An Inflection Point for Technological Leadership?

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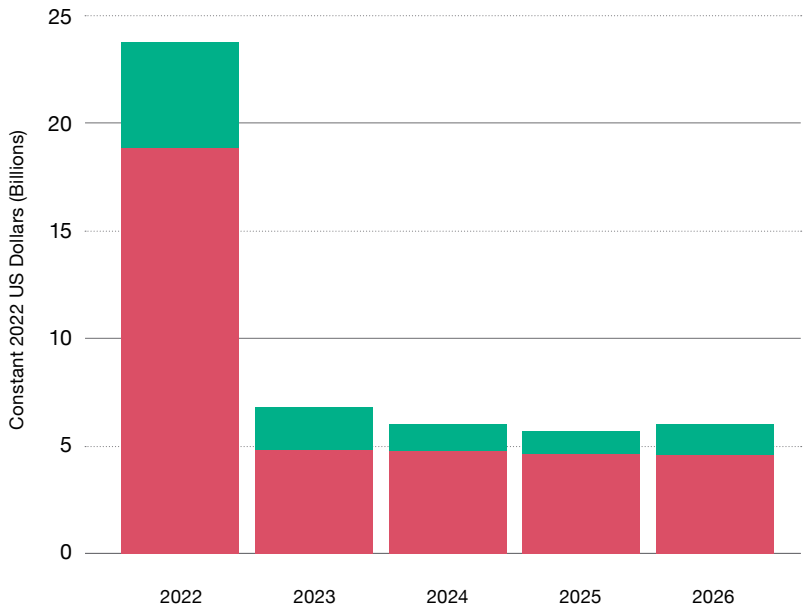
During the White House signing ceremony, President Biden described the CHIPS and Science Act of 2022 as an "inflection point" in restoring America's global leadership in research and development, as well as in high-technology manufacturing. The CHIPS Act may indeed be a watershed development, but whether it truly marks an inflection point for American competitiveness remains to be seen. Global technological leadership is likely to be determined by much more than simply an influx of dollars.

The CHIPS Act should be used as a fulcrum to usher in a cultural change—within the federal government and beyond—reflecting the recognition that, combined with the search for novelty, technological advances and scientific discoveries are intimately linked. That linkage can simultaneously propel both technological progress and scientific discoveries to greater heights in contributing to the long-term public and private good. As the chemists George

CORE CHIPS ACT APPROPRIATIONS: MANUFACTURING AND R&D



Semiconductor appropriations

The CHIPS and Science Act appropriates $39 billion for semiconductor manufacturing incentives and an additional $11 billion for semiconductor research and development. In addition to these core appropriations, the act also establishes four other funds (not shown in this figure): a Defense Fund ($2 billion), a Public Wireless Supply Chain Innovation Fund ($1.5 billion), an International Technology Security and Innovation Fund ($0.5 billion), and a Workforce and Education Fund ($0.2 billion); this part of the act also includes the Advanced Manufacturing Investment Tax Credit.

Whitesides and John Deutsch have written, "A focus on the practical does not mean ditching fundamental science. It means using fundamental science for a purpose, and practical problems as a stimulus to curiosity.… en route to addressing the big societal challenges of our times."

Building a culture based on this recognition throughout the US innovation ecosystem will require visionary leadership and effective organizational architecture that is coordinated, efficient, and strategic. There is a special role for the National Science Foundation (NSF) in driving this transformation, but NSF cannot do it alone. Other federal agencies and industry, working together, must also help bring about the change that will allow this initiative to meet its high aspirations.

Scale of funding

The "science" elements of the CHIPS Act authorize $81 billion in new funding for NSF for fiscal years 2023–2027, which constitutes a doubling of NSF's annual budget by 2027. Within NSF, the act authorizes $16.2 billion for the Directorate on Technology, Innovation, and Partnerships (TIP)—the first new directorate in decades. In addition, the Department of Energy (DOE) is set to receive $67.9 billion, along with $9.7 billion to the National Institute for Standards and Technology (NIST).

Authorization of funding is only the first step, however: there must be a sense of urgency in implementation. Indeed, the impact of the act on federal agencies depends, in part, on whether and when the funds will be received. Although funds have been authorized by Congress and President Biden, the next phase of deliberations turns to appropriation of funding. This challenge begins immediately: the act authorizes NSF's TIP directorate to receive $1.5 billion in fiscal year 2023, which started on October 1, 2022–only two months after passage of the bill. Historically, appropriations have often been delayed or failed to meet the levels that were originally authorized. While the act's potential impact should not be evaluated solely in financial terms, to move forward the authorized funds must be appropriated on time each fiscal year.

