Ambitious, Achievable, and Sustainable: A Blueprint for Reclaiming American Research Leadership

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January 23, 2020

DAY ONE PROJECT
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Summary

The next administration should accelerate federal basic and applied research investments to return funding to its historical average as a share of GDP over a period of five years. While this ambitious yet achievable strategy should encompass the entire research portfolio, it should particularly seek to reverse the long-term erosion of collective investments in physical and computer science, mathematics, and engineering to lay the foundation for U.S. competitiveness deep into the 21st century.

1. Opportunity

Investments in research are crucial for achieving the breakthroughs that drive future American economic growth and national security. Economists who study the process of innovation and technological change—which critically draws on the fruits of R&D, including federal research—have characterized innovation as the primary driver of productivity growth, which in turn is almost entirely responsible for long-run economic growth.[1]

Federal research funding plays an important role in this process, underpinning modern breakthroughs integral in everything from pharmaceuticals to smartphones.[2] In fact, a recent analysis found that roughly 30% of all U.S. patents issued by the Patent and Trademark Office now rely on federal research funding in some fashion, more than double 1970s levels.[3] In addition, federal research is vital for the work of the federal government in virtually every public mission: understanding and responding to emerging natural and manmade threats, treating diseases, ensuring safe and productive agriculture, caring for our veterans, ensuring safe and efficient infrastructure, expanding human knowledge, and more.

Yet despite everything we know about the importance of research and innovation, in recent decades the federal government has barely tread water regarding research intensity—defined as government-funded basic and applied research as a percentage of gross domestic product (GDP)—with periods of sharp decline offsetting those few periods of growth. Indeed, relative to the size of the economy, federal research dollars are more than 30% below their Apollo program-era peak, according to National Center for Science and Engineering Statistics (NCSES) data.[4] These trends are troubling given

[1] *See*, for instance, Michael J. Boskin and Lawrence J. Lau, "Generalized Solow-Neutral Technical Progress and Postwar Economic Growth," NBER Working Paper No. 8023 (December 2000).
[2] For several examples, *see* Peter Singer, *Federally Supported Innovations*, MIT Washington Office (January 2014).
[3] Lee Fleming, *et al.* "Government-funded research increasingly fuels innovation", *Science* 364, no. 6446 (June 2019): 1139–1141.
[4] Calculations based on the "National Patterns of R&D Resources" data series, available at https://www.nsf.gov/statistics/natlpatterns/.

that "research intensity" is an important gauge of the innovation potential created across an entire economy.

While private investment dominates the later developmental stages of the R&D and innovation pipeline, government tends to fund riskier research that industry often will not, which can in turn lead to more innovative or disruptive technology.[5] This is because the incentives for private investment are often too weak, as economic theory suggests. Many research inquiries—pursued with government support at national labs, academic institutions, and elsewhere—produce knowledge that is too far removed from market applications for industry to invest significant resources, or is most relevant for societal needs where a robust commercial market may never develop. The knowledge produced by scientific research may have applications across multiple industries—beyond the scope of any one firm's reach—and the fruits of such research may not be apparent until after years of effort. In addition, economists have zeroed in on the effect of so-called knowledge "spillovers" in limiting private R&D investment: a single firm will be unable to capture the full benefits of its research because competing firms will quickly appropriate them. As a result of uncertainty, long time frames, and spillovers, firms invest less in research than would be optimal from a societal perspective.

Thus, rather than substituting for private investment, as some claim, public research investment often "crowds in" private investment, prompting industry to invest additional R&D than they may have otherwise, and leading to increased knowledge output in the form of projects, patents, and technologies.[6] Much federal research activity takes place in fields of relative novelty where industry may not be investing, but in which the impacts can be technologically far-reaching.[7] And even those fields in which industry is investing in R&D can see a technology acceleration from federal investment and partnership. For instance, the field of quantum computing receives substantial industry attention, but still contains great uncertainty regarding technical and commercial feasibility, and will likely require significant government research investment over years to develop and evolve the technology, especially if the United States is to maintain its leadership in the field.[8] As another example, the Government Accountability Office has found that even venture capitalists—investors with a particularly high appetite for risk—are unwilling to fund the

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[5] Russell J. Funk and Jason Owen-Smith, "A Dynamic Network Measure of Technological Change" *Management Science* 63, no. 3 (March 2016): 791–817.
[6] Organisation for Economic Cooperation and Development (OECD), *Government R&D Funding and Company Behaviour: Measuring Behavioural Additionality* (2006).
[7] Rafael A. Corredoira, Brent D. Goldfarb, and Yuan Shi, "Federal funding and the rate and direction of inventive activity." *Research Policy* 47, no. 9 (November 2018): 1777–1800.
[8] National Academies of Sciences, Engineering, and Medicine, *Quantum Computing: Progress and Prospects*, Washington, DC: The National Academies Press (2019).

kinds of high-risk energy research projects funded by government.[9] In such sectors, government funding can be foundational for the subsequent private investment that readies new breakthroughs for the marketplace and, ultimately, for societal benefit.

