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Mobilizing for Techno-Economic War, Part 5: Transforming STEM Research Policy

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Increased federal funding for STEM research is necessary but not sufficient for America to avoid losing to China. It's also time for a new model for federal research funding that focuses on the technology needs of national power industries and directly benefits firms in the United States.

KEY TAKEAWAYS

- U.S. research policy is outmoded. It focuses too much on basic science, not enough on engineering and applied research. There is too little industry involvement, no prioritization of national power needs, and too much spillover—especially to China.
- Change must be more than incremental. Just as a new federal research model emerged after WWII, we need a new federal research model today, one that puts the mission of not losing to China in national economic power industries front and center.
- Congress should start by appropriating an additional $100 billion per year for research—and all of it should be targeted toward national economic power industries.
- The system should focus on specialized research centers, not individual awards. Funding should be sized for scale, sustained based on performance, and include more in the mid-stages so discoveries can cross the "valley of death" to be commercialized.
- The system also needs increased industry involvement, with new kinds of research universities; large-scale, non-profit research centers focused on dual-use technologies; more, better-funded Manufacturing USA centers; and a new "civilian DARPA."
- Congress should enact a 50 percent tax credit for industry-led collaborative research or funding for university or federal research; fund grants for new approaches to training scientists and engineers; and provide funding to match states' R&D funding.

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INTRODUCTION

The United States has been the world's dominant techno-economic power for over 125 years. That has induced complacency. As the Information Technology and Innovation Foundation (ITIF) has written, China is hungry and determined not only to displace American techno-economic leadership, but to also make America dependent on it.[1]

On its current trajectory, it is likely that China will, in the next decade or two, amass significantly greater capabilities than the United States and even Allies will in what we term "national power": advanced traded-sector industries that are critical to national security or sovereignty. With those greater capabilities will come geostrategic hegemony over the West, unless the United States forestalls that outcome by adopting a new, transformative national power industry strategy that goes beyond a mere competitiveness or national innovation strategy. This is not a war that the United States and allies can win in the sense of significantly weakening or retarding the growth of China's own national power industries. Rather, the only way Chinese attacks will end is if China becomes a free, democratic country. But the United States and allies can avoid defeat—keeping their national power industries relatively strong—by working together and adopting national power industry strategies.

However, the inherent weaknesses of the U.S. innovation and production system (e.g., cuts in government research and development (R&D), limited STEM (science, technology, engineering, and math) skills, an overly strong dollar, institutional resistance to change, corporate short-termism, etc.) coupled with a Chinese Communist Party hyper-focused on victory suggests that, absent major structural change in U.S. policy, relative decline and loss of techno-economic competitive position and power is inevitable.

The most important research change is to make not losing to China the top national mission for federal research funding, on par with having the most advanced military in the world.

The first report in this series laid out the context for this, including what is at risk and the need for radically new approaches in a host of key policy areas.[2] Not small steps, but big ones. Not tinkering, but transformation. "Bold" is the operative term. The crisis is at such a point that incrementalism will fail. Other reports have focused on transforming from financial capitalism to national techno-economic capitalism and from free trade agreements to strategic techno-economic-trade partnerships.

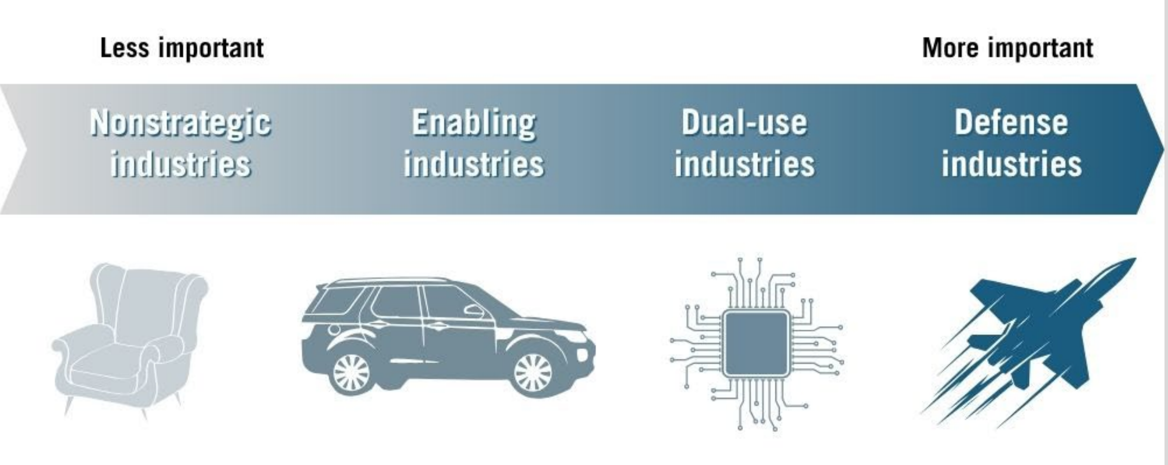
This report lays out a reform and restructuring agenda for U.S. science and engineering research policy. Federal support for scientific and research can play a key role in ensuring that the United States does not lose the techno-economic war to China, but only if Congress and the White House significantly restructure the system to make it more effective.

