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Federal R&D in the FY 2015 Budget: An Introduction

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INTRODUCTION

The President released his fiscal year (FY) 2015 budget request on March 4, 2014, a full month late due to delays in the prior year's appropriations process, which was not finalized by Congress until January; and even with the one-month delay, full details and budget justifications from many agencies did not emerge until a week later. The Administration's stated R&D priorities for this budget reprise some common themes from past years, including advanced manufacturing, low-carbon energy technology, STEM education, neuroscience, and other fields. However, as in past years, the possibility for increased investments in most areas is deeply constrained for FY 2015. In December 2013, Congress passed the Bipartisan Budget Act of 2013 (Public Law 113-067), which resolved the ongoing dispute over discretionary spending levels in FY 2014 while also revising the spending caps for FY 2015.[1] Through these caps, the agreement managed to stave off further partisan gridlock during the FY 2015 appropriations cycle, but in so doing, left very little additional room for discretionary spending growth: the overall spending caps will increase by roughly 0.2 percent in FY 2015 compared to FY 2014, less than the 1.7 percent inflation rate.

Within this context, the President's base budget, which meets the agreed-upon caps, would essentially keep funding for the federal R&D

[1] "What the Ryan/Murray Budget Deal Might Mean for R&D Budgets," AAAS R&D Budget and Policy Program, December 11, 2013, http://www.aaas.org/news/what-ryanmurray-budget-deal-might-mean-rd-budgets

enterprise treading water. There are some areas primed for increased investment in the base budget, but these increases are modest compared to years past, and many agency budgets would fail to keep pace with inflation. However, in addition to the base budget, the President also proposes an additional package of discretionary spending for FY 2015 dubbed the Opportunity, Growth, and Security Initiative (OGSI). This additional spending would add $56 billion to the discretionary budget for FY 2015, in effect restoring all but a fifth of the overall discretionary spending cuts required under the Budget Control Act of 2011 (the BCA).[2] The President also proposes an overall increase in discretionary spending through the rest of the decade. This extra spending would make a big difference for federal R&D departments and agencies, but would require Congress to raise the current discretionary spending limits, an unlikely scenario at this time.

In the overall picture, the President's budget does propose a mix of mandatory spending cuts and revenue increases, in addition to the increases to discretionary spending, but the improvements to the long-run deficit picture would be marginal, and mandatory spending would continue to engulf other federal expenditures.

THE FY 2015 BUDGET: THE BASICS

President Obama's $3.9 trillion FY 2015 budget request estimates a $564 billion deficit in the next fiscal year, a decrease of 13.1 percent from the FY 2014 deficit of $649 billion. Alternatively, the Congressional Budget Office (CBO) has estimated that the President's budget would produce a $509 billion deficit in FY 2015. The deficit reduction would come from a mix of policy changes, including some limitations on tax benefits for high-income earners and closures of loopholes; implementation of immigration reform, which CBO believes would ultimately lead to a net increase in tax revenues, and thus have some deficit reduction impacts; and some targeted spending cuts for Medicare.

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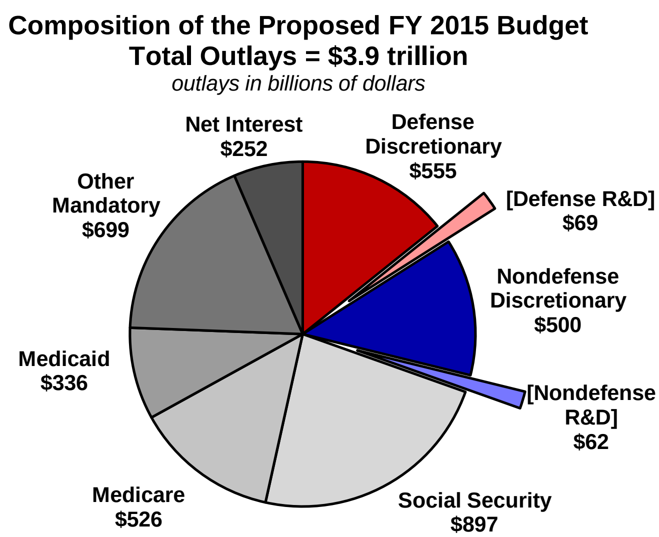
[2] "The President's Opportunity, Growth, and Security Initiative: What's In It?" AAAS R&D Budget and Policy Program, April 9, 2014, http://www.aaas.org/news/president%E2%80%99s-opportunity-growth-and-security-initiative-what%E2%80%99s-it

This $3.9 trillion budget is divided into mandatory spending – which consists largely of entitlements on “autopilot” like Social Security and Medicare, as well as interest payments on the national debt – and discretionary spending, which consists of defense spending and most other nondefense functions the government fulfills, including nearly all research and development (R&D) expenditures (see Figure 1). Discretionary spending is subject to the annual appropriations process, while mandatory spending is not. In FY 2015, the Administration estimates that discretionary spending would account for only 30.4 percent of the total budget. Discretionary spending has been subject to a long-term drop relative to the rest of the budget. For comparison, discretionary spending was 40 percent of the budget in 1990, 46.8 percent in 1980, and 61.5 percent in 1970 (see Table I-3).

