spending on R&D in the United States only began in earnest in the wake of the Second World War, so we begin our study with an overview dating back to the early 1950s. Figure 1 tracks total U.S. spending on R&D in both nominal terms and real terms (in constant 2005 dollars to adjust for inflation). Over the past sixty years, R&D spending—including spending by government, industry, and all other sources—has been rising fairly steadily overall. As the graph shows, spending stagnated from the late 1960s to the mid-1970s. But in the decade from 1979 to 1989, annual spending increased by about $78 billion (in constant dollars), another $78 billion from 1989 to 1999,

Figure 1: Total Domestic R&D Spending



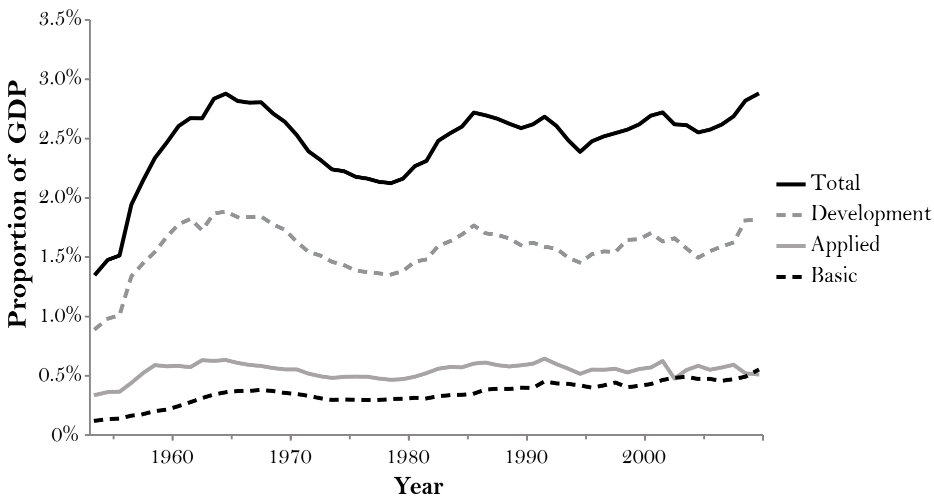
Source: National Science Foundation, *Science and Engineering Indicators 2012* (*SEI 2012*), table A4-7.

and a further $83 billion from 1999 to 2009. In 2009, the last year for which figures are available, total spending on R&D dropped by about $6 billion (in 2005 dollars), likely due to the recession. A closer look at the data shows that the drop from 2008 to 2009 resulted from the private sector sharply reducing its R&D spending by almost $13 billion (again, in 2005 dollars); this decline in industry spending was partially offset by a substantial increase in federal funding for science under the 2009 stimulus bill.

Looking at the same data in terms of the U.S. gross domestic product (GDP), we see that R&D spending has held roughly steady as a percentage of the nation's total economy, averaging around 2.6 percent since 1965 (see Figure 2). Compared to real spending, which has increased consistently, this figure has fluctuated over the years, rising to 2.9 percent at the height of the space race in the 1960s. Even though real spending on R&D declined between 2008 and 2009, spending as a percentage of GDP actually increased slightly, due to the decline in GDP during the recession. And while the rate of growth of real R&D spending has been slowing in the 1990s compared to earlier decades, as a percentage of GDP it has been on a long-term increase since 1994, rising from 2.4 percent to nearly 2.9 percent in 2009.

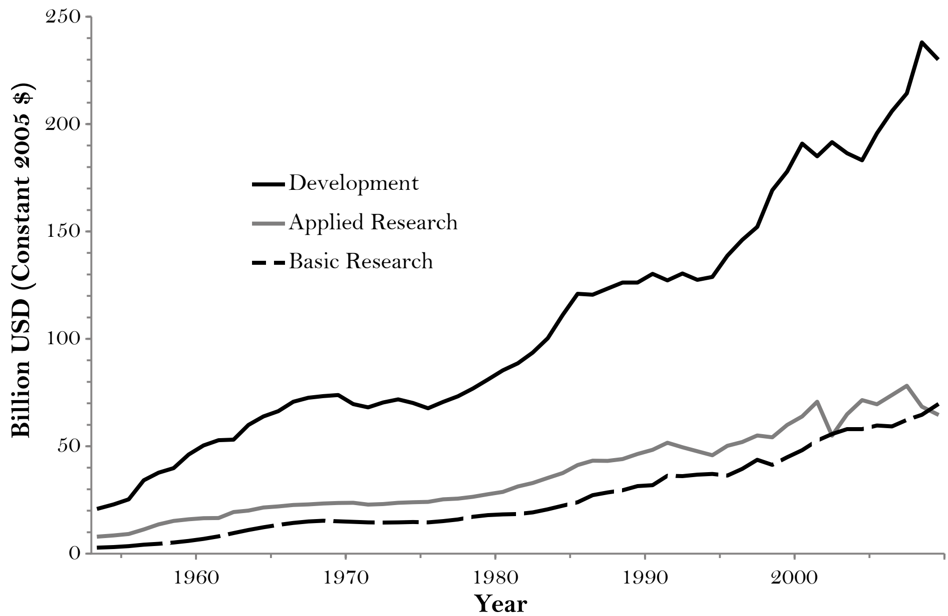
Figure 2 also shows that the trends for R&D spending in general have held as well for the three basic components of that spending—basic research, applied research, and development.

