

Science Policy From the Ground Up

It's time to modernize the federal role in the nation's increasingly decentralized R&D ecosystem and unleash innovation at the local level.

The United States' system for federal support of scientific research and development emerged in the 1950s. Driven by the goal of building domestic STEM capability for meeting modern society's needs, the nation quickly established itself as the dominant force in R&D globally. By the 1960s, US funding, which was largely dispensed by the federal government, accounted for an astonishing 69% of global R&D expenditures, and American scientists ranked among the most prominent in the world.

Seventy years later, the global landscape has changed, reducing the primacy of the US R&D enterprise. In response, policymakers and influential thought leaders, alarmed that the nation has fallen behind, seek to shore up US leadership in R&D by increasing funding to federal science agencies while expanding their mission areas, leaving their core operational models intact. This approach, however, fails to account for a key development that is shaping R&D in the twenty-first century.

The American R&D ecosystem has become dramatically decentralized. The federal government now supports less than 22% of domestic R&D spending—and an even smaller fraction of the global total. Today, the country's innovation system is as vibrant as ever, but federal preeminence has changed. While the government remains a critical player, it is less dominant than it once was: federal agencies now support less than 50% of basic science funding, with the balance coming from business, philanthropy, and academic endowments, as well as state

and local governments. This innovation system may appear messy and chaotic when compared to those of nations with top-down approaches to managing R&D—but it is also extraordinarily productive. At its best, this decentralized system incentivizes individuals and organizations to compete not only for the best ideas, but also the best solutions that the market will support.

Despite these shifts in the innovation landscape, federal science agencies still operate in a highly centralized manner. Decisions about which research areas to prioritize and which projects merit funding are made by program managers in Washington, DC, who inevitably apply a highly nationalized lens. Because most applications of scientific and technical knowledge require some localization to specific circumstances within a given community, this centralized approach favors research that is abstract and theoretical in nature. As a result, federally supported science has been less effective than it could be at helping American communities deal with long-standing and emerging goals and concerns, including clean water and sanitation for both rural and urban areas, increasingly severe drought and flooding, wildfires, crumbling infrastructure, increases in preventable chronic diseases, and the opioid addiction epidemic, among others.

To become the steward of a domestic R&D enterprise aimed at meeting the needs of the 21st century, the federal government must fundamentally re-envision its role, embracing the reality of the United States' decentralized innovation system and taking on an updated

set of responsibilities. In addition to cultivating the development of cutting-edge scientific knowledge, it is time for the government to ensure the translation of that knowledge into solutions for local and regional problems prioritized by communities across America. This means adopting a more inclusive, bottom-up approach to selecting which questions get researched, as well as partnering to provide more regional funding and infrastructure for local innovation across the country. Making this shift will reinvigorate America's domestic capacity for innovation and unleash our talents to regain global competitiveness while improving the quality of life for people here at home.

Embrace the chaos

Under the current system, even when the federal government decides to tackle socially relevant issues, it often lacks the processes to account for the local and regional aspects of national problems, limiting the direct applicability of research output. For example, while rural water sanitation problems plague multiple US communities, questions of target microbes, priority climate zones, and infrastructure solutions will be highly localized. Similarly, while the subject of climate change is high on the list of federal science priorities, myriad related concrete local problems badly need to be addressed today: wildfire control in California, rural sanitation challenges in Alabama, flood control in areas as diverse as New York City and Louisiana, drought-tolerant agriculture in Arizona, and sustainable fishing as habitat zones change in the Northeast.

The very mechanics of our centralized system pose significant barriers to exploring regionally important research questions, even when they're part of research priority areas such as climate resilience. Although some policy and advisory processes incorporate broad input when setting priority research areas at the top level, decisions about which specific research topics and questions get detailed in funding solicitations typically lie with a small number of federal program managers. Despite their best intentions, these national decisionmakers are ill-equipped to answer, and unlikely to articulate, highly localized questions on their own.

