science progress

U.S. Scientific Research and Development 101

Understanding Why These Investments Are Key to Our Future Economic Competitiveness

February 16, 2011

"After investing in better research and education, we didn't just surpass the Soviets; we unleashed a wave of innovation that created new industries and millions of new jobs."
– President Barack Obama, 2011 State of the Union

President Obama this week released his budget proposal to Congress for fiscal year 2012, which begins in October of this year. The president matched his important State of the Union observation last month that "maintaining our leadership in research and technology is crucial to America's success" with new investment targets for an array of key science and innovation programs. Republicans have mapped out a different strategy, arguing that we need to cut almost all of these science R&D programs in a bid to reduce the federal budget deficit.

The budget debate every fiscal year sparks new questions about how much support the federal government should provide for the critical research and development in science and technology. But in this year of a politically split Congress, the question of "how much" is center stage. Perhaps the better question is not "how much" but "what for?" After all, if policymakers can agree on what has to be done to ensure our future economic competitiveness, then deciding how much to spend should become an easier task.

This "charticle"—a series of charts with accompanying explanations—breaks down U.S. spending on scientific research and development to its key components. The purpose: to enable a meaningful discussion about the kind of investments we need to make as a nation to remain globally competitive in the 21st century. That's why our first chart shows the level of R&D investment relative to gross domestic product (the total amount of goods and services produced in an economy) of the United States and its main global competitors. (see Chart 1 on page 2)

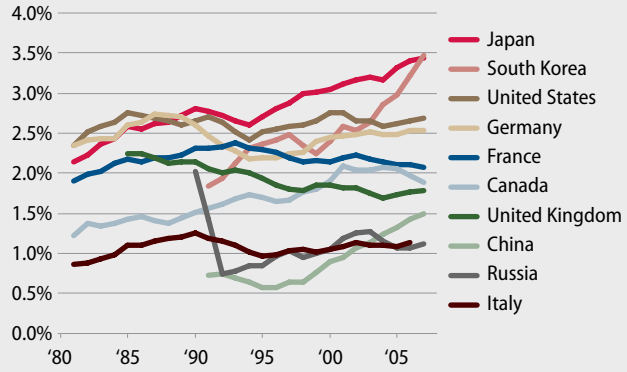
The federal role in science investment

In answering the question "what for," it's important to remember that the key to American prosperity and competitiveness over the past century has been its ability to lead the world in science, technology, and innovation. American scientists still publish the most peer-reviewed papers in the world but China is gaining fast. And while we still develop and commercialize some of the best technology in the world, as of 2008 foreign patents surpassed U.S. patents; countries including China, Japan, and Germany are nipping at our heels. To continue to lead the world in technology and innovation, we need to continue to invest in the pool of scientific knowledge from which new technologies are drawn.

CHART 1

The United States needs to up its game

Total R&D spending relative to gross domestic product among major global economies, public, private and non-profit



OECD, Main Science and Technology Indicators (2009/1), via National Science Foundation, available at http://www.nsf.gov/statistics/seind10/c4/fig04-16.xls.

Think of it as "trickle-up" rather than "trickle-down" economics. A robust science system fueled by federal, university, and private research is needed for knowledge to trickle up into the market in the form of new technologies and products that support new businesses, new industries, and of course new jobs.

As the president said in his State of the Union address last month, cutting the deficit by gutting our investments in this critical engine of long-term growth and competitiveness is "like lightening an overloaded airplane by removing its engine. It may make you feel like you're flying high at first, but it won't take long before you feel the impact."

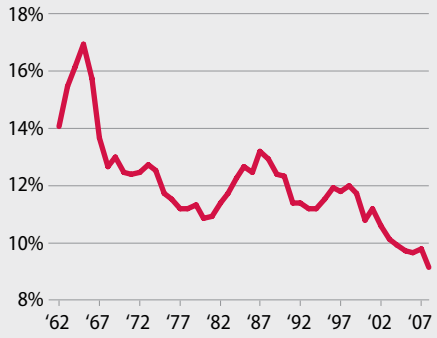
This series of charts detailing our nation's federal and private-sector science and innovation investments in the past and present should help give a sense for the issues at hand. Alas, the news is not good (see Chart 2), though there is time to fix the problems.