Figure 2: R&D Spending as a Percentage of GDP



Sources: *SEI 2012*, tables A4-1, A4-7, A4-8, A4-9, and A4-10.

Figure 3: Components of Real R&D Spending



Sources: *SEI 2012*, tables A4-8, A4-9, and A4-10.

The consistency of the proportions of R&D spending on these three basic components can also be seen in terms of real spending (Figure 3). Spending on development has dominated R&D expenditures in the United States, accounting for roughly 61 percent of R&D spending and remaining fairly constant for the last two decades. During that time, the share going to basic research increased slightly, from 15 percent in 1990 to 19 percent in 2009, while the share going to applied research fell by a roughly equivalent amount, from 23 percent in 1990 to 18 percent in 2009.

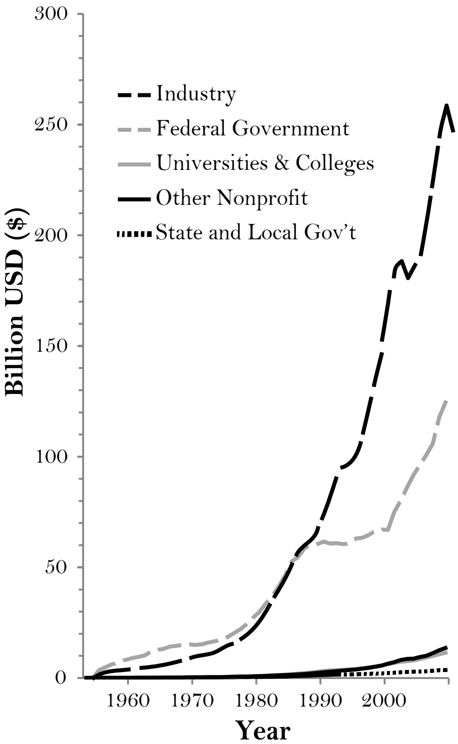
By far, the dominant sources of funding for R&D in America have been private industry and the federal government; together, they accounted for 93 percent of R&D spending in 2009. In that year, as shown in Figure 4 (facing page), private industry spent $247.4 billion, or 62 percent of total R&D spending, while the federal government spent $124.4 billion, accounting for 31 percent of the nation's spending on R&D.

Figure 4 also shows that the role of private industry in underwriting R&D has increased significantly since the late 1980s. Until then, industry and federal expenditures roughly tracked each other, but industry has since considerably outpaced government in funding R&D. The federal share of support for overall R&D in the United States grew from 57 percent in 1955 to a peak of 67 percent in 1964, before slowly declining to

31 percent in 2009. As Figure 2 showed, 1964 and 2009 represent the two highest peaks of spending on R&D as a percentage of GDP in American history—2.88 percent and 2.87 percent, respectively. But the proportions coming from government and industry have reversed over the past five decades: in 1964, 1.92 percent of GDP was spent by the federal government on R&D, while in 2009, 1.77 percent was spent by private industry.

Private industry and the federal government dwarf all other sources of R&D in the United States, as shown by the lines along the bottom of Figure 4. Universities, colleges, and other non-profits accounted for just 6.2 percent of national R&D funding in 2009, while state and local governments underwrote less than 1 percent of the national total.

Figure 4: Sources of Funding for Domestic R&D

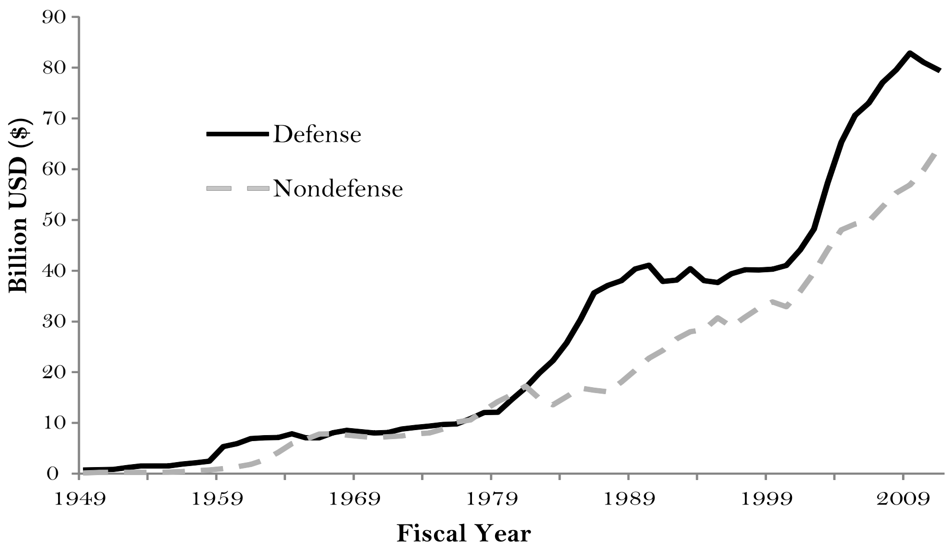


Source: *SEI 2012*, table A4-7.