The federal government fills the resulting gap by funding a range of research activities, spanning everything from fundamental, curiosity-driven research as a driver of serendipitous advances to applied research as a generator of use-oriented knowledge, as well as substantial investment in development for military technology and other government purposes. These investments have yielded impressive historical results, laying the scientific groundwork for genetically improved corn, MRI machines, LED lighting, solar photovoltaics, and many other technologies.

And in the current environment the United States can hardly afford to be complacent, with competitor nations dramatically increasing their investment in R&D. Much of this activity is focused on strategic initiatives designed to capture the lead in key industries of the future, from artificial intelligence and machine learning to biotechnology.[10] These efforts are predicated on the recognition that, even in a globalized economy, the location of research has important domestic economic implications. For instance, surveys suggest that major factors influencing corporate decisions to locate R&D sites and other industrial facilities include access to highly skilled R&D personnel and university collaborations—even more than tax breaks.[11] Not only do clusters of research strength attract and sustain relevant industrial sectors, but so-called "brain hubs" are key sources of economic advantage and job creation in the 21st century. That's because high-tech, highly innovative sectors have a much higher employment multiplier than other sectors.[12]

Taken together, these considerations mean that the federal government is currently at greater risk of spending too little on research than too much. For instance, in recent years grant application funding rates at the National Science Foundation and the National Institutes of Health have been 25% below the rates of two decades ago, meaning much worthy research goes unfunded.[13] On the other hand, an extraordinary array of new capabilities await in fields as diverse as quantum science, synthetic biology, ecology, space exploration, cybersecurity, robotics, and other areas—with the proper investments

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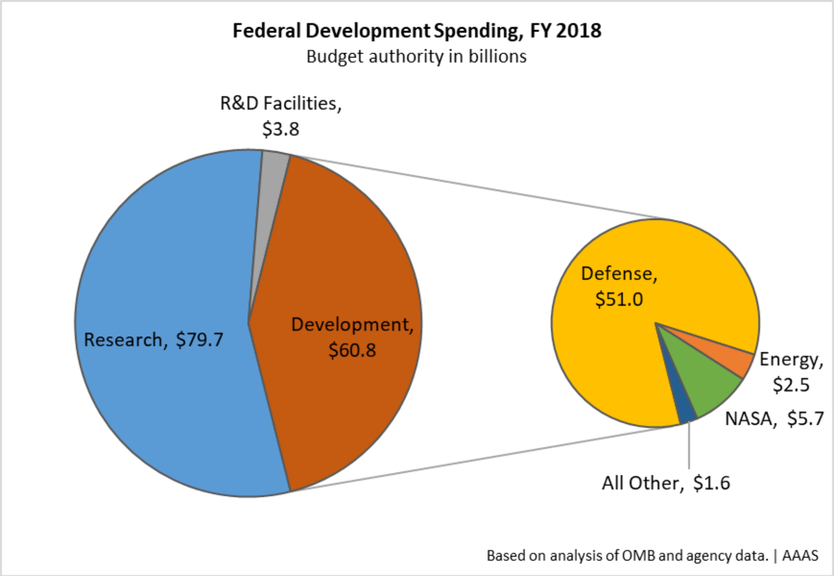
[9] Government Accountability Office, *Department of Energy: Advanced Research Projects Agency-Energy Could Improve Its Collection of Information from Applications*, GAO-12-407T (2012).
[10] Task Force on American Innovation, *Second Place America? Increasing Challenges to U.S. Scientific Leadership* (2019).
[11] Jerry Thursby and Marie Thursby, *Here or There? A Survey of Factors in Multinational R&D Location* Report to the Government-University-Industry Research Roundtable, Washington, DC: National Academies Press (2006).
[12] Enrico Moretti, *The New Geography of Jobs*, Mariner Books (2012).
[13] For NSF data, see historical budget requests available at https://www.nsf.gov/about/budget/ as well as the "Report to the National Science Board on the National Science Foundation's Merit Review System—Fiscal Year 1998" available at https://www.nsf.gov/nsb/documents/1999/nsb9928/98meritrpt.htm. For NIH data, see the NIH Databook available at https://report.nih.gov/nihdatabook/.

in research.[14] Increased investments could also do quite a bit to enhance the national welfare overall: economists estimate that the socially optimal level of combined public and private R&D investment in the United States may be two to four times actual investment, even with a conservative estimate of the impact of spillovers.[15] It is worth underscoring the implications of this conclusion: the federal government could significantly boost research investment—along with an increase in industry-performed R&D—without overspending.