The most important research policy change is to make not losing to China the top national mission for federal research funding, on par with having the most advanced military in the world. That means not only significantly increased funding focused on technology needs related to national economic power industries, but also research conducted in such a way as to provide tangible mid-term benefits to existing and start-up firms in national economic power industries.

Box 1: Defining National Economic Power Industries

The conventional view is that the only industries that matter to national power are defense industries. But that is now vastly too limiting. As Corelli Barnett wrote, “For munitions production for modern war is not primarily a question of specialized armament industries, as some suppose, but of all those varied industrial and scientific resources that in peacetime make for a successful and expanding export trade.”[3] As such, ITIF has developed a classification of U.S. industries for their relevance to national power. This can be viewed as a continuum between defense industries on one side, nonstrategic industries on the other, and strategic industries and strategic enabling industries in the middle. See figure 1.

Figure 1: Industrial power scale



At one end of the continuum are defense industries. Clearly industries such as ammunition, guided missiles, military aircraft and ships, tanks, drones, defense satellites, and others are strategic. Not having world-class innovation and production capabilities in these industries means a weakened military capability. Policymakers across the aisle generally (with the exception of the isolationist Right and the pacifist Left) agree that these industries are strategic and that market forces alone will not produce the needed results.

At the other end of the spectrum are industries in which the United States has no real strategic interests. These include furniture, coffee and tea manufacturing, bicycles, carpet and rug mills, window and door production, plastic bottle manufacturing, wind turbine production, lawn and garden equipment, sporting goods, jewelry, caskets, toys, toiletries, running shoes, etc. If worst came to worst and our adversaries (e.g., China) gained dominance in any of these industries and decided to cut America off, we’d survive—in part, because none of these are critical to the running of the U.S. economy, as many are final goods that might inconvenience consumers but wouldn’t cripple any industries, and also because, in most cases, domestic production could be started or expanded relatively easily because none of these products are all that technological complex from either a product or process concern and the barriers to entry are relatively low.

Next to defense industries, dual-use industries are critical to American strength. Losing aerospace, pharmaceuticals, chemicals, semiconductors, displays, advanced software, fiber optic cable, telecom equipment, machine tools, motors, measuring devices, and other dual-use sectors would give our adversaries incredible leverage over America. Just the threat to cut these off (assuming that they have also deindustrialized our allies in these sectors) would immediately bring U.S. policymakers to the bargaining table. National power industries tend to also need global scale in order to compete. Moreover, many are intermediate goods such as semiconductors and chemicals, where a cutoff would cripple many other industries. Finally, these industries are hard to stand up once they're lost because of the complexity of the production process, product knowledge, and the importance of the industrial commons that support them. In other words, barriers to entry are high and, if lost, would be very difficult and expensive to reconstitute.

Finally, there are enabling industries. These are industries wherein, if the United States were cut off, the immediate effects on military readiness would be small. And the U.S. economy could survive for at least a while without production. America could survive for many years without an auto sector, as we would all just drive cars longer. But because of the nature of these industries—including technology development, process innovation, skills, and supporting institutions—their loss would harm both dual-use and defense industries. That is because enabling industries contribute to the industrial commons that support dual-use defense industries. A severely weakened motor vehicle sector would weaken the tank and military vehicle ecosystem. Similarly, a weakened commercial shipbuilding sector has weakened military shipbuilding. A weakened consumer electronics sector weakens military electronics.