An Outline of Federal Funding

Money devoted to defense has long accounted for the majority of federal outlays for R&D. In the years since 1980, spending on defense R&D as a proportion of total federal R&D peaked in 1987 at 69.7 percent before falling to 54.3 percent in 1999. This reflected a decline in overall defense spending after the end of the Cold War—part of the so-called "peace dividend." Since 2001, however, national defense has attracted significantly greater resources and this has been reflected in a rise in federal defense R&D spending, which accounted for 59.5 percent of all federal R&D outlays in 2006. (More recently, the proportion dipped from 59.3 in 2009 to 55.5 in 2011, but this was due to the large influx of R&D spending in the stimulus package, which appropriated $15.1 billion for R&D, almost all going to nondefense purposes.)

Figure 5: Federal Budget Outlays for R&D



Source: Office of Management and Budget, *Historical Tables 2013*, table 9.7.

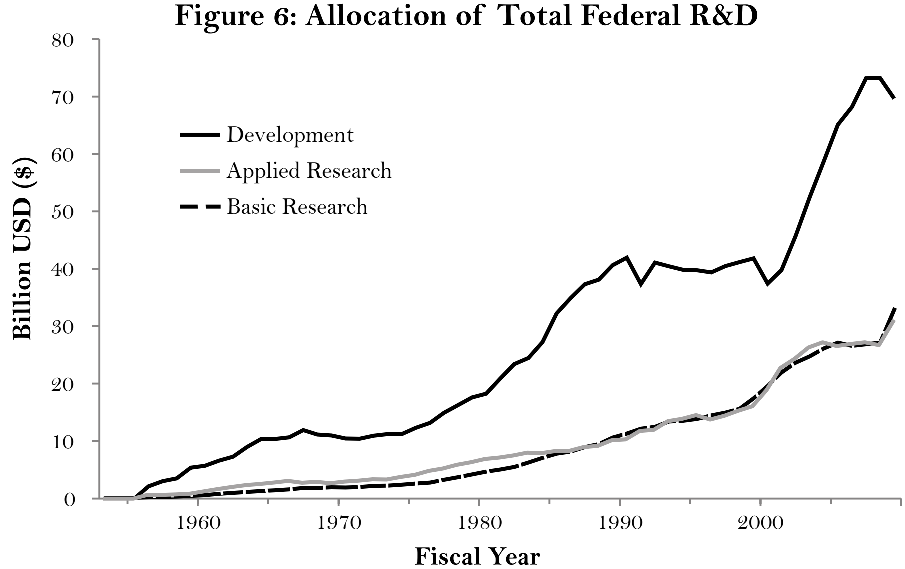
Figure 5 tracks the changes in federal R&D funding over the past six decades, illustrating how the rise in defense R&D outpaced the rise in all other sectors of federally funded R&D combined. Among the non-defense sectors, it is worth noting that outlays to medical research have risen considerably, both in absolute terms and as a proportion of the R&D budget—in part the result of a legislative effort to double the budget of the National Institutes of Health (NIH) between 1998 and 2003. Health R&D rose from 10.7 percent of total federal R&D spending in 1986 to 24.8 percent in 2011. This rise has been accompanied by a relative decline in outlays for space exploration. The National Aeronautics and Space Administration (NASA) spent 13.6 percent of federal R&D dollars in 1998, but only 5.8 percent in 2011.

Historical data also show the federal government's intermittent spending on energy research. In 1979, during the second oil crisis, energy research (not including atomic energy general science) accounted for 12.6 percent of total federal R&D outlays, a proportion that fell to 3.7 percent by 1990, before rising slightly in the early 1990s, and then declining again to a low point of 0.9 percent in 2008. However, roughly 4 percentage points of this latter decline was due to a reclassification of several Department of Energy programs from energy to general science, starting in 1998. In 2011, energy jumped up to 2.6 percent of the federal R&D budget, partly due to the relatively large amount of stimulus money devoted to energy research.