Meanwhile, an opportunity to connect Americans with our domestic research enterprise is being overlooked. If we want nonscientists to understand the value of federally supported R&D, they need to see it in their communities; they need to know it can and will be brought to bear on the problems that matter to them; and they need to know the scientists and engineers who are developing these solutions in order to trust the outcomes. We have models to draw from, most notably the US Department of Agriculture Cooperative Extension

System, created in 1914 to help farmers, ranchers, and rural communities solve problems, leverage knowledge and technology, and create resilience. Although we still celebrate this program, we haven't modernized the model or extended it to other communities and scientists, and we are missing an opportunity to engage today's landscape of potential funders to support such local efforts.

To accomplish this, the federal government should leverage its unique power to convene, gathering diverse groups of people and organizations to work together to articulate, understand, prioritize, and support a broader range of questions and problems. By bringing states, localities, universities, national labs and other research institutions, industry, and philanthropy together, the government can move beyond simply funding research, to amplifying the impact of dollars spent by all the stakeholders. Through outreach and a new emphasis on engaging and convening a broad spectrum of Americans, the major science funding agencies can help build bridges between diverse stakeholders, empowering them to solve problems together; and they can help communities develop and sustain the talent and infrastructure needed to continue meeting new challenges over time. We applaud the National Science Foundation (NSF) for introducing such efforts, and we'd like to see them expanded, amplified, and implemented across the science funding agencies.

Beyond profits and prestige

We want to be clear that we are not advocating to end federal support for foundational scientific research. Instead, we are calling for an additional focus to bring basic scientific results to life across the country by applying them to real-world problems. Currently, the US R&D ecosystem is largely driven by two goals: profits and prestige. The former motivates industry, which measures success in earnings and shareholder returns. The latter fuels academia, which counts success by publications in high-impact journals and federal grants. What are the incentives for innovating solutions to local and regional problems without clear profit or prestige drivers?

Even when institutions try to prioritize real-world outcomes, as often seen with philanthropic funders of research, they still find an R&D landscape optimized for different incentives. Those incentives matter. Making research applicable to real-world problems takes time, people, and resources. And to do it effectively, we must recognize the difference between invention—developing a new idea published in a high-impact journal or protected with a patent—and innovation—taking an idea and applying it in novel ways to solve problems. Many of the incentives in academia favor invention and assume the next steps of applying those ideas and inventions to real-world innovations will be driven by other actors who are motivated by different incentives.

When the right incentives exist, the United States innovates extremely well—even if it doesn’t always look nice on a flow chart. Consider, for example, the story of Apple’s voice assistant, Siri. This technology was invented as part of research funded by the Defense Advanced Research Projects Agency (DARPA) and conducted at the nonprofit research institution SRI in the mid-2000s. The technology was then spun out and commercialized by a private company that was acquired by Apple in 2010. In other words, federal R&D funding for defense supported invention of a technology by a nonprofit research center, which was then developed by a for-profit start-up company that was then purchased by a large company, which later contracted with multiple suppliers. It took this chain of events and multiple organizations to put Siri’s digital voice in pockets all over the world. Siri demonstrates the interlocking capacities—well outside of academic labs—necessary for invention to become innovation. But what happens when profits are not the goal, and therefore incentives are unclear?

typically place a high value on the investigators’ publications and prizes in globally recognized fora, while questions of community benefit such as NSF’s Broader Impacts are often framed vaguely and evaluated inconsistently. But these are not the only ways that federal support inadvertently diverts R&D capacity away from local communities.

Education is one of the core missions of our nation’s taxpayer-supported public university system. Attending college to learn from professors who are also active researchers is an important way for nonscientists to gain direct exposure to practicing scientists and engineers, and it connects researchers to the communities in which they live and work. Nonetheless, university professors are allowed, and even encouraged, to leverage federal grants to “buy out” of teaching, further divorcing the federally supported research system from the people it is supposed to benefit.

Federal incentives also inadvertently create barriers that prevent communities from building local research capability and capacity. Today, most project research money cannot be used to support developing infrastructure or buildings—

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To translate the science and invention it currently funds into innovations and solutions to society’s problems, the federal government will need to learn how to convene and collaborate with the existing innovation ecosystem to bridge gaps and connect players. This process will require a cultural change that creates incentives beyond prestige and profits to get multiple players working toward beneficial outcomes. At the same time, the federal research establishment must acknowledge its role in creating today’s incentive structures for academic science and take proactive steps to reshape them.