U.S. SCIENCE AND RESEARCH POLICY: 1945 TO THE PRESENT

U.S. science policy has gone through a number of relatively distinct stages.

Prior to WWII, there was limited federal support for science other than establishment of land grant colleges and some funding for agricultural research and aeronautics. In fact, before the war, federal support for research was only around 0.1 percent of gross domestic product (GDP). Foundations and companies were the principal funders of university research.

That changed in and after WWII when science became seen as critical to winning the Cold War and addressing a host of national challenges. A bipartisan consensus emerged that the federal government needed to expand its funding of science. But it was not clear what the model should be. On one side was Senator Harley Kilgore (D-WV) who wanted a federal science agency to advance explicit national goals and purposes. On the other side was scientist Vannevar Bush who, in his 1945 report to the president, *Science: The Endless Frontier*, advocated a scientist-led model with individual scientists free to pursue their own interests.[4] With the establishment of the National Science Foundation (NSF) in 1950, Bush's vision prevailed. Bush articulated a linear model of innovation, wherein the federal government funded basic research and, through some unexplained process, out came commercial innovations. That oversimplified model has been thoroughly debunked in the science policy literature.[5]

Bush envisioned five key aspects of this system:

1. **There must be significant federal funding.** By the early 1960s, federal support for research had reached 2 percent of GDP.
2. **Funding should be merit based and go to the best universities and researchers,** with no focus on geographic diversity.
3. **There should be no strings.** As Bush wrote, "Scientific progress on a broad front results from the free play of free intellects, working on subjects of their own choice, in the manner dictated by their curiosity for exploration of the unknown. Freedom of inquiry must be preserved under any plan for Government support of science."[6]

4. **All disciplines are equal.** If science is supposed to be investigator led, then government should not favor some disciplines over others. The primary goal is knowledge generation. And all fields are equally capable of producing knowledge. Astronomy is as valuable as computer science.
5. **Science should be global.** Bush wrote that “the Government should take an active role in promoting the international flow of scientific information.”[7] The advancement of science benefits humanity, so international collaboration is valued.

The United States could afford to focus on science because we dominated global manufacturing. It wasn’t even close. And leaders then through to the 1970s at least could not conceive of it being otherwise. And so, the science system was established and remains embedded, even as the United States lags behind dramatically in manufacturing compared with world leaders, especially China.

Bush articulated a linear model of innovation, wherein the federal government funded basic research and, through some unexplained process, out came commercial innovations.

While science was to be “pure,” there was also a realization that science and engineering played key roles in supporting key national missions. Indeed, the dictates of the Cold War meant that certain disciplines, especially physics, engineering, and later computer science were privileged. This included defense, space, health, agriculture, and energy. These were all seen as acceptable areas for government support for not just early-stage research but also later-stage development because they were areas the private sector would underinvest in.

Starting in the mid-1980s, this model was complemented by a modest focus on international competitiveness. As the United States faced techno-economic competition from Japan and Germany in particular, there was an increasing focus on having universities play a supportive role. The passage of the Bayh-Dole Act, the creation of Small Business Innovation Research (SBIR), and the establishment of industry-university programs at NSF was emblematic of that. But these programs were add-ons to the prevailing system and were only tolerated, not embraced.

LIMITATIONS OF THE CURRENT SYSTEM

This two-part system—basic research for knowledge discovery and mission-oriented applied R&D—is no longer adequate. Too little university research is oriented toward knowledge generation related to national power industries. And even where it is, too much of that knowledge is used globally, including in China, and too little is commercialized into U.S. innovations. And while mission-driven research in areas such as defense and energy does have benefits for national power industries, its “efficiency” rate is limited since its core purpose is not to support the broad array of national economic power industries.

These limitations are becoming more evident. The Endless Frontier Act and its incorporation into the Chips and Science Act was an attempt to recognize these limitations, largely by identifying support for 10 key technology areas and providing funding for NSF’s new Directorate for Technology, Innovation, and Partnerships (TIP).