In summary, research funding is an under-appreciated policy tool with the power to fuel productivity growth, win a share of industries of the future, and tackle key societal challenges—yet the federal government should be doing much more. What follows is an ambitious plan for how the federal government can embark on a path to address this challenge.

1.1 Why focus on "research" but not "development"?

Focusing on basic and applied research most directly addresses the goal of driving innovation and seeding next-generation technology. The core function of *research* is to create knowledge, either by studying physical phenomena or its potential applications. On the other hand, federal *development* activities are less about experimentation and knowledge creation and more about bringing maturing, nearer-term technology into federal use—activity that is less certain to generate societally beneficial spillovers.



[14] MIT's *Future Postponed* report series, http://www.futurepostponed.org/
[15] Jones, C. and J. Williams (1998) 'Measuring the Social Rate of Return to R&D', Quarterly Journal of Economics, 113(4): 119-35.

Of a $61.0 billion development budget in FY 2018, the Department of Defense funded 83.6%; NASA funded 9.6%; and the Department of Energy funded 4.2%, mostly via the National Nuclear Security Administration (NNSA), with the remaining 2.6% spread across several other agencies (see chart). These activities are generally for mission-driven, big-ticket technology acquisition tailored to a government use, often without a corresponding private market. For instance, most NNSA development spending is for naval nuclear propulsion, while most DOD spending is for validation and field-testing of new systems as they approach full rate production.

Funding decisions in these line items are driven less by enhancing long-term national capacity in science and innovation, and more by specific nearer-term mission needs: better naval reactors, space exploration capacity, or near-term defense superiority. And not only is the funding concentrated within DOD, but universities and government labs are mostly excluded from these funds, with the potential for societally beneficial spillovers correspondingly attenuated.

Focusing on research, on the other hand, ensures involvement of all parts of the national innovation ecosystem (universities, major industrial firms, startups and spinoffs, and national labs), and allows for greater odds of knowledge spillovers. Even in the defense space, research is what creates a technology base that offers revolutionary dual-use capability while also ensuring technological superiority of the future force, by identifying the scientific or engineering principles that underly both civilian *and* defense purposes. Indeed, analyses suggest there are obstacles to parallel innovation for civil and defense technology once systems have reached the latter developmental stages, partly because by that point DOD is dealing with *systems* rather than simply *components*. Factors related to export controls, classification, industrial production, and especially the cost/performance tradeoff all contribute to what has been called "segregation" of military and commercial development.[16] This segregation can even occur *within* large firms, with levels of separation between military endeavors and other R&D activities.

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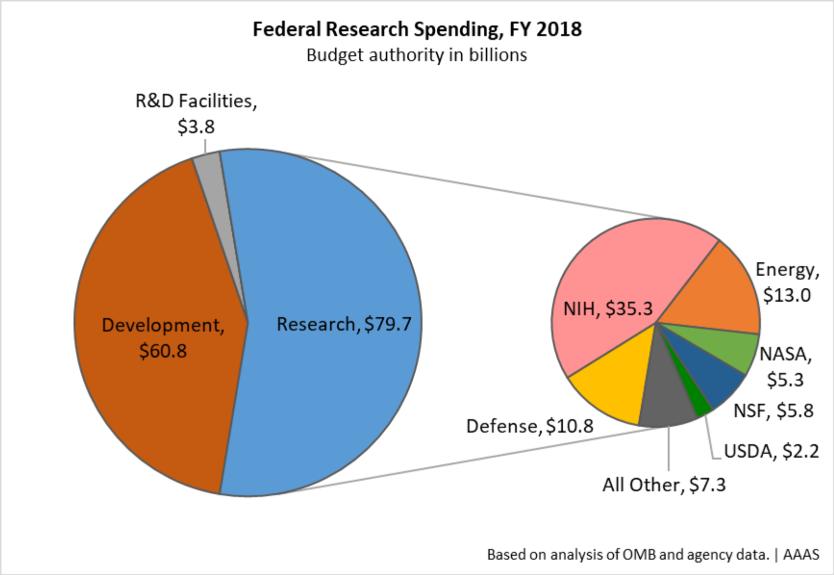
[16] John A. Alic, *et al.*, *Beyond Spinoff: Military and Commercial Technologies in a Changing World*, Boston, MA: Harvard Business Publishing (1992).



There is a broader rationale here as well. Over many years, industrial R&D has been increasingly focused on development, including for reasons suggested by economic theory: development activities focus on technology that is closer to market under a shorter time horizon, and thus with less risk. One recent analysis found a steady, long-term decline in scientific publications by company scientists, and that financial valuation of scientific capability among firms has also declined.[17] And another analysis has found that industrial research expenditures are more sensitive to firms' operating liquidity relative to development, meaning when internal financing is constrained, research may be the first to go.[18] Surprisingly, there appears to be little if any statistical relationship between a firm's research investment and its stock market valuation.[19] The fact that industry tends toward development activities further highlights a particular role for federal research dollars.