Figure 1.



Source: *Budget of the United States Government FY 2015.* Projected deficit is $564 billion. © 2014 AAAS

Discretionary outlays (including war funding, OGSI spending, disaster relief, and other items not subject to the BCA caps) would increase by 1.0 percent overall from FY 2014 in the President’s budget. Defense spending would keep pace with inflation while nondefense spending would receive a sub-inflation increase (see Table I-2).

Within this constrained context, many science agencies would outpace the rest of the discretionary base budget, which adheres to the spending caps agreed upon in the December budget deal mentioned above. Indeed, nondefense R&D spending would actually **increase** by 1.2 percent above FY 2014 levels in the President's budget, compared to an overall discretionary growth rate of 0.2 percent under the BCA caps.

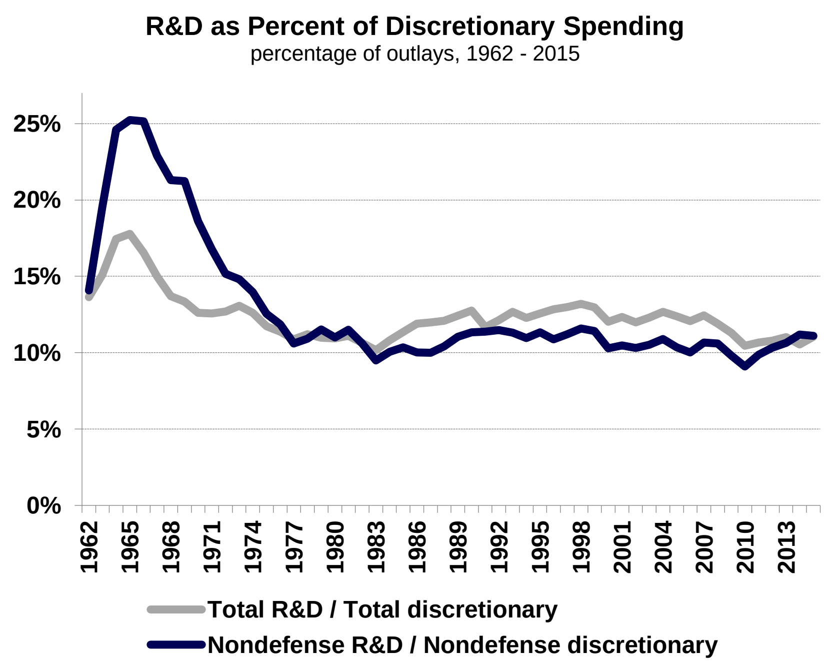
Looking ahead to future years, the Administration expects discretionary outlays to continue declining relative to the overall budget beyond FY 2015. By FY 2019, for instance, discretionary spending could drop to 24.6 percent of total federal outlays, even as the Administration seeks to increase discretionary spending relative to the current BCA caps. This relative decline would be largely driven by continued growth in mandatory spending, which even the Administration's proposal for looser discretionary spending limits would not offset.

R&D IN THE FEDERAL BUDGET

Although the President's budget presentation each year contains a section devoted to R&D and several tables summarizing proposed and historical R&D expenditures, it is important to recognize that **there is no overall R&D budget** and no special treatment for R&D within most agency budgets. R&D budgets are folded into the budgets of more than two dozen federal departments and independent agencies as shown in Table I-1. Expenditures for R&D programs are frequently included as part of regular budget items and accounts, though some agencies – like the National Science Foundation and the Department of Transportation, to name two – do break out R&D funding data, though detailed breakdowns are generally limited. For instance, a particular science program may have a $200 million budget, of which $125 million might go towards the conduct of R&D and $10 million towards research equipment and infrastructure, while the remaining $65 million might go towards overhead, workforce development, security, and other non-R&D functions; there may be little or no distinction made between the two activities in the budget materials.