Collaborative opportunities

New funding is a necessary but not sufficient condition for strengthening the American technology innovation ecosystem. Future technological competitiveness will require promoting synergistic alliances among industry, government, and academia—as well as making the boundaries among these institutions increasingly porous. To truly transform this system requires leaders of federal science agencies to blaze new trails of collaboration by dismantling silos within and between agencies.

Critical to interagency collaboration is the director of the Office of Science and Technology Policy (OSTP). The director's role as interagency facilitator stems from OSTP's remit to foster "the creation of bold visions, unified strategies, clear plans, wise policies, and effective, equitable programs for science and technology, working with departments and agencies across the federal government and with Congress." Furthermore, OSTP also manages the National Science and Technology Council (NSTC), chaired by the president (who often delegates the role to the OSTP director), which "is the principal means by which the executive branch coordinates science and technology policy across the diverse entities that make up the federal research enterprise," according to a recent NSTC report. NSTC is therefore able to convene interagency coordinating committees to foster alignment across agencies to advance future science and technology policy.

Thus, OSTP must take a visionary approach to orchestrating these entities. In particular, it must encourage them to actively combine their science and engineering competence with conflict management and interest-based negotiation skills to find points of strategic synergy within and across agencies. Additionally, in many presidential administrations the OSTP director is also designated as assistant to the president for science and technology. If dually appointed, therefore, the director/assistant is positioned to facilitate cooperation using the platform of the mission of OSTP, the leadership of NSTC, and the gravitas of the role of assistant to the president, which confers additional direct access to the president's priorities.

Reimagining the role of NSF

In addition to further elevating NSF's role in America's national research and innovation ecosystem, the CHIPS Act also impels NSF to reimagine itself by appointing bold leaders for the new initiatives—TIP, Regional Innovation Engines, and Translation Accelerators. These leaders are tasked with implementing new ways to distribute funding that go beyond peer review (e.g., by utilizing strong program managers to build an entrepreneurial culture and complement the conservative nature of the peer review process). A further reason for optimism about NSF's rejuvenation is that the director holds a six-year term, which augments continuity across presidential administrations and is not reliant on political election cycles.

The act provides an opportunity for NSF to leverage its existing resources, as well as enlarge its role. It contains a substantial commitment to advance foundational, or curiosity-driven, research across a broad range of sciences and engineering in NSF, as well as by DOE (e.g., in the Office of Science) and NIST. Notably, the act takes a vital additional step by enhancing synergies between science and engineering research and the concurrent enhancement of technological innovations. NSF should build on this to promote interdisciplinary engagement across centers and institutes such as the Science and Technology Centers (STCs), Engineering Research Centers (ERCs), and Materials Research Science and Engineering Centers (MRSECs). These centers,

which have extensive networks of researchers and industry partners, conduct significant foundational research and—especially in the case of ERCs—invention of commercial prototypes of engineered systems. NSF leadership must therefore further strengthen infrastructure for a "network of networks" to strategize about new frontiers of discovery research that harness the work of STCs, ERCs, and MRSECs (including properly incentivizing program managers in NSF's directorates to collaborate) and funnel new discoveries into the technological innovation process that is led by TIP.