Meanwhile, Figure 6 shows how federal dollars are allocated among basic research, applied research, and development. Contrary to the conventional wisdom that government spending should be focused on basic research, where the private sector is least likely to invest, Figure 6 shows that government support for development far outpaces investment in either basic or applied research. This focus on development is due to the high proportion of the Department of Defense's large R&D budget that is devoted to the development of weapons systems and other military technologies. While high-visibility programs like the Defense Advanced Research Projects Agency focus on the cutting edge of innovative technologies, even they only devote a small proportion of their budget, roughly 6.5 percent in 2010, to basic research. (At least that is the publicly released figure; part of DARPA's budget is classified.) Of the total budget authority for defense R&D in 2009, only 2.1 percent was devoted to basic research. By contrast, the nondefense portion of the federal R&D budget has been much more focused on research, with roughly 50 percent of nondefense R&D spending devoted to basic research since 2000.

The distribution of federal funding can be analyzed further by looking at the amount spent by different agencies on basic research, applied

Figure 6: Allocation of Total Federal R&D



Sources: *SEI 2012*, tables A4-8, A4-9, and A4-10.

research, and development—as shown in Table 1. While the Department of Defense does indeed spend the vast majority of its substantial R&D budget on development, most other federal agencies focus more on research, with NASA and the Department of Homeland Security being the only other agencies that spend more than half their R&D budget on development. The importance of development for these three agencies is due to their concern with executing specific operational missions: building better fighter planes, building better tools for studying and exploring space, and developing systems for detecting bombs and other threats.

At the other extreme, the Department of Health and Human Services (HHS), the National Science Foundation, and the Smithsonian Institution

Table 1. Federal R&D Budget Obligations Allocated by Agency, Fiscal Year 2009

	Percent of Spending Applied to			
Department or Agency	**Basic Research (%)**	**Applied Research (%)**	**Development (%)**	**Total ($ million)**
Defense	3	7	90	68,113
Health and Human Services	53	47	< 1	35,584
Energy	41	32	27	9,890
National Science Foundation	92	8	0	6,095
NASA	17	12	71	5,937
Agriculture	41	51	8	2,270
Commerce	12	72	16	1,147
Transportation	0	71	29	826
Interior	7	83	10	732
Homeland Security	15	37	48	673
EPA	15	70	15	553
Veterans Affairs	40	54	6	510
Education	1	62	37	322
Smithsonian Institution	100	0	0	152
All other agencies	2	90	8	544
All Agencies	**25**	**23**	**52**	**133,349**

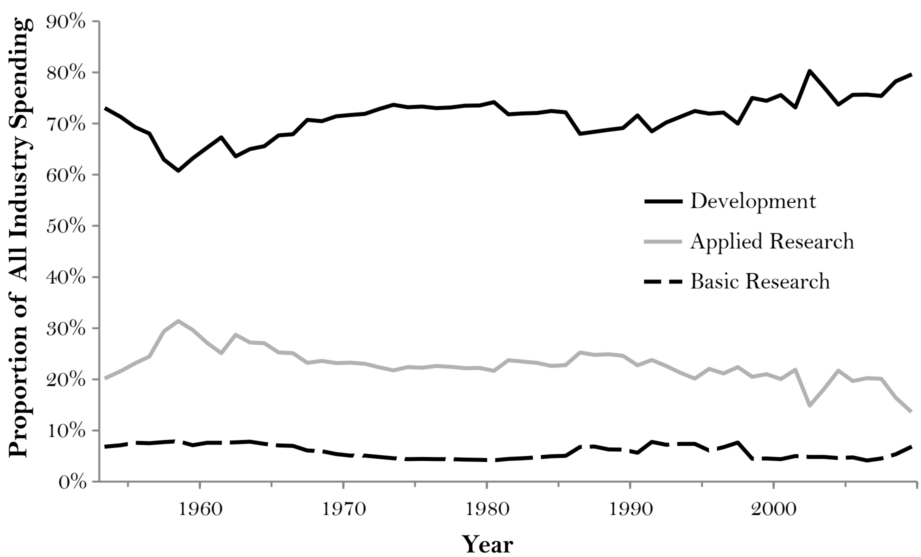
Sources: NSF, *Federal Funds for Research and Development: Fiscal Years 2009–11*, tables 98, 104, 106, and 108.

all report that their entire R&D budgets are devoted to research. (Although the Smithsonian is technically a private entity, it is administered by, and receives about two-thirds of its funding from, the federal government.) While NSF and the Smithsonian devote almost their entire budgets to supporting basic research, HHS, which funds the medical research at NIH, splits its budget roughly in half between basic and applied research. (It is worth noting that NIH decided to reclassify its development spending as research spending in 2000. The previous year, NIH reported spending $1.88 billion on development—13 percent of its total R&D budget for that year—with no spending on development reported since then. This apparently drastic change in NIH spending, which in fact only reflected a change in NIH's reporting practices, helps to illustrate the limitations of statistical data for understanding what sort of scientific work is being funded by government and industry in the United States.)

Understanding Industry R&D Spending

In contrast to federal nondefense spending, industry spending on R&D in the United States has been much more focused on development than on research. As Figure 7 shows, in 2009 less than 7 percent of private industry spending on R&D went to basic research, with almost 80 percent of spending going to development.