Federal R&D outlays would represent 3.4 percent of the total $3.9 trillion budget for FY 2015, and 11.1 percent of total discretionary outlays. R&D funding has stayed surprisingly steady as a share of overall discretionary spending, hovering between 11 and 13 percent of the discretionary budget since the end of the space race (see Figure 2). Such a relatively stable trend is a rather remarkable outcome over so many years, given a complex and decentralized appropriations process involving the hundreds of budget decisions over individual programs. However, when disaggregated into defense and nondefense spending, the trend is not quite so static. The rise of advanced technology for national security has caused defense R&D to claim a somewhat larger relative share of the defense budget, though it has declined lately. Meanwhile, following some years of modest decline, nondefense R&D has generally outpaced the rest of the discretionary budget in recent years.

Figure 2.



Source: Budget of the U.S. Government FY 2015. © 2014 AAAS

Overall, **the FY 2015 budget would invest $136.5 billion in R&D**. In nominal dollars, this represents an increase of just 0.7 percent above FY 2014, which means a real-dollar decline of approximately 1.0 percent when accounting for inflation.

This top-line figure can be split into **defense** and **nondefense R&D,** and can be further divided by **character.** Generally speaking, in recent budgets, the Administration has shown a preference for boosts to nondefense R&D coupled with cuts to defense R&D, and similarly to boosts for research coupled with cuts to development. This year's R&D budget **again shows a preference for nondefense R&D**, though this preference is mild, with defense R&D receiving a small funding increase, and nondefense R&D receiving a smaller boost than has been proposed in past years. However, the budget departs somewhat from the recent past by **cutting research funding while boosting development activities.**

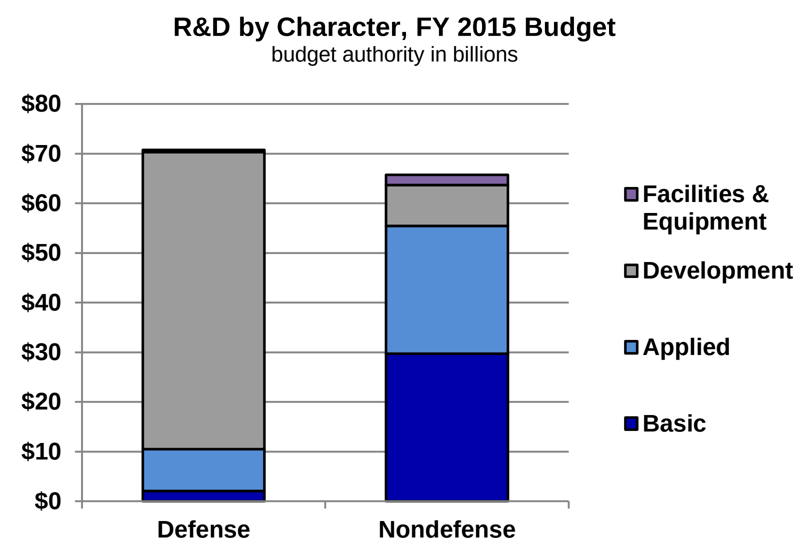
The defense and nondefense division is fairly straightforward. Defense only includes two components: the Department of Defense (DOD) R&D budget and defense-related R&D funded by the DOE, primarily through the National Nuclear Security Administration (NNSA). The DOD R&D portfolio is more than 10 times that of the defense R&D portfolio at DOE, and so generally speaking, as the DOD budget goes, so goes the defense R&D budget, though the two components have been moving opposite directs of late. Nondefense R&D is everything else, including health, space, energy, agriculture, environment, and social science research.

Another wrinkle comes when examining the R&D budget by character. There are five of these: basic research, applied research, development, R&D facilities construction, and capital equipment for R&D (see Appendix 3 for definitions). Adding basic and applied research together produces a figure for "research" or "total research," while the two research categories plus development compose "conduct of R&D." AAAS tables combine R&D facilities spending and capital equipment, often described together as simply "R&D facilities" or "R&D plant." Adding R&D facilities to "conduct of R&D" yields "total R&D."

Defense and nondefense R&D have very different characters, as shown in Figure 3. More than 85 percent of defense R&D consists of development activities, due to the development costs associated with high-tech weapons, vehicles, and other systems pursued by DOD. In addition, development activities consume more than a third of DOE's atomic defense R&D budget. However, the combined defense research budget is also quite large at over $10 billion.

On the other hand, nondefense R&D is very much focused on research activities, which account for nearly 90 percent of that budget; it is also split fairly evenly between basic and applied research, with a slightly larger basic research budget in FY 2015. Lastly, nondefense agencies spend about five times as much as defense agencies for R&D facilities and capital equipment, for laboratories, telescopes, satellites, particle accelerators, and other items. Altogether, because of these differences and the varying sizes of agency budgets, development accounts for more than half of the federal R&D budget, while basic research is only one-fifth.

Figure 3.