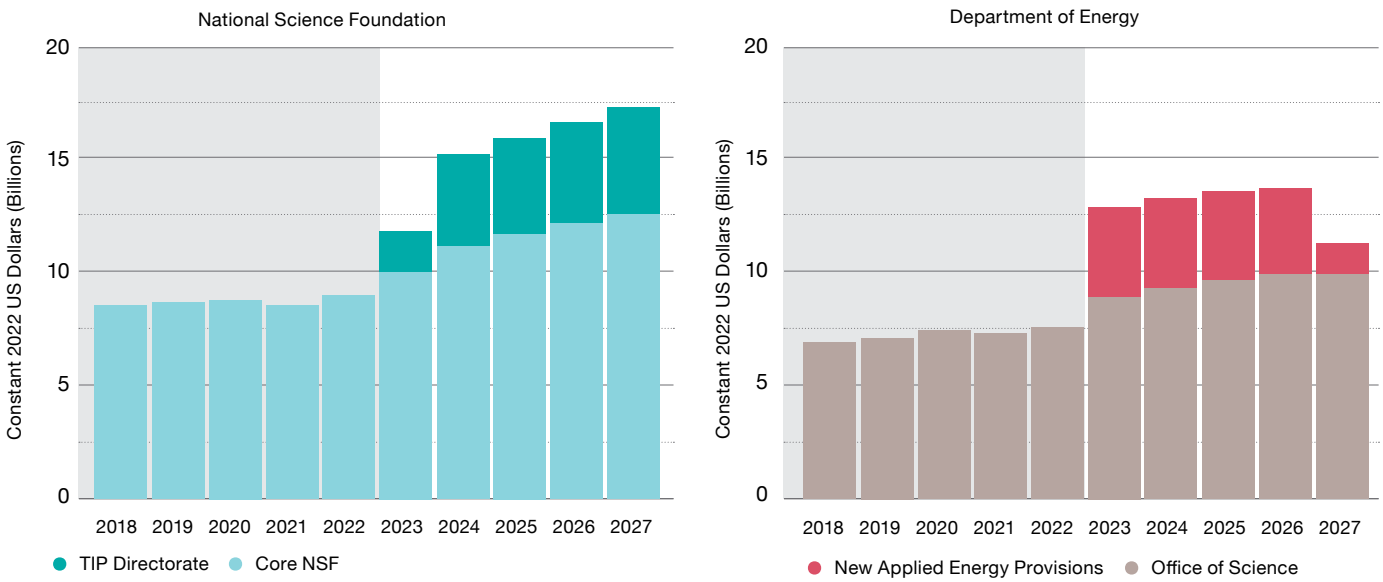
With the range of innovation programs supported by the act, however, NSF leadership must avoid a scattershot approach. It should effectively orchestrate programs, build teams, and balance divergent and convergent thinking among participants while minimizing duplication of programs. As we have written previously in *Issues*, this is where the new TIP directorate must serve as an indispensable bridge between foundational science and engineering research and the commercialization of innovations. It is here that the act's additional funding of TIP promises to profoundly elevate NSF's pivotal role in America's innovation ecosystem.

We find TIP's "P"—for partnerships among government, industry, and academia—particularly noteworthy. These partners and participating institutions must come to share common aspirations for American global competitiveness, a grasp of the research and development process, and a balance for the importance of both public and private goods. Regarding the role of industry, there is much policymakers can learn from the history of the great industrial laboratories in the United States. AT&T's Bell Labs, for instance, emphasized a spirit of national service and the synergies among foundational science and engineering discoveries, use-inspired research, and manufacturing.

Since the 1980s, many American corporations have focused on shorter-term product development at the expense of longer-term research. At the same time, they have pursued an ideology of extreme shareholder capitalism preoccupied with quarterly stock prices, off-shoring manufacturing, and growth through mergers and acquisitions. This ideology contributed to the erosion of America's global technological leadership. In recent years, however, Big Tech firms (e.g., Alphabet, IBM, and Microsoft) have invested substantially in research and development in artificial intelligence and computational software technologies, which depend on continual advances in semiconductors and materials to ensure American global competitiveness. Indeed, for the act to reach its potential, industry must hold a pivotal role in the partnerships required to create more coherent national strategies for America's global technological leadership. Policymakers can encourage industry to transcend extreme shareholder capitalism by supporting financial incentives for R&D and discouraging stock buybacks.

Recently, NSF Director Sethuramen Panchanathan spoke

NATIONAL SCIENCE FOUNDATION AND DEPARTMENT OF ENERGY: PREVIOUS FUNDING AND NEW AUTHORIZATIONS



Science authorizations

The CHIPS and Science Act authorizes increased funding for three key science agencies: the National Science Foundation (NSF), the Department of Energy (DOE), and the National Institute of Standards and Technology. If fully funded, these authorizations would strengthen basic research at DOE and NSF, create new DOE applied energy programs, and expand NSF's new Technology, Innovation, and Partnerships (TIP) directorate.

Note: Previous DOE funding excludes existing Applied Energy programs because the CHIPS and Science Act did not modify them. The act authorizes $11.2 billion as a lump sum under Sec. 10771; that sum has been spread evenly across the four years.

of the opportunity presented by the CHIPS Act as "a new Sputnik moment," and indeed, the act represents a landmark commitment by the federal government. Whether it becomes an inflection point for American competitiveness, however, is likely to be determined by the presence of visionary leadership and effective organizational architecture, rather than an influx of dollars alone. To achieve the act's promise, leaders of federal agencies, industry partners, academic thought leaders, philanthropic institutions, and nonprofit organizations must converge on a renewed social compact that advances a bold vision for America's technological leadership.

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