Figure 7: Composition of Industry R&D Spending



Sources: *SEI 2012*, tables A4-7 A4-8, A4-9, and A4-10.

Private sector R&D is heavily concentrated in just a handful of industries. In 2008, manufacturing industries supplied $164.4 billion, or 70.7 percent, of all industry spending on domestic R&D. Within that amount, the vast majority came from just five subcategories of manufacturing: computers and electronics ($52.9 billion), pharmaceuticals ($45.2 billion), automobiles ($12.2 billion), aerospace products and parts ($10.4 billion), and machinery ($9.8 billion). Of the fraction of private-industry R&D that did not come from the manufacturing sector, fully two-thirds of it came from just three subcategories: software publishers ($27.7 billion), computer systems design ($8.6 billion), and scientific research and development services ($8.7 billion).

It can sometimes be helpful, instead of referring to these raw spending figures, to refer to a figure called "R&D intensity"—a calculation that, in this case, shows the amount spent on R&D in an industry as a percentage of that industry's total sales. Table 2 shows R&D intensity in several select industry categories and subcategories for the year 2008; these figures include only domestic sales and domestic R&D, and do not include outside sources of funding, such as government money. As is clear from the table, R&D intensity varies widely across different industries. By far the most R&D-intensive industries involve semiconductors: semiconductor machinery manufacturing devoted 28.8 percent of sales to R&D, while the semiconductor and other components industry had an intensity of 20.2 percent. The average across all industries is 3.0 percent. Other notable industries that invested intensely in R&D were electronic shopping and mail-order houses (13.4 percent), communications equipment (13.3 percent), pharmaceuticals and medicines (12.2 percent), and software publishing (10.6 percent).

Some large industries, such as food and mining, devoted relatively little to R&D, with both of these sectors having an R&D intensity of just 0.4 percent. The manufacturing sector also invested more on average than the rest of the economy, putting 3.5 percent of sales into R&D, while the nonmanufacturing industries invested only 2.2 percent on average, although there is considerable diversity across different subindustries.

The size of companies, in terms of their number of employees, is helpful for estimating R&D intensity: smaller companies invested in R&D at considerably higher intensity than larger ones. The smallest companies for which data are available, those with between five and twenty-four employees, spent an average of 14.1 percent of sales on R&D, while the largest, those with over 25,000, spent only 2.3 percent. When the NSF's

Table 2. Domestic Sales, Domestic R&D Performed and Paid for by Company, and R&D Intensity, by Select Industries, 2008

Industrial sector	Domestic sales ($ million)	Domestic R&D ($ million)	Intensity (% R&D/ sales)
ALL INDUSTRIES	***7,796,340***	***232,505***	***3.0***
Manufacturing industries	***4,681,443***	***164,386***	***3.5***
Food	476,888	2,063	0.4
Chemicals	902,410	55,042	6.1
Pharmaceuticals and medicines	371,760	45,169	12.2
Other chemicals	530,650	9,873	1.9
Machinery	278,700	9,846	3.5
Semiconductor machinery manufacturing	7,328	2,113	28.8
Computer and electronic products	522,717	52,912	10.1
Communications equipment	86,150	11,484	13.3
Semiconductor, other electronic components	106,658	21,588	20.2
Other computer and electronic parts	329,909	19,840	6.0
Electrical equip., appliances, components	108,730	2,947	2.7
Transportation equipment	888,777	23,039	2.6
Automobiles, bodies, trailers, and parts	491,483	12,234	2.5
Aerospace products and parts	372,438	10,371	2.8
Other transportation	24,856	434	1.7
Other manufacturing	1,980,109	20,600	1.0
Nonmanufacturing industries	***3,114,898***	***68,118***	***2.2***
Retail trade	79,571	1,029	1.3
Electronic shopping, mail-order houses	5,030	674	13.4
Other retail trade	74,541	355	0.5
Information	776,062	36,922	4.8
Publishing	273,765	27,871	10.2
Software publishing	261,451	27,665	10.6
Other publishing	12,314	206	1.7
Other information	502,297	9,051	1.8
Professional, scientific, technical services	453,444	20,539	4.5
Computer systems design, related services	204,868	8,569	4.2
Scientific research and development services	136,105	8,708	6.4
Other professional, sci., technical services	112,471	3,262	2.9
Other nonmanufacturing	1,805,821	9,628	0.5