Source: OMB R&D data, agency budget justifications, and other agency documents. © 2014 AAAS

The figures shown in Tables I-5 and II-1 represent agencies' best efforts to classify basic and applied research, development, and R&D facilities within their R&D portfolios. The data reported here are imprecise and reflect the agencies' judgments as to how their R&D fits into the definitions for character of work, which can be subjective. To summarize the major points:

Total federal investment in research would decline by 1.7 percent to $65.9 billion. Several agencies would see moderate increases in research funding under the President's budget over FY 2014, especially the Departments of Energy, Transportation, and Interior, and the National Oceanic and Atmospheric Administration (NOAA). Additionally, patient outcomes research funded by the Patient-Centered Outcomes Research Trust Fund is scheduled for a substantial increase. However, large cuts in NASA research on the nondefense science, and DOD research on the defense side, would more than offset these other increases. It should be noted, however, that some of the NASA decline is due to a reclassification of ongoing work within NASA's Science Mission Directorate; and some of the DOD decline is due to reductions in Defense Health Program medical research funding, which Congress typically restores.

Both basic and applied research would decline. Basic research would decline by 1.8 percent and applied research by 1.6 percent, falling to $31.7 billion and 43.2 billion, respectively. Factoring in inflation would mean both classes of research would drop by at least three percent in real dollars. Basic research would decline across defense and nondefense accounts, while applied research would only decline on the defense side, which again can be partially explained by the medical research reduction at DOD; the basic research decline can also be partially explained by the NASA reclassification. The Department of Energy (DOE) is the only agency that would see double-digit percentage increases in both categories in the President's request, due to boosts for some low-carbon energy technology programs and for NNSA research, but some agencies would see smaller increases for one or both research categories.

Development funding would increase by 3.2 percent, or $2.1 billion. This is due in part to increases to DOD's downstream weapons development activities, representing a break from recent trends. Nondefense development activities would receive a large increase of 15.0 percent or $1.1 billion. This is again partially explained by a reclassification of some NASA work, while DOE would also see large increases for both defense and nondefense development.

R&D facilities funding would be cut by 4.3 percent, or $111 million, falling to $2.6 billion. Large investments in R&D equipment and facilities at NNSA would be offset by cuts at DOD, the Department of Homeland Security (DHS), and NASA.

ADMINISTRATION PRIORITIES IN THE R&D BUDGET

The President again highlighted the role of science and innovation in economic growth during the State of the Union, when he stated, “We know that the nation that goes all-in on innovation today will own the global economy tomorrow. This is an edge America cannot surrender. Federally-funded research helped lead to the ideas and inventions behind Google and smartphones. That’s why Congress should undo the damage done by last year’s cuts to basic research so we can unleash the next great American discovery – whether it’s vaccines that stay ahead of drug-resistant bacteria, or paper-thin material that’s stronger than steel.”[3] However, in spite of this rhetoric, the President’s base budget – excluding OGSI funding, which has been met with a somewhat frosty reception by Congress – makes only limited progress towards increased investment in science and innovation (see Figure 4 below). This is no doubt due in part to the limited fiscal room provided by the current BCA caps as described above. Still, some areas would see clear if modest increases in nominal dollars in the base budget, and at least keep pace with inflation. Some of these areas are outlined below.

The Department of Energy (DOE). By far, DOE would be the biggest winner in the President’s R&D request (see Table II-11 and Chapter 8). DOE’s R&D portfolio is divided into three categories: atomic defense, primarily NNSA; energy programs, which include funding for more applied research and development in efficiency, renewables, nuclear energy, fossil energy, and the grid, as well as funding for the Advanced Research Projects Agency-Energy (ARPA-E); and the Office of Science (SC). Of these, only SC would fail to keep pace with inflation, while the other two categories would see major increases.

On the defense side, the NNSA would receive a major R&D boost of 14.2 percent, or $628 million, to reach $5.1 billion for R&D. This would be driven by increases in NNSA’s science, engineering, and readiness activities, and through increased investment in NNSA’s portfolio in

[3] http://www.whitehouse.gov/the-press-office/2014/01/28/president-barack-obamas-state-union-address

naval nuclear propulsion, while nonproliferation R&D would be cut by 9.8 percent.

Within nondefense programs, major increases for R&D are slated for energy technology programs dealing with efficiency and renewables; with electricity delivery and grid reliability; and at ARPA-E, as well as $200 million in new R&D funding proposed through the President's Energy Security Trust, which would redirect funding from oil and gas revenues. In dollar terms, these collective increases far outweigh moderate cuts to nuclear energy technology R&D, and much larger cuts to fossil energy R&D. While some programs within SC would also see fairly large increases, others would be cut, and overall the President's energy R&D budget clearly favors national security, applied activities, and potential nearer-term payoffs.