Amid weaker-than-expected private investment following tax reform,[20] and a growing chorus of concern over whether companies are holding up their end of the bargain, it is worth underscoring that additional federal research investment tends to spur complementary industry R&D activities, offering a foundation and a catalyst for additional industry spending.[21]

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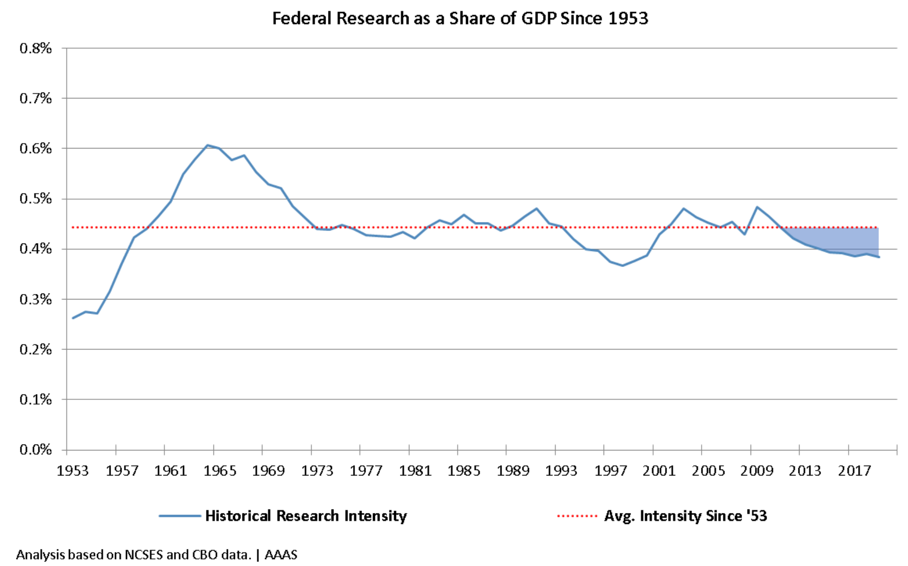
[17] Ashish Arora, Sharon Belenzon, and Andrea Patacconi, *Killing the Golden Goose? The Decline of Science in Corporate R&D*, NBER Working Paper 20902 (January 2015).
[18] Czarnitzki, D; Hottenrott, H; and Thorwarth, S (2011) "Industrial research versus development investment: the implications of financial constraints." Cambridge Journal of Economics: 35 (3), 527-544, https://doi.org/10.1093/cje/beq038
[19] Markovitch, D; O'Connor, G; and Harper, P (2017) "Beyond invention: the additive impact of incubation capabilities to firm value." *R&D Management* 47 (3): 352-367.
[20] Cassidy, J, "A Decline in Capital Investment Reveals the False Promise of Trump's Tax Bill." *The New Yorker.* July 30, 2019. https://www.newyorker.com/news/our-columnists/a-decline-in-capital-investment-reveals-the-false-promise-of-trumps-tax-bill
[21] For a summary, see Hourihan, Matt, "If Government Scales Back Technology Research, Should We Expect Industry to Step In?" AAAS, Oct 17 2017, available at https://www.aaas.org/news/new-brief-could-industry-fill-gaps-following-federal-rd-cuts

2. Proposed action

2.1 How much to spend?

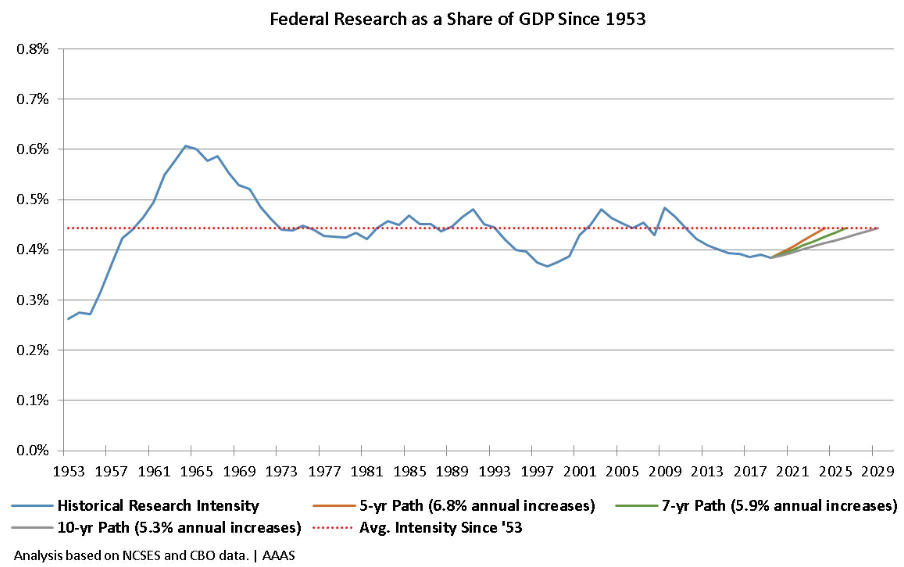
Since 1953 (the earliest year for which data is available), the average GDP intensity for federal research dollars—*i.e.*, the percentage of GDP allocated to federal research—has been 0.44%, as indicated by the red line in the below graph. This period has been marked by substantial swings punctuated by stretches of relative stability. But federal research spending as a share of GDP was last at the historical average in 2011 (see shaded area).