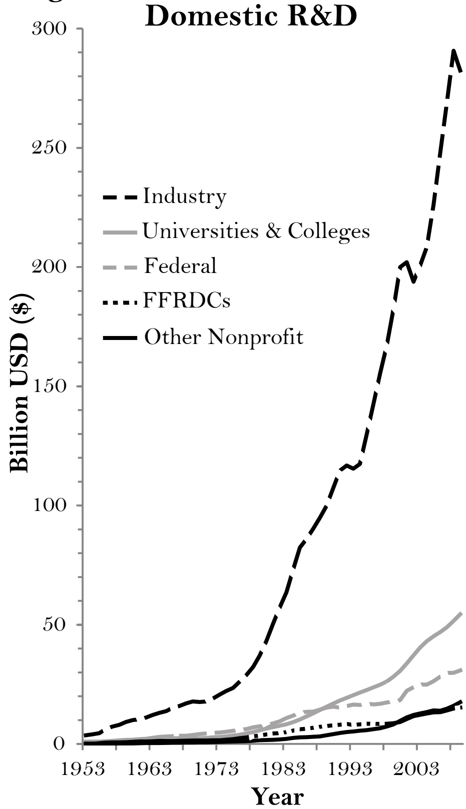
Source: *SEI 2012*, table A4-16.

new Microbusiness Investment in Science and Technology survey arrives, it will be interesting to see whether the smallest companies, consisting of fewer than five workers, have an even higher intensity of R&D.

Performance of R&D

The *sources of R&D funding* and the *performers of R&D* are often distinct. For example, much of the R&D funded by the federal government is actually conducted not by government agencies but by universities or private industry. So-called "intramural research," performed by scientists directly employed by federal agencies, accounts for only 22.8 percent of all federal R&D dollars. Most federally funded private research is conducted by private industry (40 percent) and universities (23.7 percent). There are also hybrid public-private entities called Federally Funded Research and Development Centers (FFRDCs), which are large organizations that perform R&D under the sponsorship of one or more federal agencies. Some of the best-known FFRDCs—including the Los Alamos, Sandia, and Oak Ridge National Laboratories—are sponsored by the Department of Energy. Although some of the nation's most prominent and sensitive scientific research is conducted at the nation's thirty-nine FFRDCs, they receive only 7.5 percent of federal R&D dollars.

Figure 8: Institutions Performing Domestic R&D



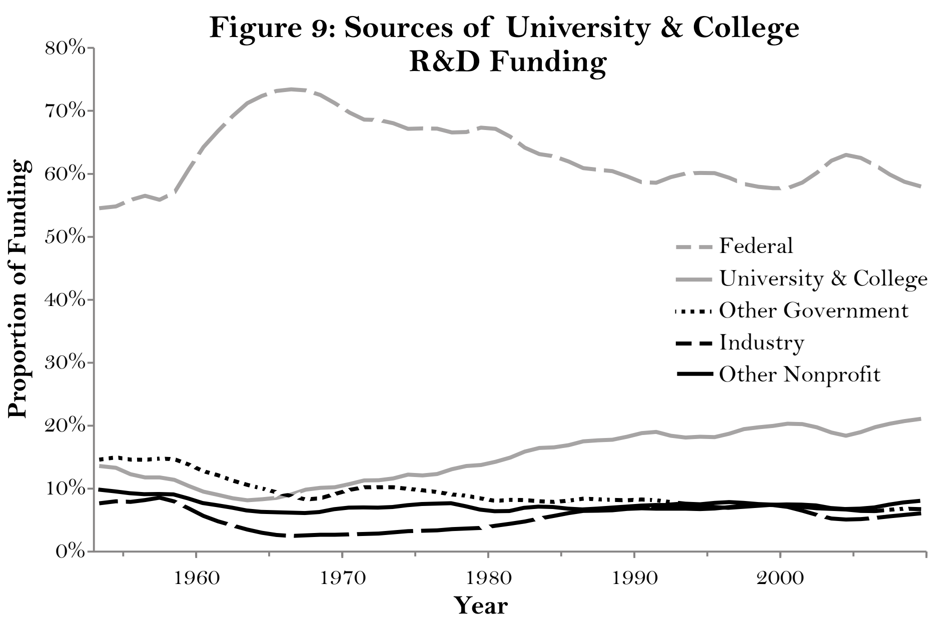
Source: *SEI 2012*, table A4-3.

In addition to direct spending, the federal government subsidizes research and development in a number of other ways. By far the largest of these is the federal research and development tax credit, which allows companies to subtract a portion of their eligible R&D spending from their federal taxes. Although the credit is not a permanent part of the U.S. tax code, it has been extended repeatedly, and failing to continue it would be a major change in tax policy and company expectations. In 2008, companies claimed roughly $8.3 billion in tax credits under this law, with over half of the benefit going to just three industries: computer and electronics products ($1.8 billion), pharmaceuticals and medicines ($1.2 billion), and transportation equipment ($1.2 billion).

In 2008, industry performers of R&D received $36.4 billion from the federal government and $21.8 billion from nonfederal sources. The vast majority of this federal money (71 percent) went to aerospace products and parts. In fact, the aerospace industry is exceptional for being the only industry that receives the majority of its R&D funding from the federal government, with public money accounting for 69.9 percent of the R&D performed by the industry. Navigational, measuring, electromechanical, and control instruments captured another 10 percent of federal funds.