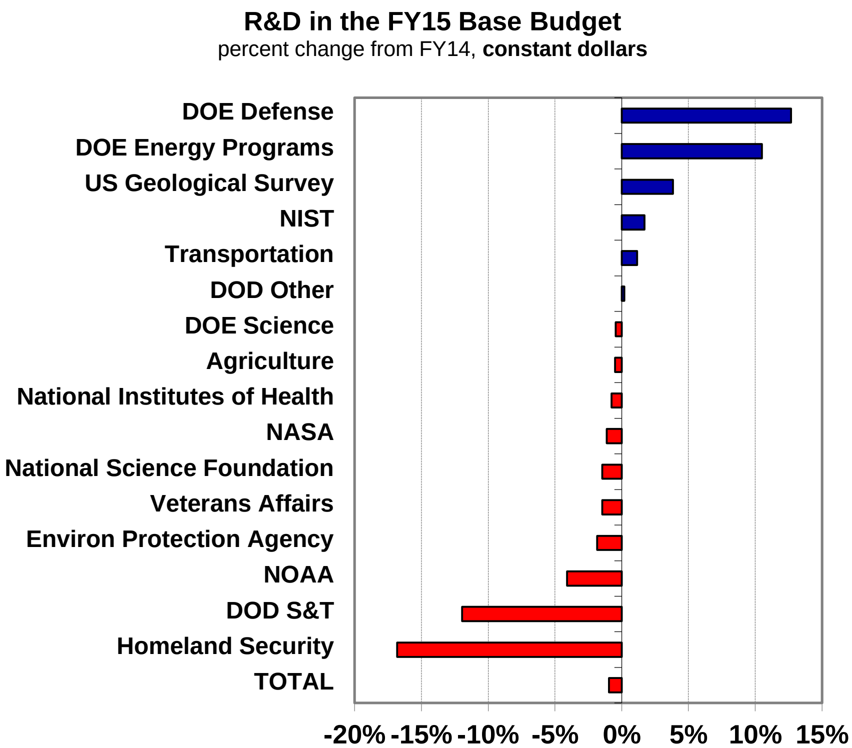
Neuroscience. The President's budget proposes to double the Brain Research through Advancing Innovative Neurotechnologies Initiative, or the BRAIN Initiative, to $200 million, with half of this funding coming from the National Institutes of Health (NIH), and the rest coming from the National Science Foundation (NSF) and the Defense Advanced Research Projects Agency (DARPA). Some other neuroscience-related activities at these agencies would also receive funding increases (see Chapter 7).

Public-Private Partnerships for Space Exploration. In a mixed budget for NASA, the space agency's programs to partner with industry would receive by far the largest increases. These would include programs supporting private-sector capacity for human space travel, and technology development programs that seek to accelerate technology innovation by industry partners for future use in transport systems. Both programs would receive increases of at least 21 percent above FY 2014 levels (see Table II-12 and Chapter 9).

Extramural Agricultural Research. While the U.S. Department of Agriculture (USDA) R&D budget would fail to keep pace with inflation, only intramural research would be cut, as R&D at the extramural National Institute of Food and Agriculture (NIFA) would increase by 8.6 percent, or $69 million, rising to $876 million (see Table II-13 and Chapter 10). This includes a small 2.8 percent increase for the

Agriculture and Food Research Initiative, the premier competitive grants program at NIFA.

Figure 4.



Source: AAAS analysis of the FY 2015 President's Budget. Does not include additional funding proposed via Opportunity, Growth, and Security Initiative. Inflation is 1.7%.
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Transportation R&D. The President's budget proposes Department of Transportation (DOT) R&D boosts in two areas. The Federal Highway Administration would receive a 10.3 percent boost, or an additional $38 million above FY 2014 levels, for R&D activities in surface transportation and intelligent transportation systems. Additionally, the Federal Railroad Administration would receive a 62.2 percent increase, or an additional $25 million above FY 2014 levels, for a new R&D initiative focused on high-performance rail (see Table 11-15 and Chapter 12).

Environmental Research. While the Environmental Protection Agency (EPA) would receive flat R&D funding from FY 2014 levels, the U.S. Geological Survey (USGS), NOAA, and the Forest Service would all receive at least modest increases in the President's request.

The Opportunity, Growth, and Security Initiative (OGSI). While the base budget clearly takes a modest approach to R&D funding, the OGSI offers a different spin. As mentioned above, the OGSI would provide $56 billion in additional discretionary funding. It would include $5.3 billion for R&D, divided between defense and nondefense R&D programs. While this would no doubt make a major difference for many science and innovation agencies, Congress will likely have other ideas about granting this extra funding. Discussion of OGSI funding is spread throughout agency and discipline chapters in this volume, but see in particular Table II-20.