The first modest funding goal for the next presidential term should be to remedy this shortfall. While the historical average represents no magic number, it is nonetheless an important marker: a spending level that is achievable—we've managed to reach it fairly recently—yet significantly more than current spending. Re-attaining this spending level is a way to correct what amounts to an innovation deficit (shaded blue in the above graph).

The graph below illustrates some options for achieving this goal. Beginning with a conservative estimate of federal research in 2019, and GDP projections from the Congressional Budget Office, we lay out trajectories for returning federal research dollars to the average post-1953 GDP intensity in five years, seven years, and ten years.

Our estimates suggest meeting our target in five years would require annual increases of 6.8%, which would allow the research budget to rise from an estimated $82 billion in 2019 to nearly $115 billion in 2024, before inflation. We believe such a goal is also achievable, reasonable, appropriate, and fiscally responsible, and should be a major fiscal priority for the next term. This is for a few reasons.



First, over the past 40 years, federal research dollars have grown by 4.9% on average before inflation, according to NCSES data. More recent Congressional research appropriations have been extremely inconsistent, however, with stagnation, steep cuts, or sequestration in some years and strong growth in others. This deviation from historical norms coupled with steady GDP growth is what has knocked federal research dollars off track. An annual growth target of 6.8% thus means asking Congress to return to their historical norms, and then do a bit more than what they have been doing since the Carter administration anyway.

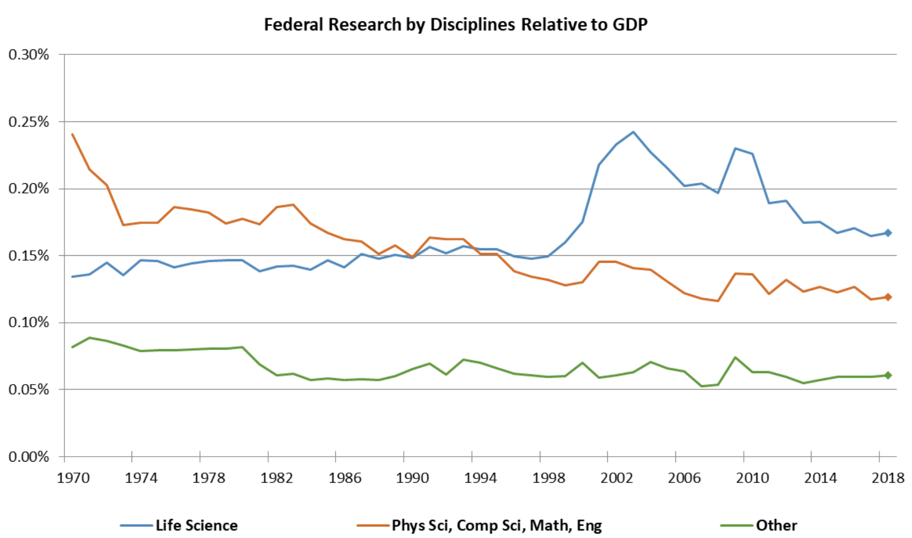
This target also allows research agencies to grow in real, sustained terms above the rate of inflation, which has long been a goal for many science advocates. It allows agencies to sustain the important work they're already doing *and* increase investments in areas of strategic or emerging interest, or to explore new research areas or funding models. Recent evidence also suggests that an incremental approach may increase the likelihood that agencies can support new primary investigators, tapping into new perspectives and insights and broadening the talent pool.[22] And because this approach is more likely to be sustainable, it avoids some of the downsides of more rapid funding growth as seen with the NIH doubling from 1998 to 2003, which eventually led to overbuilding and inflation of the research ecosystem, followed by a collapse in funding rates and hardship for young researchers when the large annual increases became unsustainable.

[22] Martin D. Sorin and Randall J. Hannum, "Which extramural scientists were funded by the US National Institutes of Health from its ARRA funds?", *Science and Public Policy* 41, no. 1 (June 2013): 58–75.

Our recommended approach is both modest and phased, designed to be implemented and sustained at a time when the underlying structural dynamics for federal spending are stark: mandatory spending and interest payments on the debt will continue to take up a greater share of the federal budget, and discretionary dollars (for research or anything else) will likely become increasingly scarce. These broader fiscal constraints contributed to the ultimate failure of previous efforts to double federal research dollars under the George W. Bush administration (through America COMPETES) and the Obama administration.