But the university lobby successfully pressed for most of the bill's funding to go to the other divisions at NSF for principal investigator-led grants. The last thing they wanted was limits on their freedom. And even with some money going to TIP, the internal and external pressure on the program ensures that it is at least somewhat focused on the Bush doctrine. Moreover, in FY 2023, TIP funding was 8.9 percent of total NSF funding and fell to just 6.8 percent in FY 2024.

The current U.S. STEM research system, while possessing strengths, is not likely to sustain U.S. techno-economic strength vis-à-vis China.

Many will argue that the Bush science system maximizes knowledge creation and even innovation and that is in national interest. But sometimes it does and sometimes it does not. The answer depends. Doctrinaire views that principal investigator-directed scientific research is best are a distraction from real analysis. But overall, the current U.S. science system, while possessing strengths, is not likely to sustain U.S. techno-economic strength vis-à-vis China.[8] The current model will not succeed in addressing the China challenge.

Why not just rely on the current Bush system coupled with agency-specific mission driven research to achieve national techno-economic power? The reason is that this can diverge from the goal of techno-economic power in at least four ways: 1) the balance between science and engineering, 2) the stage of the research, 3) the areas invested, 4) the involvement of industry, and 5) the duration of research funding. Relying on the current system, even with incremental reforms to reduce these divergences, is wishful thinking.

Too Much Science, Too Little Engineering and Technology

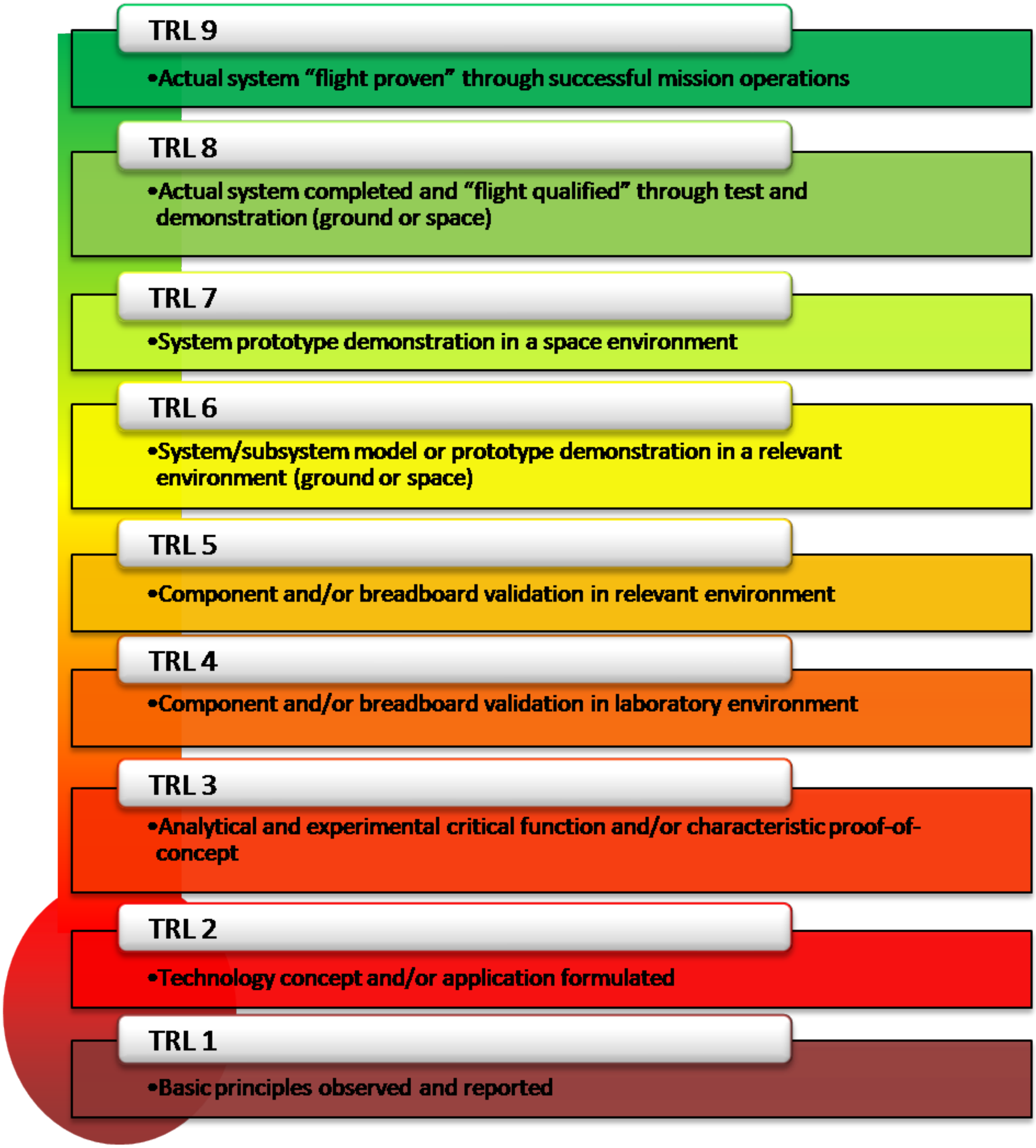
In the *Endless Frontier,* Bush mentioned science 119 times, but technology just 5. This was not an oversight. This reflected the entire purpose of his enterprise: advance science research. Today, engineering receives just 15.6 percent of federal support for research.[9] At NSF, this share is even lower at 8.2 percent.