Unleash problem-solvers everywhere

To start this process, the federal government needs to quickly change the incentives that discourage and even prevent scientists from working on local problems. These barriers exist at different levels and have individual as well as institutional effects. As one of the largest single sources of academic and basic research funding, the federal government has played a significant role in giving a global focus to the overall culture and promotion system for scientists and engineers. In applications for federal funding, for example, determinations of merit

adhering to a tenet that funds should directly support research. But today’s research often requires specialized facilities. As a result, the lack of federal funds for research infrastructure privileges wealthier states, regions, and institutions that can afford to build their own facilities. Though valuable, programs such as NSF’s Established Program to Stimulate Competitive Research are insufficient to overcome wide structural inequities, which ultimately serve to deepen the divide between the rich and the rest.

While balance between research outcomes and facilities investment is needed, blanket restrictions on the latter limit the ability of regions to develop local capacity that could enhance their ability to solve local problems proactively. Broad access to research infrastructure allows ideas to be tested wherever they arise and both inspires and empowers more diverse bright minds to enter the research pipeline. One model for this kind of federal support is the Defense University Research Instrumentation Program, which funds research infrastructure and instrumentation. Developing locally operated research infrastructure can also provide benefits by, for example, providing access to local small businesses or aspiring entrepreneurs who need to test an idea. Sharing such benefits with the community builds trust and supports the economy.

Finally, the effects of the value system implicit in federal funding extend beyond the research it funds—sometimes inadvertently discouraging researchers from accepting state or local funding. As more than one university professor who has sought to conduct locally relevant, state-funded research has discovered, the institutional processes and practices that have developed around federal grant management can make accepting other forms of funding an onerous task, requiring herculean efforts to complete. In this way, federal incentives dominate institutional priorities as well as those of individual researchers—and may prevent them from conducting research that is relevant to the communities where they live.

To realize the benefits of STEM research for all Americans, we need to align more incentives in the research ecosystem toward helping society, not simply increasing global scientific knowledge. Not only do federal science funding agencies have the power to reshape the incentive structure for engineers and scientists; but doing so is a necessary step to ensure we have a robust STEM ecosystem capable of meeting tomorrow's complex needs.

Vaccines against SARS-CoV-2 provide an example. Our federal research support system rapidly mobilized scientists across the country toward the singular goal of developing effective vaccines. This effort demonstrated our domestic research enterprise's greatest strengths, but it also exposed one of our greatest weaknesses: failure to contend with the multifaceted challenges of on-the-ground innovation. In the case of vaccines, lack of trust in the healthcare system in some communities has slowed vaccination rates. If the problem had been formulated as one of achieving effective immunity through vaccination, rather than simply developing a vaccine, we might have identified these challenges early on and worked to develop broader solutions. In the future, a more human-centered, design-based approach to fully articulating problems could encourage both stakeholders and subject matter experts to map the entire problem space.

In the longer term, decentralization provides significant opportunity for the full range of R&D actors across industry, academia, philanthropy, states, and

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Creating a science culture that solves problems

There are several near-term changes federal funding agencies could implement to elevate the value of public service, local solutions, and local capability and capacity in our domestic science and engineering enterprise. One simple change would be making time spent doing direct community engagement, such as working with local government and/or community leaders, an allowable expense on a grant. More proactively, requiring a summary of direct community engagement efforts and beneficial community outcomes in grant-reporting requirements would begin to shift incentives toward local action. To elevate community concerns at the federal level, peer review boards and advisory bodies established under the Federal Advisory Committee Act should include members with diverse experiences including community engagement, local leadership, and small business. The Environmental Protection Agency's National Environmental Justice Advisory Council provides one example of how such a broad-based advisory body could be constituted.