Robust investment in research and development is a critical building block of the innovation economy. Yet federal investment has been declining as a portion of the budget for decades. While at the height of the space race in the 1960s our government dedicated fully 17 percent of its budget to critical economy-driving investment in R&D, total outlays in 2008 were scarcely more than 9 percent of the federal budget. (see Chart 3 on page 3)

CHART 2

Our nation investing less and less overall in science R&D

Total federal R&D outlays as a percentage of total descretionary spending FY1962–2008



Source: Science Progress calculation using "National Patterns of R&D Resources: 2008," Table 5, available at http://www.nsf.gov/statistics/nsf10314/content.cfm?pub_id=4000&id=2; and Historical Tables, *Budget of the U.S. Government Fiscal Year 2011*, available at http://www.whitehouse.gov/omb/budget/Historicals.

In 1976 we invested nearly 1.3 percent of our economic output back into research and development to help drive long-term growth. These wise investments paid off in the form of an array of new products and services that eventually formed the backbone of

the Information Age that dawned in the United States and then around the world toward the end of the last century. The idea that gave birth to search-engine giant Google Inc. was originally funded by the National Science Foundation, and the lithium-ion battery that powers everything from iPhones to electric cars was developed by federally sponsored materials science research at the University of Texas at Austin in the 1980s. Inquiries that began as broad questions about natural phenomenon and mathematical concepts developed into revolutionary innovations because of federal grants in past decades.

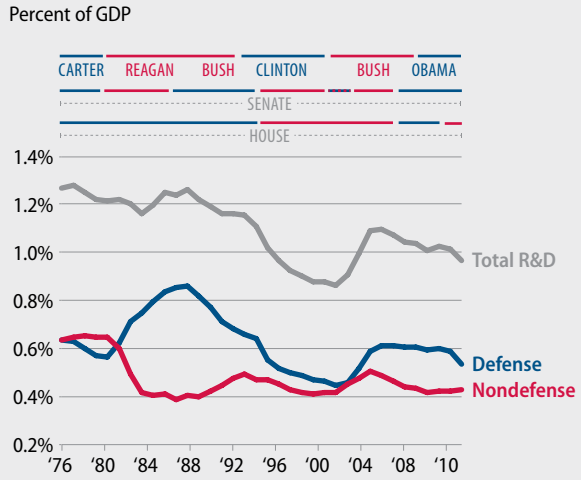
But since then our public investment levels have been dropping. In 2011, federal investment in research and development has dropped below 1 percent of GDP.

A slight bump can be seen in the late 1990s, though it does not change the overall downward trend of our investments. The temporary increase was largely due to the doubling of the budget of the National Institutes of Health as well as a substantial increase in defense R&D under the Bush administration during the Iraq War, as can be seen in Chart 4.