But engineering research is a critical part of advances in industrial production that is needed in order to be able to compete with China. It's not enough for the United States to advance new ideas; it needs to be able to produce the results in the United States, and engineering plays a key role.

Too Much Focus on Basic Research

In terms of science funding, most is classified as basic research as opposed to applied. NASA has developed a measurement system to assess the maturity level of a particular technology based on Technology Readiness Levels (TRLs). (See figure 2.) Using that framework, a significant share of federal support is for early-stage research (TRLs 1 and 2), while most private sector research is much latter, around TRLs 7 to 9. In between—around TRL 4 to TRL 6—there is a huge gap that is often called the "valley of death" because it is where promising, early-stage technologies die from lack of funding.

Figure 2: NASA Technology Readiness Levels[10]



TRL 9
- Actual system “flight proven” through successful mission operations

TRL 8
- Actual system completed and “flight qualified” through test and demonstration (ground or space)

TRL 7
- System prototype demonstration in a space environment

TRL 6
- System/subsystem model or prototype demonstration in a relevant environment (ground or space)

TRL 5
- Component and/or breadboard validation in relevant environment

TRL 4
- Component and/or breadboard validation in laboratory environment

TRL 3
- Analytical and experimental critical function and/or characteristic proof-of-concept

TRL 2
- Technology concept and/or application formulated

TRL 1
- Basic principles observed and reported

The idea of doing research related to a particular technology, such as AI or new jet engines, is different than scientific research at an earlier stage trying to understand core principles.

One way to frame this is the goal of science being to acquire knowledge and understanding of the natural world, whereas the goal of technology is to solve practical problems and fulfill human needs. The focus of science is discovery; the focus of technology is invention. The outcome of science is facts, theories, principles, and laws; whereas the outcome of technology is tools, machines, processes, products, and services. In a world without Chinese competition, support for technology might be less important. In a world with it, it's much more important.

In addition, early-stage basic research is often not useable for industry, as it can be too basic and general. And there is often not enough support to move it up to later TRLs, or the valley of death.

Another challenge with the overfocus on basic research is that many of the results "spill over" to other nations. Scholarly research shows that when a country, even one as large as the United States, funds basic research, the majority of the benefits spill over to other nations that can use the knowledge discovered to help their own economies.[11] Basic research produces general-purpose knowledge that is nonrival and difficult to exclude others from using, crosses industry boundaries unpredictably, and tends to be published openly rather than kept proprietary. Applied research, by contrast, is more targeted, more likely to be patented or kept as trade secrets, and more valuable precisely because it creates advantages for the firm or country that conducts it.[12]

Another challenge with the overfocus on basic research is that many of the results spill over to other nations.

For too long, the United States has been doing the responsible thing and other nations the "selfish" thing. The United States has long invested significant funds into basic research at agencies such as NSF, National Institutes of Health, and Department of Energy (DOE). In contrast, nations such as China, France, Germany, Japan, South Korea, and Taiwan devote a significantly larger share of their R&D budgets to applied research to benefit their domestic industries.