Figure 8 (facing page) tracks the performers of R&D in the United States since the 1950s, bringing together R&D from *all* funding sources, not just federal dollars. The vast majority of R&D has been conducted by private industry, which performed 70.5 percent ($282.4 billion) of all R&D in 2009. Most of the remaining R&D was performed by the federal government itself ($30.9 billion, or 7.7 percent), FFRDCs ($15.2 billion, or 3.8 percent), and universities and colleges ($54.4 billion, or 13.6 percent), with other nonprofits accounting for the rest ($17.5 billion, or 4.4 percent).

Figure 9 shows sources of funding for R&D performed at universities and colleges. The federal government is by far the largest source of this funding, accounting for $31.6 billion (58.1 percent) of all funds in 2009.



Source: *SEI 2012*, table A4-3.

However, this proportion has declined significantly during the last several decades. The major reason for the relative decline has not been a drop in federal funding (which actually rose 72.5 percent in real terms between 1994 and 2004, and has held steady since then) but rather because universities themselves have increased the amount of money they have supplied for R&D. Such internal funding accounted for $11.4 billion, or 21 percent, of all university and college R&D funding in 2009.

State-by-State Differences

Scientific research is more likely to be conducted in some parts of the United States than others. Boston and California are known for their

Table 3. R&D Spending, Federal Funding, and Intensity by State, 2008

	State	All R&D ($ mil)	Federal ($ mil)	Inten. (%)		State	All R&D ($ mil)	Federal ($ mil)	Inten. (%)
1	California	81,323	19,585	4.22	27	Tennessee	3,871	1,993	1.57
2	New Jersey	20,713	1,504	4.28	28	Utah	2,522	962	2.24
3	Texas	20,316	4,461	1.70	29	New Hamp.	2,496	1,397	4.24
4	Mass.	20,090	5,981	5.53	30	Iowa	2,136	646	1.57
5	Washington	16,696	3,160	4.96	31	S. Carolina	2,086	592	1.31
6	Maryland	16,605	12,883	5.92	32	Kansas	2,029	416	1.62
7	New York	16,486	4,944	1.48	33	Delaware	1,594	112	2.73
8	Michigan	15,507	1,465	4.12	35	Kentucky	1,463	279	0.94
9	Pennsylvania	13,068	2,797	2.39	34	Idaho	1,375	365	2.48
10	Illinois	11,961	2,515	1.88	36	Rhode Island	1,233	634	2.59
11	Virginia	11,472	7,636	2.86	37	Louisiana	1,193	466	0.56
12	Connecticut	11,322	575	5.10	38	Oklahoma	1,030	272	0.68
13	Ohio	10,164	3,438	2.15	39	Nebraska	988	212	1.17
14	N. Carolina	8,612	1,835	2.13	40	Nevada	913	206	0.69
15	Arizona	7,010	2,877	2.68	41	Mississippi	808	465	0.84
16	Minnesota	6,697	819	2.56	42	West Virginia	778	405	1.27
17	Florida	6,515	2,265	0.87	43	Arkansas	747	176	0.75
18	Indiana	6,111	811	2.32	44	Hawaii	663	381	1.00
19	D.C.	5,946	5,631	6.15	45	Vermont	546	110	2.18
20	New Mexico	5,906	5,203	7.58	46	Maine	516	172	1.02
21	Colorado	5,810	1,951	2.28	47	North Dakota	511	129	1.64
22	Georgia	5,232	1,668	1.30	48	Montana	401	186	1.12
23	Wisconsin	4,967	770	2.06	49	Alaska	269	191	0.54
24	Alabama	4,870	3,582	2.85	50	South Dakota	254	90	0.67
25	Oregon	4,802	607	2.83	51	Wyoming	154	48	0.40
26	Missouri	3,884	676	1.62		**State Total**	372,660	110,543	2.60

Source: *SEI 2012*, table A4-18.

research universities, suburban Maryland is home to NIH, Texas and Florida have major NASA centers, and so on. Although not all R&D spending can be neatly allocated to specific states, the vast majority (around 92 percent of domestic R&D in 2008) can. Table 3 (facing page) shows the distribution of R&D spending among all fifty states and the District of Columbia—listing all R&D spending as well as specifically federal R&D spending. Since the state list is ranked in order of total R&D spending in each state, it is no surprise that the top of the list is dominated by states that are populous and have major science hubs. (The table, which relies on NSF data, is somewhat skewed by the convention of including the administrative costs of managing federal R&D contracts and allocating this cost to the state where the federal agency is located rather than to where the research is done.)

Each state in Table 3 is also given a ranking for R&D intensity, which in this case refers to the R&D spending as a percentage of the state's GDP. New Mexico ranks highest with an intensity of 7.58 percent, largely due to the presence of two prominent national laboratories. The District of Columbia ranks second at 6.15 percent, but this is heavily influenced by the administrative costs associated with federal funding. Surprisingly, Florida—a populous state with the country's fourth-highest GDP—has one of the lowest intensity ratings, coming in at under 1 percent.