3. A balanced portfolio for competitiveness: allocating among disciplines

There is another component to this proposal. Over many years, Congress has prioritized life sciences research in annual appropriations, for good reason, but has simultaneously allowed the physical sciences and engineering (PS&E) —a broad category including chemistry, physics, math and computer science, materials research, and other disciplines—to stagnate (see graph below). Some disciplines within this category like mathematics and computer science have been on the rise, but they remain small relative to the life sciences, and growth in these few has not offset the relative decline in the physical sciences and engineering overall. As competitor nations increasingly make highly strategic investments in priority disciplines, the time has come for the federal government to pursue a more balanced portfolio to better compete.



Analysis based on NCSES (*National Patterns* and *Federal Funds* series) and CBO data.

The stagnation of federal funding for physical science and engineering is problematic because of the integral role they play in several critical industrial sectors like semiconductors, computing, electronics, chemicals, aerospace, artificial intelligence, machinery, and others, according to polls of corporate R&D managers.[23] Patent and citation data also illustrate the relative importance of these disciplines to industrial innovation: of the scientific publications cited in the nearly 70,000 patents issued by USPTO in 2016, biological and medical publications accounted for 58%, but the physical sciences and engineering account for nearly all of the remainder.[24] There is robust evidence of the interaction between industrial and university research endeavors, which can include formal partnerships and joint research activities, licensing, new firm creation, or the movement of talent. And ensuring robust support for the *physical* sciences now has relevance for the *life* sciences given the increasing focus on convergence research, which finds productive endeavor at the boundaries of traditional disciplines.[25]

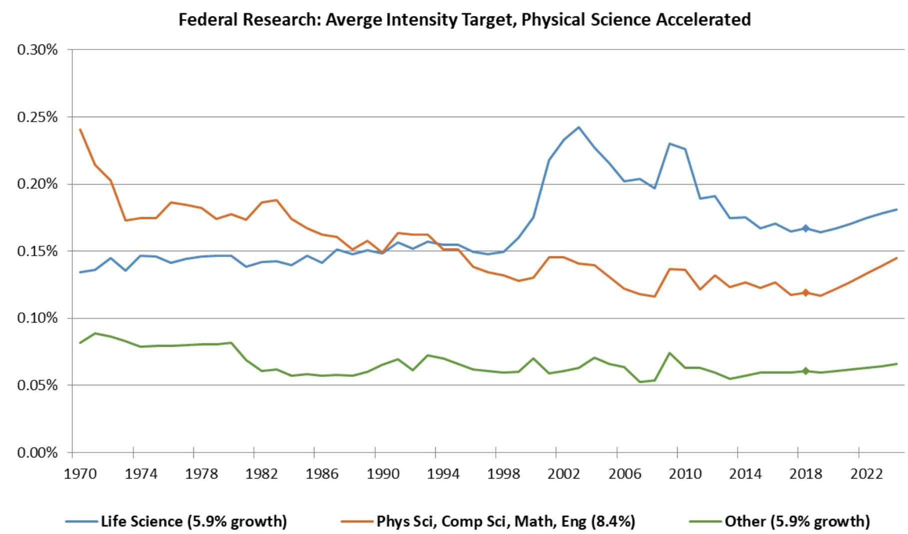
Meanwhile, other countries—particularly China—have pushed forward in these sectors and disciplines, making them central to their national competitiveness strategies. In some instances, this has come at the expense of U.S. leadership. For example, China surpassed the United States in the number of physics publications in the scientific literature in 2012; in mathematics publications, in 2013; and in chemistry publications, in 2006. The US share of all global publications in the physical sciences and engineering dropped from 22.8% in 2003 to only 12.8% by 2016, according to NSF data. And in the past few decades, the US share of triadic patenting activities has eroded in an array of relevant fields including advanced materials, information and communications technologies, and semiconductors.[26]

So how might government boost physical science and engineering research without sacrificing other investments? In the context of a growing research portfolio, we recommend modestly increasing emphasis on the physical sciences and engineering to enable catch-up, while still allowing robust growth in other research including the life sciences.

What might this look like? In 2017, physical science and engineering (including math and computer science) accounted for 34.4% of the federal research portfolio, according to NCSES data. A modest preferential strategy might be to get them to 37% of the portfolio in five years. Within the context of overall portfolio increases of 6.8% annually, physical

[23] Wesley M. Cohen, Richard R. Nelson, and John P. Walsh, "Links and Impacts: The Influence of Public Research on Industrial R&D" *Management Science* 48, no. 1 (2002): 1–23.
[24] National Center for Science and Engineering Statistics, "Science & Engineering Indicators 2018: Chapter 8—Invention, Knowledge Transfer, and Innovation", National Science Board, National Science Foundnation, 2018, https://www.nsf.gov/statistics/2018/nsb20181/report/sections/invention-knowledge-transfer-and-innovation/knowledge-transfer#sources-of-economically-valuable-knowledge.
[25] National Research Council, *Convergence: Facilitating Transdisciplinary Integration of Life Sciences, Physical Sciences, Engineering and Beyond*, National Academies of Science, Engineering, and Medicine, Washignton, DC: National Academies Press (2014).
[26] Task Force on American Innovation, *Second Place America?*

science and engineering research expenditures would have to receive increases of 8.4%, while life sciences should receive increases of 5.9% (which would mean, for instance, increases of at least $2.3 billion for NIH each year).