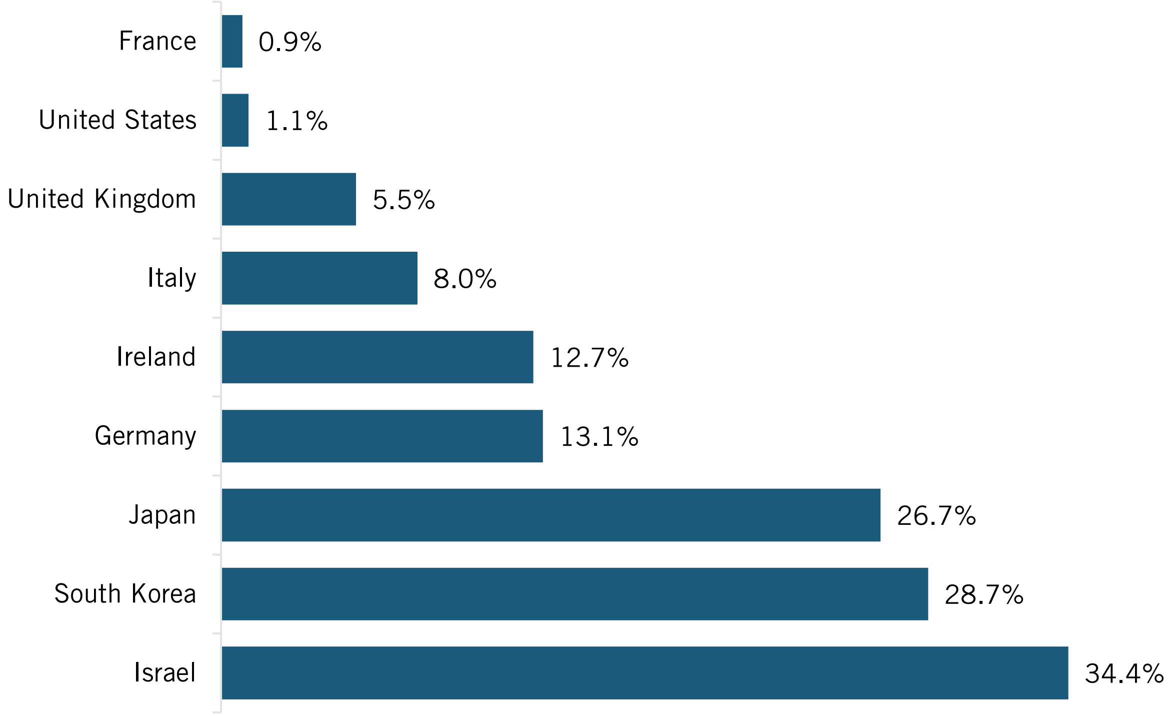
It would be one thing if other nations, especially China, stepped up to their global responsibilities and invested much more in basic research that the whole world would benefit from. But China does not. Most of China's research is later stage designed to give its firms advantage.[13] China knows that it can free ride off of U.S.-funded basic research.[14] Chinese researchers attend international conferences to hear U.S. researchers present their findings. Their China National Knowledge Infrastructure (CNKI) Express system provides them with access to over 300 million international scientific articles. They send their graduate students to U.S. universities. And they also cut off other countries from access to their own scientific publications.[15]

Research Related to National Power Industries

Mission-driven research agencies play key roles, but much of their focus is also on basic research (e.g., DOE's efforts to discover matter) or national missions, such as energy. To be sure, some of the research on energy, health, and defense supports national economic power industries, but research targeted to the needs of national economic power industries is quite limited and occurs by happenstance.

If we compare the United States with other nations, the difference is stark. Twenty-nine percent of South Korean government R&D is focused on industrial technology, compared with just 1 percent of U.S. R&D. (See figure 3.)