BY BUDGET FUNCTION

Most federal R&D is mission oriented; that is, it is intended to serve the public interest goals and objectives of the agency that provides the funds, such as agricultural research in the USDA. Only NSF has a primary mission to support general science and engineering research and education across a wide range of disciplines. For most of the rest of the federal R&D portfolio, R&D investments are a means to achieve public ends within a defined subject area, outlined by Congress when legislators established each agency.

To illustrate these national missions, the federal government divides the budget into 20 "functions," each with an assigned function number.[4] The President's budget and the congressional budget resolution typically divide the total recommended budget into these functional categories, which serve as non-binding guides for appropriators in allocating funds to agencies and programs (see Appendix 1 for a full summary). The actual funding amounts contained in each function can vary widely. Virtually all R&D funding is contained in about half of these budget

[4] AAAS separates the general science, space, and technology function (function 250) into its subfunctions of General Science (251) and Space (252). AAAS also counts Department of Veterans Affairs R&D programs in the health (550) function instead of veterans' affairs (700). Otherwise, AAAS function definitions are similar to OMB's.

functions; the other functions contain little or no R&D (see Table I-4). Viewing the R&D portfolio by function can reveal changes in funding priorities in the different areas over time, and can allow for international comparisons with other nations' spending on R&D by objective.

R&D in most budget functions would not keep pace with inflation, though some would post modest gains reflecting the President's priorities for the base budget. Unsurprisingly, the energy function would receive the largest relative gains, due to the Administration's focus on efficiency, renewables, and grid-related R&D. Energy function R&D would increase by 11.7 percent, or $281 million, to $2.7 billion. The environmental research function and the agriculture function would also keep ahead of inflation, due to the increases at NOAA, USGS, the Forest Service, and NIFA, as described above. The health function would receive the largest increase in total dollars, at $302 million, though this would only represent a 0.9 percent increase given the size of that function and NIH's place within it. Again, the limited growth in most functions is partly attributed to the tight fiscal environment, and again, R&D in most functions would still grow at a faster rate than the discretionary budget overall.

FEDERAL R&D BY PERFORMER

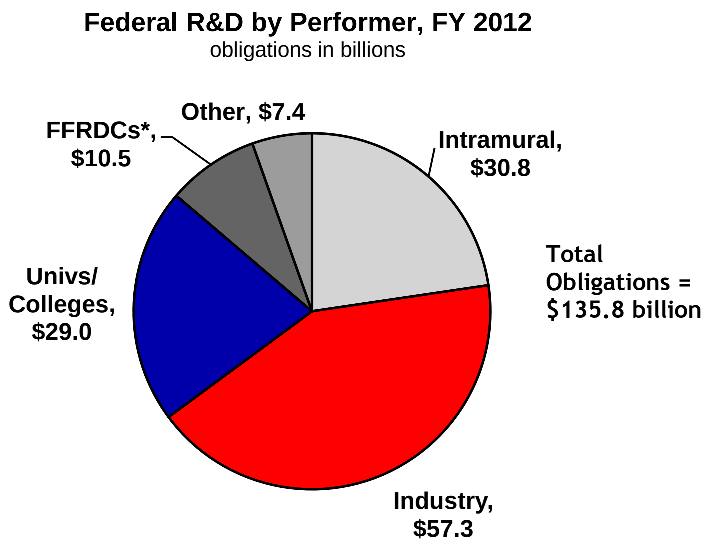
Less than one quarter of federally supported R&D is actually carried out in federally operated labs (see Figure 5). The largest share of federal R&D is in fact carried out by industrial firms under contract – largely defense firms – which accounted for 42.2 percent of federal obligations for R&D in FY 2012. The federal R&D performed by colleges and universities in FY 2012, accounting for 21.4 percent, was slightly less than federal intramural R&D, at 22.7 percent. Other nonprofit institutions – such as research institutes and hospitals – performed the smallest portion, at 5.4 percent, and 8.3 percent of the federal R&D portfolio was performed by approximately 40 FFRDCs,[5] or federally funded R&D centers (national labs), which are owned by government but operated by contractors.

Each federal funding agency has its own mix of performers, depending on the agency's mission, character of work, and historical relationships

[5] A full list is available on the NSF website (http://www.nsf.gov/statistics/nsf13326/content.cfm?pub_id=4243&id=6).

with performers. For instance, the majority of DOD's R&D portfolio is performed by private industrial weapons developers, while a substantial portion of DOE's R&D portfolio is carried out at the national laboratories, and the NIH and NSF portfolios are oriented towards colleges and universities.