Analysis based on NCSES (*National Patterns* and *Federal Funds* series) and CBO data.

As can be seen above, this trajectory would not actually supplant life sciences as the primary discipline within the federal research portfolio. But it would allow some physical science catch-up, while still enabling strong and sustained growth elsewhere.

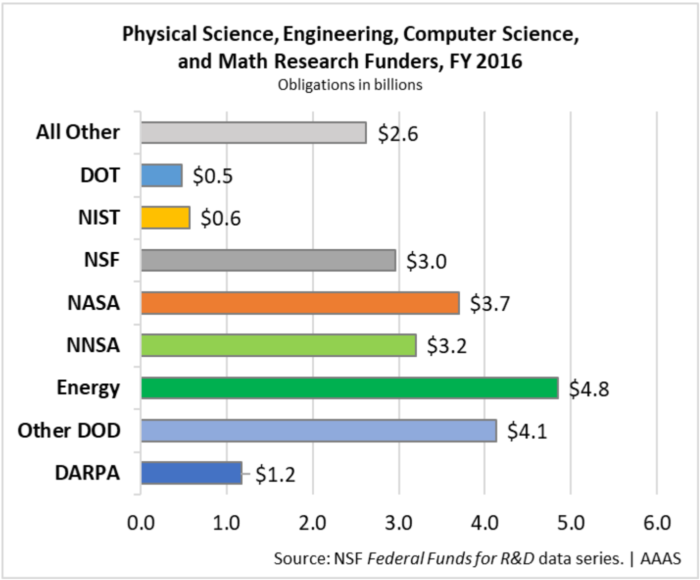
4. Implementation

As with other spending priorities, the incoming president should highlight these investment priorities as a cornerstone of economic policy, reflected in rhetoric in key moments such as the initial joint address to Congress. In practical terms, these overarching goals should be included as part of the guidance flowing down from the OMB Director to the agencies, and to OMB's Resource Management Offices, to ensure they are reflected in budget formulation from the start. Working hand in hand with the White House Office of Science and Technology Policy, OMB staff should work to ensure these targets are met during fall review, with an eye to the entire portfolio in addition to specific agency-relevant decisions. Congress ultimately has the power of the purse, but research funding should be treated as a critical element of the White House's public and legislative strategy on budget matters.

We have presented big-picture targets, but how best to operationalize these investments agency-by-agency is a choice for OMB and for the agencies themselves. There may be compelling reasons to vary the allocation for some agencies; the goal is to allow the overall portfolio to grow in the ways we've outlined. A review of some of the major research programs are below.

4.1 Physical science and engineering agencies and programs.

The agencies shown in the graph below are the major funders with a focus on the physical sciences, engineering, mathematics, and computer science, though many also



fund research in other disciplines like the life and environmental sciences. Possible targets for extra increases to allow physical science catch-up could include:

- **The National Science Foundation**, the #2 university research funder overall behind NIH and #1 in physical science research. NSF has a hand—or a leadership role—in several far-reaching federal research efforts including quantum science, advanced manufacturing, nanotechnology, and others, and supports an array of noted programs like the Engineering Research Centers and I-Corps, which connects scientists and engineers with entrepreneurs.
- **The Department of Energy**, which funds Nobel-winning basic research programs in physics, materials, chemistry, advanced computing, and many other topics, as well as applied research across energy technology realms and by a diverse array of performers including national labs. It also maintains extensive user facilities that provide academic, government, and industry partners with cutting-edge research tools. Other innovative programs include the Energy Innovation Hubs, the Energy Frontier Research Centers, and ARPA-E.
- **The Department of Defense, including DARPA.** There is a clear national security rationale for increasing intramural and extramural research funding here, as it lays

the groundwork for transformational technology and future military superiority. This fact is what prompted the 2001 Quadrennial Defense Review to recommend that DOD set its science and technology funding (which includes experimental development, as well as basic and applied research) at 3% of the department's overall budget. But science and technology funding has not kept up, and as of FY 2019 stood at 2.3% of DOD's budget, including overseas military operation funding. However, as it turns out, if DOD's budget grows at the rate of inflation over the next five years, the 8.4% annual growth rate we recommend for physical science funders is about what it would take for defense science and technology to catch up and reach that 3% target out of DOD's budget overall.