Figure 3: Share of national government R&D expenditures focused on industrial technology[16]



Too Little Industry Involvement

Before WWII, industry funded a significant share of university R&D. However, as federal research funding increased dramatically during and after the war, industry's share fell to just around 3 percent in the 1970s. That percentage started to rise again in the late 1970s and early 1980s, in part due to the growth of more science-based industries, including information technology and biopharmaceuticals, but also because of federal and state policy changes. For example, the Bayh Dole Act in 1980 gave universities rights to intellectual property generated from federal funding, which spurred many universities to work more with industry. Separately, NSF during the Reagan administration developed new industry partnership programs such as the Engineering Research Center (ERC) program, while many state governments developed university-industry research centers to grow technology-oriented businesses. Both of these types of initiatives spurred industry funding. As a result, the share of university research funded by industry increased from 4.9 percent in 1980 to a high of 7.4 percent in 1999. The share has fallen since then, however, even as federal funds have dropped overall. In 2024, industry funded around just 6 percent of U.S. university research.[17]

Box 2: The American vs. Chinese STEM Research Model

The conventional wisdom in the United States is that the U.S. STEM Research model is the envy of the world and, not only that, but that China seeks to copy it. This is a very comforting vision. No need to consider significant system change. Just expand federal funding and high-skill immigrants and all will be good.

The United States system was the best in the world, and may still be if we lived in a world where all other nations played by shared techno-econoimc and trade rules and some were not our main international adversary. But in such a world, every devloped country at least would be investing significant funds into basic research that the rest of the world would share. No country would have to worry too much about deindustrialziation and the loss of national power that brings. But that is not the world we live in anymore, and the U.S. STEM research system needs to evolve in that direction.

Not only that, but, as discussed below, it's a myth to believe that the Chinese Communist Party's (CCP's) goal is to evolve its STEM research system into one that looks and operates like ours. Their system is designed to advanced national techno-economic power.

The Chinese system is diferent than the U.S. system in at least two main ways.

First, the U.S. system is principal-investigtor driven. Some really smart researcher identifies the research they want to do, writes a proposal for it, gets money, hires a team of graduate researchers, hopefully makes discoveries, and publishes them in top-ranked peer-reviewed articles. The idea is based around individuals.

China's system is not that. It's based around teams who are motivated by one overarching mission: beating the United States. Perhaps this is a funciton of China's more communal culture. Or perhaps it's the CCP's realization that winning in national power industries takes big dedicated teams working together. Either way, it's a different system.

The systems differ in terms of mission-oriented labs—perhaps not so much in terms of their organization, but in terms of goals. Federal labs are there for a reason, as long as it is not commercial competitiverness. It can be agricultural productivity, health innonvation, transportation materials, weapons, or energy. But there is no federal lab, even accounting for National Institute of Standards and Technology (NIST), whose mission is to beat China technologically in a slew of national economic power indsutries.

China has been reorganizing and expanding its laboratory system as a core component of its National Innovation Systems, particularly prioritizing this in its 14th Five-Year Plan (2021–2025), with "self-sufficiency and self-made success in science and technology" as overarching goals.

Fore example, as of 2023, there were 533 State Key Laboratories (SKLs) approved in China. Their mission is to carry out cutting-edge basic research, attract and train domestic and foreign talent, and conduct academic exchanges inside and outside China. Their areas of research include quauntum computing, nanotechnology, opto-electronics, AI, Advanced semiconductors and microelectronics, photonics, and materials science. It is not that U.S. national labs don't also conduct reearch in these areas, it's that their goal is not U.S. commercial advancment.

We see this focus in the second area where China's system is different than the U.S. system. While the U.S. system gives lip service to commercialization, its not front and center of the activity. It is something that just hopefully happens. In contrast, the Chinese system seeks to "promote deep integration of scientific and technological innovation with industrial innovation" and to establish "concept verification and pilot verification platforms" that bridge laboratory research and commercial deployment.[18] And by 2030, a main goal is to achieve "major breakthroughs in developing new quality productive forces, building a new development pattern, and constructing a modern economic system."[19]

Too Little Long-Term Funding

Federal funding is often short term, with investigators having to constantly apply for grant renewal. And funding for research centers, while somewhat longer in duration, is still also short term. This makes it hard for researchers and centers to tackle big, bold, complex challenges and work on them until success if achieved.

China is different. For example, its National Natural Science Foundation of China, coupled with state-backed industrial policies, provides stable funding mechanisms for basic science that enable large-scale research initiatives.[20] This approach reduces fragmentation in research efforts and allows for sustained progress in the high-risk, high-reward domain of basic science.