International Comparisons

How do all these R&D figures compare to other countries? In absolute terms, U.S. spending on R&D far exceeds that of any other country: in current dollars, the United States spent $401.6 billion in 2009, more than twice as much as the second-highest R&D investor, China, which spent $154.1 billion. American spending on R&D also outweighed the total R&D spending of the European Union, which came to $297.9 billion.

The picture is slightly different if we look at R&D expenditures as a percentage of GDP. Measured that way, the United States spends more on R&D (2.9 percent) than the EU as a whole (1.9 percent), and more even than Europe's top R&D investors, Germany (2.8 percent) and France (2.2 percent). However, Japan has long devoted a greater share of its economy to R&D (3.3 percent) than the United States. Over the last few decades, South Korea has also begun to surpass the American commitment to spending on R&D (3.4 percent in 2008), and China, too, has been engaged in a drive to increase its investment in R&D, with the proportion of the Chinese economy put into R&D doubling over the past decade (to 1.7 in 2009).

If we look more narrowly at just *government* spending on R&D in foreign countries, the most recent *Science and Engineering Indicators* shows that the U.S. government's budget for R&D exceeded spending by the governments of France, Germany, the United Kingdom, and Japan combined. However, more than half the U.S. government's spending on R&D is for national defense, a much higher proportion than in any of these countries. France devotes the next highest proportion of its R&D budget to defense, with 28.3 percent in 2009, while Japan is at the low end of the spectrum with only 3.7 percent.

Today, thanks to globalization, multinational companies not only market and sell products in many countries, they also fund and perform R&D internationally. Table 4 shows the amount of U.S. R&D spending by domestic affiliates of foreign companies. In 2008, these companies spent $40.5 billion on R&D in the United States—a figure that has risen steadily over the last decade. The list is dominated by European countries, Japan, and Canada; the presence of Bermuda in the top ten is likely related to the island's business-friendly tax policies.

Table 4. R&D Expenditures by Domestic Affiliates of Foreign Companies, 2008

Region	R&D expenditures ($ million)
United Kingdom	7,369
Switzerland	6,926
France	5,978
Germany	5,520
Japan	4,637
Netherlands	1,789
Canada	1,435
Bermuda	1,224
Finland	587
Belgium	470
Total	40,519

Source: *SEI 2012*, table A4-22.

Table 5 (facing page) shows the amount and destination of spending by majority-owned foreign affiliates of U.S. parent companies—for instance, when IBM sets up a research center in China. In 2008, U.S. companies spent about $37 billion performing R&D abroad. This figure has also risen steadily over the last two decades. Europe, Japan, and Canada dominate this list, too, although it also includes China, with its cheap labor and growing higher education sector, and Israel, a highly educated high-tech hotbed.

From Numbers to Policy Analysis

For six decades, the scientific enterprise has received systematic and reliable funding in the United States, with a general trend toward relatively increased involvement by the private sector over the past two decades. As one would expect, industry tends to invest in the development stage of the innovation pathway. However, while the federal government is the primary supporter of basic scientific research, it too provides more money for the development stage than for research.

It is important to keep in mind that the measurement of these different characters of work is not precise. The apparent levels of funding in these categories reflect evolving reporting practices of different private-sector entities and government agencies, as in the case of NIH's decision in 2000 to no longer classify any of its spending as development.

But the figures presented here offer a useful outline of spending on research and development in the United States, making it possible to begin seriously examining the fundamental policy questions about science, technology, and innovation—questions that too often go unasked because the answers are generally assumed. What is the real significance of the distinctions between basic research, applied research, and development for the problems that public policy tries to address through the funding of science? How should we balance the goals that we hope to accomplish through the scientific enterprise—ensuring progress in useful areas like medicine and national defense; understanding the natural world for its own sake, independently of the material benefits of knowledge; and promoting innovation, growth, and prosperity? How should we allocate federal R&D dollars to reflect that balance? What is the relationship between spending on scientific research and breakthroughs in medicine and technology that contribute to genuine human flourishing?

Table 5. R&D Performed Abroad by Foreign Affiliates of U.S. Companies, 2008

Region	**R&D expenditures ($ million)**
Germany	7,039
United Kingdom	5,157
Canada	3,040
France	2,171
Japan	1,872
Sweden	1,576
China	1,517
Ireland	1,503
Netherlands	1,484
Belgium	1,259
Switzerland	1,123
Israel	1,060
Total	36,991

Source: *SEI 2012*, table A4-11.

In some measure, these are scientific questions. After all, whether a particular research program is likely to bear fruit requires an evaluation of the science itself and its potential applications. These are also economic questions, requiring analysis of spending, performance, and incentives in order to understand whether private or public money is being used effectively. More deeply, however, these questions touch on the kind of society we are and wish to be—the hopes that we have for the future, the price we are willing to pay for progress, and the values we seek to preserve. That is to say, they are fundamentally political questions, requiring political answers.