Another opportunity for the federal government to take creative new approaches can be found in the problem definition phase itself. Too often our current system overlooks the importance of intentional problem formulation.

localities to fully engage in shaping our research culture. Today's American innovation ecosystem has many holes and mismatches. Scientists want to do societally relevant work, but cannot find institutional support. Communities and regions seek research-based solutions to their problems, but cannot marshal the needed resources. Policymakers at local and state levels try to navigate untested novel technologies as well as uncharted climate and health-related problems, but cannot find trustworthy technical advice. Philanthropies seek to fund solutions to long-standing societal challenges, but cannot align the multidisciplinary talent. These disconnects provide an opening for the many players outside the federal government to help bridge gaps to support a more responsive and inclusive research enterprise. And once engaged, this enterprise could take on new tasks.

With this mindset, for example, an independent organization could use digital technology to connect communities, researchers, and funders in new ways. Many researchers spend ever-increasing hours developing proposals to get funding for their laboratories. Simultaneously, many smaller institutions across philanthropy and state and local governments lack

the resources to manage large calls for proposals and burdensome review processes. This situation results in both groups narrowing their pools of ideas and potential grantees. Creating an independent proposal marketplace that serves stakeholders ranging from states and localities to industry and philanthropy could expand opportunities for everyone. In such a marketplace, researchers could post white papers or proposals for their research ideas, and funders seeking outcomes could post their questions and problems. Even the most niche funders could search and find proposals aimed at their priorities. The marketplace could further incentivize the full diversity of research, encouraging a range from short-term and problem-focused proposals to longer term, high-risk research and allowing a myriad of specific topics and geographies. Such a single, streamlined process would respect the time and expertise of our researchers, funders, and citizens. It would also encourage the transparency needed to build a culture of consideration around how science can meet many different social needs.

Finally, the federal science agencies need to reshape the incentives that currently cast academia as the primary career path for serious researchers. Perhaps a place to start is by funding not only academic postdocs, but postdocs and fellowships across state and local governments, philanthropies, and industry. Currently, we train every graduate student for a career in academia even though it is no longer the most common career path. This process often leaves graduates feeling they have somehow failed if they opt out of that path. Instead, to ensure we proactively leverage our STEM professionals more effectively and compassionately, we should incentivize and enable careers that span the invention to innovation spectrum.

What would Vannevar Bush do?

Many of today's proposals to reinvigorate R&D through increased federal spending are returning, compulsively, to the template put forth by Vannevar Bush in 1945. But Bush's true contribution wasn't his policy prescription for science, but his analysis of the landscape and context of 1945, coupled with his sense of which actions could be feasibly taken by government to effect change.

In his seminal report commissioned by President Franklin D. Roosevelt, Bush looked carefully at the research resources of the time, as well as the challenges the country faced: curing disease, securing the nation, and serving the public good. He emphasized that his recommendations were not a solution to all the problems he delineated, but rather a few targeted actions that government could feasibly take to fill research gaps that would have the greatest impact. As a result, Bush's

recommendations centered on creating, from scratch, a sustained commitment to and infrastructure for government-funded research. His success in achieving this outcome is remarkable.

Today, an analysis of our R&D and innovation system will show that what's missing isn't federal funds for academic research or even scientific expertise within the federal government; what's missing is connective tissue between ideas, inventions, and innovations and the problems faced at local, state, and regional levels. We lack mechanisms and platforms for communities with problems to help set the research agenda. We lack pathways for bringing people together and taking research ideas from laboratory demonstrations to real-world solutions. If Bush were here today, he wouldn't ask why we aren't spending more on scientific research. He would ask why we are not using the resources at our disposal to solve our problems.

We no longer live in a world where top-down command and control approaches are effective. In fact, outside the postwar era, such a model has never been part of America's cultural history. Instead, the federal government must learn to make today's decentralized structure work in ways that unleash our energies and genius onto the many issues we face now.

Through strong engagement and leadership, we can find a way for science to reconnect with communities and provide creative solutions. This process will involve not only the federal government reimagining its role. It will also require industries to commit to responsibility to their workers and communities, philanthropies to collaborate as part of the ecosystem, academic institutions to invest in efforts that lift up the entire community, and individual scientists and engineers to see themselves as civic actors and participants in the communities they serve. Seventy-five years from now, we hope our present moment is remembered as the time when we decided to embrace our powerful, bottom-up, chaotic, and often wonderful system.

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"The Next 75 Years of Science Policy" has been made possible through the generous support of The Kavli Foundation.