- **The National Institute of Standards and Technology.** While a relatively small agency, the NIST research budget is wholly focused on advanced physical science and engineering, which is why its lab programs were tabbed for budget doubling in the original America COMPETES Act, alongside NSF and the Office of Science at DOE. NIST has a long track record of economically-relevant research: for instance, NIST organized the first federal workshop on quantum computing in 1994.
- **The Department of Transportation**. DOT administers a research budget roughly as large as NIST's, with a particular focus on engineering research to tackle infrastructure challenges related to safety, reliability, and transformational technologies like autonomous vehicles. Major programs include the University Transportation Centers and the NextGen air traffic modernization initiative, among others.
- **NASA** is unsurprisingly a major funder of aeronautical and astronautical research, along with other disciplines. The scale and scope of NASA spinoff technologies over the years is oft-noted, and NASA continues to play varied roles in deep space exploration and discovery, earth observation, commercial space, and aeronautical innovation.

4.2 Advancing progress in the life sciences for improved health.

Public health science has long been a Congressional priority, particularly by supporting the National Institutes of Health. Analyses have suggested a correlation between long-term NIH funding and declining mortality from stroke, cancer, and other illnesses, as well as increased industry research investments, production of new drugs, and increased pharmaceutical patenting.[27–29] Congress also has supported Department of Veterans Affairs funding of research on an array of topics relevant to the well-being of American veterans, including through the nationwide Million Veteran Program. VA investigators also perform research funded by other agencies, including NIH and the Centers for Disease Control and Prevention.

4.3 Ensuring a safe and productive food supply

The U.S. Department of Agriculture boasts a $2 billion research enterprise with a *very* long history of returns on research investment in terms of agricultural productivity.[30] USDA programs establish a knowledge foundation to address food and livestock production, nutrition and human health, agricultural disease prevention, environmental stewardship, and other topics, as well as data collection and analysis. The department funds capacity programs in all 50 states, competitive grants, and will soon take full stewardship of the new National Bio and Agro-defense Facility.

4.4 Promoting conservation, stewardship, and responsible use of natural resources

Understanding the nation's natural resource base is perhaps the oldest government research function dating back to Lewis & Clark, and the establishment of the U.S. Geological Survey, the Weather Bureau (now part of the National Oceanic and Atmospheric Administration, or NOAA, as the Weather Service), and other offices in the 19th century. These and other agencies monitor natural hazards, characterize land- and sea-based natural resources for use or preservation, and seek to understand the drivers and impacts of climate change from the global to the local scale. Their research endeavors often lead to environmental technologies available for licensing and industrial use.

4.5 Protecting our borders, our citizens, and our critical infrastructure

Ensuring the security and resilience of critical infrastructure—including communications, power, transportation, water, and information technology—is of increasing importance to the nation, including research that leads to new technologies and capabilities. Much of this work falls to Department of Homeland Security components like the Science & Technology Directorate and the Countering Weapons of Mass Destruction Office. Several other agencies also have a hand in research for domestic security, including the

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[27] Kenneth G. Manton, *et al.* "NIH funding trajectories and their correlations with US health dynamics from 1950 to 2004", *Proceedings of the National Academy of Sciences* 106, no. 27 (2009): 10981–10986.
[28] Andrew A. Toole, "Does public scientific research complement private investment in research and development in the pharmaceutical industry?", *The Journal of Law & Economics* 50, no. 1 (2007): 81–104.
[29] Andrew A. Toole, "The impact of public basic research on industrial innovation: Evidence from the pharmaceutical industry, *Research Policy* 41, no. 1 (2012): 1–12.
[30] Ammon J. Salter and Ben R. Martin, "The economic benefits of publicly funded basic research: a critical review", *Research Policy* 30, no. 3 (2001): 509–532.

newly formed Office of Cybersecurity, Energy Security, and Emergency Response in the Department of Energy.

5. Conclusion

Federal research investment is a potent policy tool, one that can drive the breakthroughs that enhance modern life while fueling the productivity that is responsible for economic growth. Yet even as our economic competitors race to grow their R&D investments, the United States has allowed the intensity of its research spending to stagnate. The next presidential term offers an opportunity to correct this trend by embarking on an ambitious but achievable path to accelerate federal basic and applied research investments to return funding to its historical average as a share of GDP over a period of five years of sustainable growth. While this strategy should encompass the entire research portfolio, it should particularly seek to reverse the long-term erosion of investments in physical and computer science, mathematics, and engineering to lay the foundation for U.S. competitiveness deep into the 21st century.

About the authors

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About the Day One Project

The Day One Project is dedicated to democratizing the policymaking process by working with new and expert voices across the science and technology community, helping to develop actionable policies that can improve the lives of all Americans, and readying them for Day One of a future presidential term. For more about the Day One Project, visit dayoneproject.org.