CHART 3

U.S. government R&D spending on a sharp decline

Trends in federal R&D budget authorities as percentage of U.S. GDP, FY1976–2011



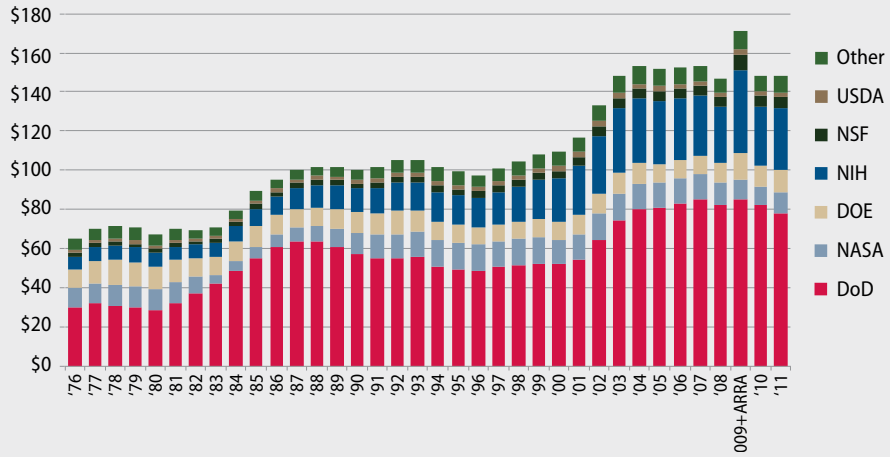
Source: American Association for the Advancement of Science, "AAAS Report XXXV: Research & Development FY 2011" (2010), available at http://www.aaas.org/spp/rd/rdreport2011/.

The doubling of the NIH budget between 1998 and the early 2000s was a bipartisan triumph that was later championed by newly elected President George W. Bush. Thanks to continued support from presidents and congresspeople of both parties, the NIH budget increase made health research a national priority and provided broad financial support to many diverse areas including the Global Fund to Fight HIV/AIDS, Malaria, and Tuberculosis, and led to the creation of new bioterrorism research facilities with the National Institute of Allergy and Infectious Diseases. In

CHART 4

How our government allocates R&D investment

Trends in agency R&D budget authority, FY1976–2011



Source: American Association for the Advancement of Science, "AAAS Report XXXV: Research & Development FY 2011" (2010), available at http://www.aaas.org/spp/rd/rdreport2011/.

his Strategy for American Innovation, President Obama calls for a doubling of the budgets of three other key science bureaus: the National Science Foundation, the National Institutes for Standards and Technology, and the Department of Energy's Office of Science. Let's hope our lawmakers can summon the same spirit of bipartisan cooperation and agree to invest in the scientific research and development that will fuel the innovations of tomorrow.

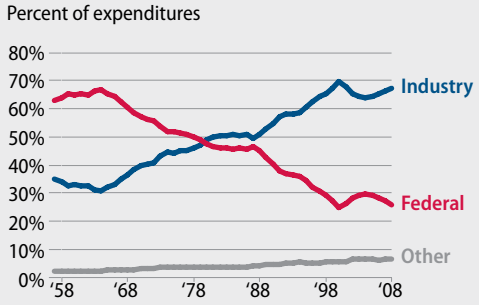
Industry research and development trends

As federal investments in research and development declined relative to growth in economic output over the past several decades, industry investments have increased to pick up some of the slack. Chart 5 shows how federal investment has decreased relative to industry investment in overall national spending on science and technology research and development. Universities, colleges, and nonprofits represented in the "other" category account for a small but rising share of R&D investment. These figures sum to 100 percent. (see Chart 5)

CHART 5

Total U.S. R&D investment by sector

Proportion of national R&D investments coming from the public, private, and non-profit sectors



Source: "National Patterns of R&D Resources: 2008," Table 5, available at http://www.nsf.gov/statistics/nsf10314/content.cfm?pub_id=4000&id=2.

Today, private industry invests nearly three times what the federal government spends on research and development. As charts 6 and 7 indicate, of the roughly $400 billion invested in research and development nationally each year, private industry accounts for nearly two-thirds, or $272 billion in today's dollars.

But these numbers are misleading. Many investing in "research and development" may not be investing in potentially new high-growth, job-creating technologies of the future with high social value, as our next series of charts detail.