Figure 5.



* Federally funded R&D centers: government-owned, contractor-operated laboratories (national labs). Source: National Science Foundation, Federal Funds for R&D: Fiscal Years 2010-12. Figures are preliminary. Includes conduct of R&D and R&D facilities.
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Altogether, private industry performed 70 percent of the nation's total R&D in 2012, including research funded internally, through other private sources, and through government contracts. U.S. academic institutions performed a further 13.9 percent, while federal laboratories, nonprofit institutions, and FFRDCs performed the remainder.[6] The industry share in 2012 represented a slight increase from earlier years, while the university share represented a slight decline, perhaps due in part to constrained federal R&D spending, which accounts for a majority of university-based R&D.

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[6] National Science Foundation, *National Patterns of R&D Resources 2011-12* (http://www.nsf.gov/statistics/natlpatterns/).

SETTING PRIORITIES FOR FEDERAL R&D INVESTMENTS

Priorities for R&D programs generally depend on the priorities of the agencies in which they are located and the missions of those agencies. From the standpoint of serving the nation's interests, at least in the short term, this makes good sense, since these R&D programs are not ends in themselves but the means to the ends that their sponsoring agencies serve. From the standpoint of the long-term health of the government-wide research enterprise, however, it can pose evaluative challenges. The mission orientation of R&D programs makes it difficult for policymakers to assess the overall health of the research enterprise, to coordinate programs among different agencies, to achieve long-term planning goals across agencies, and to address issues of balance among various scientific and engineering fields and disciplines.

The Office of Management and Budget (OMB), which has overall responsibility for preparation of the President's budget, is in a position to provide some coordination. Coordination is also provided by the White House Office of Science and Technology Policy (OSTP), including through a yearly science and technology priorities memo sent out by the OSTP and OMB directors. This memo typically describes the Administration's science and technology priorities as agencies are formulating the budget more than a year in advance, so that agencies can integrate that guidance during their internal planning process (see Appendix 1).

Some R&D budget coordination also takes place under the National Science and Technology Council (NSTC), an interagency body comprised of cabinet officers and the President. NSTC has organized a number of key interagency science and technology initiatives, including the U.S. Global Change Research Program, the Networking and Information Technology R&D Program, and the National Nanotechnology Initiative. Budgets for these initiatives are shown in Table I-9.

Congressional responsibility is even more decentralized – and less coordinated – than in the executive branch. R&D programs are considered at two levels in Congress: authorizations and appropriations. Authorizing committees (such as the House Committee on Science, Space, and Technology) develop special expertise in the programs they oversee, and prepare legislation that addresses program substance, provides guidance, changes or creates programs, and sets multiyear funding ceilings; these committees do not, however, actually allocate funding through appropriations. Instead, the authority to allocate discretionary program funding, including R&D, resides in the Appropriations Committees of the House and Senate. These committees are each divided into 12 subcommittees, each one of which is responsible for a bill that controls one portion of the budget, with twelve appropriations bills in total.

In the congressional appropriations process, federal R&D is contained in 11 of the 12 appropriations bills. Table I-7 shows the distribution of R&D funding among these appropriations bills/subcommittees. It is important to remember that each subcommittee produces its appropriations bill separately from the others, and that each bill is usually signed into law separately, although in recent years several bills have had to be bundled into a single omnibus appropriations bill at the end of the congressional session (or beyond).

The division of the budget into 12 appropriations, and the fact that these committees pursue their business separately and do not negotiate with one another, serves to limit any possible coordination or trade-offs between agency or mission R&D portfolios in the congressional process. For example, three R&D agencies – NSF, NASA, and the Department of Commerce – are under the jurisdiction of the Appropriations Subcommittee on Commerce, Justice, and Science. NIH appropriations reside in the Labor, Health and Human Services, and Education appropriations subcommittee. This means that money used to increase the NASA R&D budget does not come from the same pot of money as that which funds NIH, although NASA's budget increase could be directly offset with a cut in NSF's budget, since they are in the same appropriations bill. This system also means that science agencies may compete with non-science agencies in a single bill.

THE ROLE OF R&D IN THE U.S. INNOVATION SYSTEM

Science and technology are recognized as key drivers of economic growth, improved human health, and increasing quality of life. Economists estimate that half or more of economic growth over the past several decades is due to technical progress.[7] Thus, developing a robust science, research, and innovation ecosystem has become a major focus for most forward-thinking leaders in the developed world and developing world alike. Such efforts necessarily include an array of measures, including support for universities, human capital development, appropriate immigration and tax policy, and patent reform. And they also by definition include public support for R&D, both directly (through funding) and indirectly (through tax incentives).