The critical role of the government in bridging basic, applied, and developmental research

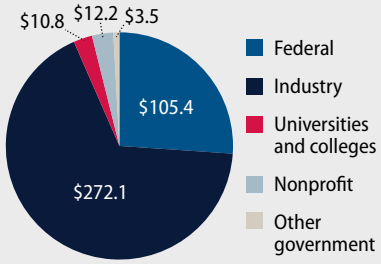
Federal investments in research and development are largely targeted toward technologies of national importance such as clean energy or life-saving medicines. (see Chart 8) In contrast, many private research-and-development dollars fund research into how to produce a better-tasting potato chip or how to formulate a slightly more fragrant soap. Federal innovation policy needs to help set incentives to draw private investment into areas of science that hold promise for future technology, goods, and services.

CHARTS 6–7

Breakdown of U.S. R&D investments by sector

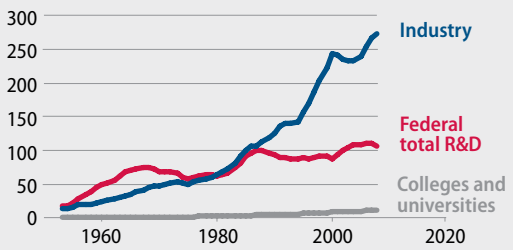
2008 R&D investments by sector

From 2008 in 2010 billions of dollars



Total U.S. R&D investment by source

Billions of 2010 constant dollars



Source: "National Patterns of R&D Resources: 2008," Table 5, available at http://www.nsf.gov/statistics/nsf10314/content.cfm?pub_id=4000&id=2.

Charts 9–12 on page 6 show how federal R&D investments play a crucial role in bridging the gap between the predominantly basic research conducted in academia and the mostly developmental research done by the private sector. The federal government needs to do more to help academia commercialize the most promising technologies with targeted programs such as the Small Business Innovation Research grants. Such programs need to be expanded in scope. But we can't lose sight of the way in which investments in basic research feed the commercialization of job-creating new technologies and businesses.

CHART 8

Where does each dollar of federal R&D investment end up?

Federal 26¢ | Industry 31¢ | Universities and colleges 34¢ | Nonprofit 9¢

Chart 8 shows where the federal government's investments in research and development go. Only about a quarter of the government's investments in R&D are spent by federal research facilities. Instead, much of it goes to universities and private companies in the form of grants.

Source: "National Patterns of R&D Resources: 2008," Table 5, available at http://www.nsf.gov/statistics/nsf10314/content.cfm?pub_id=4000&id=2.

Conclusion

Science is more than just exploration for the sake of understanding the universe. It is the critical input that drives our innovation-based economy forward. Without robust investments in research and development from basic and applied research through technology development, the pool of knowledge that fuels the innovation that drives economic growth will begin to dry up.

President Obama called for "another Sputnik moment" in science and engineering to revitalize the innovation economy, and his budget takes important steps toward realizing that goal. These investments are critical to our nation's long-term economic prosperity. Federal investments in science and technology have made possible the modern comforts we take for granted—from the Internet, to the satellites that make it mobile, to life-saving medical treatments.

And there are even more exciting and revolutionary opportunities on the horizon. Funding for stem-cell research has already helped cure at least one patient of HIV and opens the door to cures for Alzheimer's and even paralysis. Progress in synthetic biology holds the promise of cheap and effective production of chemicals—from biofuel-producing algae to good bacteria that make vaccines for human use. Research in nuclear physics could one day lead to cleaner, safer, and more reliable sources of energy. Advances in nanotechnology hold promise to help us build everything from super-effective batteries that can power the clean cars of the future to organic solar cells able to catch more of the sun's rays for a fraction of the cost.

And we don't even know what other revolutionary breakthroughs could be on the horizon. Innovation is unpredictable. But without federal support for the critical early stages of innovation that the private sector will not fund, our progress will inevitably slow.

CHARTS 9–12

Basic, applied, and developmental research investments by sector

Trends in university and college R&D investment

Billions of 2010 dollars

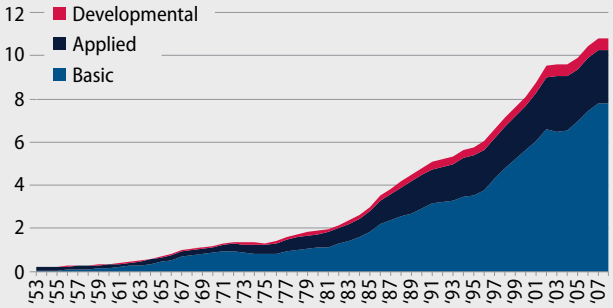


Chart 9 shows the growth of university-funded research over the years since 1953. University-funded research overwhelming focuses on basic or fundamental science. These numbers represent only those investments made by universities themselves in research, and exclude federally-funded research undertaken by universities.

Trends in federal R&D investment

Billions of 2010 dollars

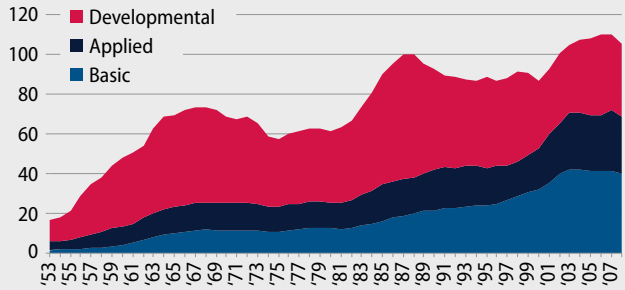


Chart 10 shows how federal research investments break down more evenly. The figures in this graph represent federally-funded basic, applied, and developmental research. Federally-funded developmental research goes pre-dominantly toward defense R&D.

Trends in private sector R&D investment

Billions of 2010 dollars

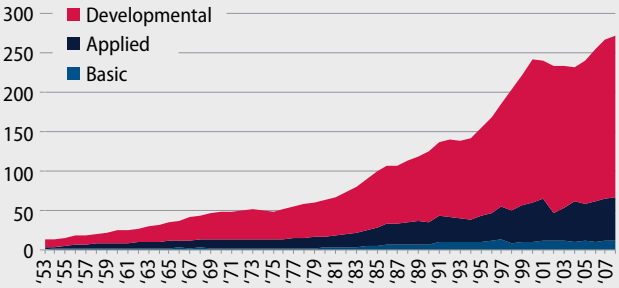


Chart 11 shows how the private sector invests heavily in later-stage, developmental research, very little in basic research. This is why federal investments in basic science are so critical. Discoveries in basic science are the first step in the innovation lifecycle that fuels are economic progress.

U.S. R&D investments by source of funds in 2008

Billions of 2010 dollars

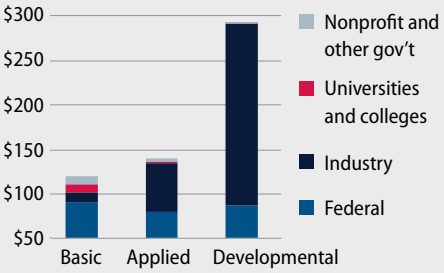


Chart 12 shows the source of funding for each of the three stages of innovation. It is clear that federal investments are critical in fueling the basic and applied research that in general are too risky for the private sector to undertake.

Note that these charts represent where the R&D investment dollars come from, not who is ultimately spending those dollars to perform the research.

Source: "National Patterns of R&D Resources: 2008," Table 5, available at http://www.nsf.gov/statistics/nsf10314/content.cfm?pub_id=4000&id=2.

Science Progress, a project of the Center for American Progress, is a magazine specifically designed to improve public understanding of science and technology and to showcase exciting, progressive ideas about the many ways in which government and citizens can leverage innovation for the common good. Since its inception in the fall of 2007, *Science Progress* has helped shape the conversation about our country's investment in science.

science progress

1333 H STREET, NW, 10TH FLOOR, WASHINGTON, DC 20005 • TEL: 202-682-1611 • FAX: 202-682-6140 • WWW.SCIENCEPROGRESS.ORG