In the United States, R&D investment reached $453 billion in 2012, nearly two-thirds of which came from industrial firms; roughly a third came from government. Federal agencies support roughly 60 percent of R&D performed in U.S. colleges and universities, most of which is basic research (see Table I-9). Not only does this help to drive discoveries that can lead to new knowledge and technological advances, which in turn can drive markets and improve quality of life, but it also serves to help educate the next-generation workforce of scientists and engineers.

It is important to remember that not all R&D is created equal: nearly 80 cents out of every dollar spent by industry for R&D goes toward near-term product development. In contrast, federal R&D – especially nondefense R&D – is far more focused on basic and applied research. While all R&D involves risk and uncertainty, the tolerance for these is lower in a competitive market, and so industry tends to favor R&D investments that offer a surer, more predictable bet over those that might take 10 or more years to yield marketable results, if ever. Conversely, basic and applied research – the kinds of research that can yield potentially greater knowledge gains, but that force the performer to cope with higher risks and greater uncertainty – are exactly those pursuits in which government is able to specialize as both funder and performer, so long as lawmakers and the public are willing to maintain support for a robust science enterprise. This is not to say that the private sector does not fund a large amount of basic and applied research, nor is it to say that government does not pursue nearer-term development activities that serve public rather than private interests. But there are clear tendencies at work that have consequences for research policy choices.

[7] See, for instance, Michael Boskin and Lawrence Lau, "Generalized Solow-Neutral Technical Progress and Postwar Economic Growth," NBER Working Paper No. 8023.

A further reason for the importance of federal R&D is the economics of knowledge spillovers. Private firms that spend money on R&D must cope with the fact that new knowledge often cannot be contained or restricted. Spillovers – essentially, the transfer of knowledge outside of the firm that created it – mean that it can be difficult for a firm to recoup all of the benefits of that knowledge, as other firms can acquire it, improve it, and use it to their benefit, in the same industry and in other industries. Because others besides the original creator can benefit from this knowledge, the **social** returns of R&D are frequently higher than the **private** returns of R&D. This presence of a broad social good, which would not enter into a private firm's market calculus, again suggests a federal role in pursuing high-risk research to generate this knowledge, to maximize social returns. There is now an enormous literature that details many of the federal R&D contributions to the modern economy in computing, energy, biotechnology, and agriculture.[8] And the importance of this role only continues to grow as the international innovation system becomes more fragmented, small firms continue to make important contributions to innovation, the global market becomes more competitive, and public-private research partnerships become more important.

U.S. Investments in an International Context[9]

In absolute terms, U.S. R&D spending in 2011 from public and private sources was twice as large as in the second-largest funder, China. The U.S. also spent more than the entire combined R&D budget of the EU, and accounted for 29.9 percent of world's R&D. This remains by far the largest share for a single nation, though it has declined steadily over the past decade as emerging R&D powers, especially South Korea, China, and others in Southeast Asia have dramatically increased their own investment levels. Even as the lead grows smaller, the United States remains the dominant R&D power in the world in terms of pure scale.

[8] For instance, see Fred Block and Matthew R. Keller, eds, *State of Innovation: The U.S. Government's Role in Technology Development,* Paradigm Publishers, (2010); and Rebecca M. Henderson and Richard G. Newell, eds, *Accelerating Energy Innovation: Insights from Multiple Sectors*, University Of Chicago Press (2011).
[9] Data in this section comes from NSF's *Science and Engineering Indicators.*

There are other ways to assess the health of the domestic R&D enterprise, however. When one looks at the research intensities of various economies – measured by national R&D expenditures as a share of gross domestic product (GDP) – the picture is still positive, but not by quite so much. R&D represented 2.9 percent of GDP in the United States in 2009. This places the U.S. below several other developed countries, including Japan (3.4 percent) South Korea (4.0 percent), Sweden (3.4 percent), and Taiwan (3.0 percent). On the other hand, the United States still ranked in the top 10, above most other major industrialized countries, including France and the United Kingdom. In 2000, as part of the Lisbon Strategy, the EU set a goal of attaining an EU-wide R&D intensity of 3 percent by 2010; President Obama and others have set the same target in the U.S. However, both the EU and the United States have yet to reach these targets. Another important note is that a significant share of U.S. R&D is for defense, which can have a markedly different impact on the civilian economy and industrial competitiveness than nondefense R&D. By comparison, other world R&D powers like Germany and Japan devote only a small portion of their R&D resources to defense. Lastly, it's important not only to take a static picture of the national research enterprise at this point in time, but to consider long-term trends, backward and forward. In this view, the United States has ever-so-slowly ceded ground to international competitors, leading some to predict that the global R&D enterprise could look very different in the coming decades.