CRAFTING A NEW FEDERAL STEM RESEARCH MODEL

A new federal STEM research model is needed—one that goes beyond simply providing more money or making incremental reforms to boost the current system's performance, including partial lotteries for principal investigator applications, agencies funding more risky proposals, expansion of the SBIR program, having more regional "accelerators" to better transfer research results to entrepreneurs, reforming the university tech transfer offices, and enhancing "the science of science" research. To be sure, these are all promising areas for change, but they still represent only incremental improvements of the current system, rather than the fundamental change that is needed.

A new federal STEM research model is needed—one that goes beyond simply providing more money or making some reforms to boost the current system's performance.

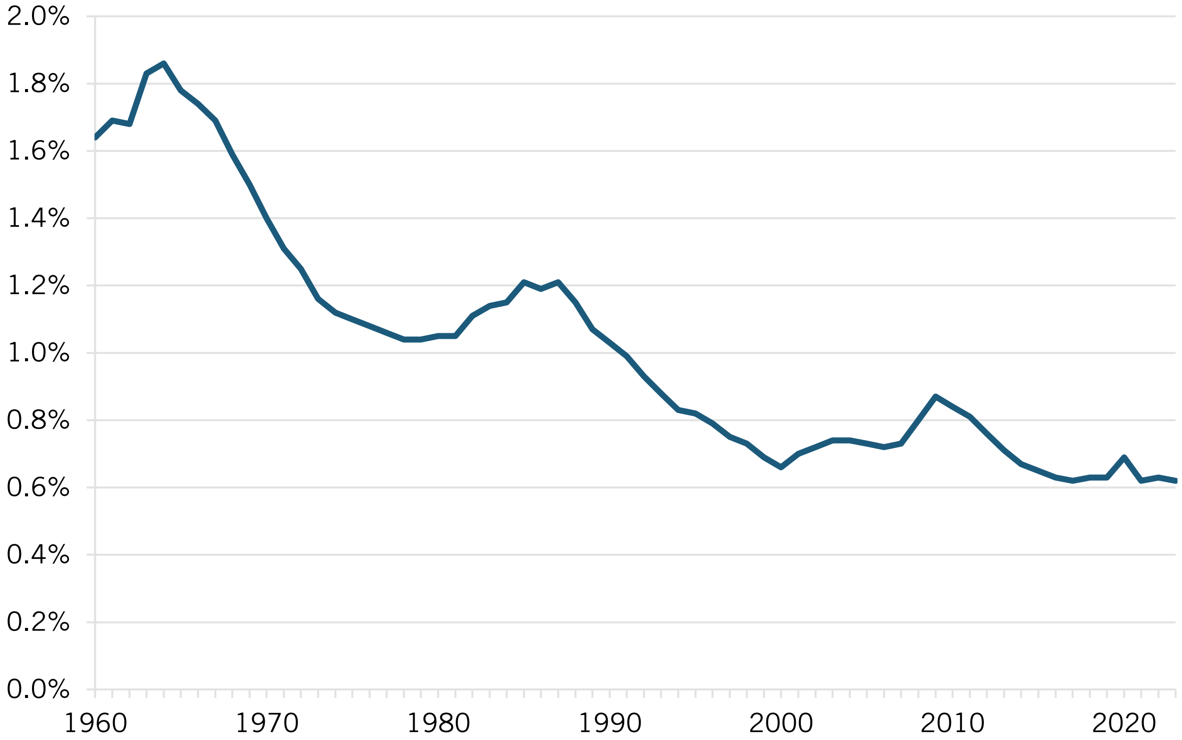
Indeed, while many of these changes would improve the system, they would not address the divergences previously discussed. That would require a move from the current system to one with an explicit alignment between STEM research and winning the techno-economic war with China. This means entering into a grand new bargain: no science funding cuts as long as the science community will commit to conducting a much larger share of their research in order to win the techno-economic cold war with China. This also means supporting certain areas of science (e.g., physics, life sciences, computer sciences, and engineering) more than others (e.g., social sciences). It means being willing to work more with industry and to actively support technology commercialization.

More Funding

First and foremost, Congress needs to increase funding. Federal R&D funding as a share of GDP peaked in 1964 at 1.86 percent during the height of the Cold War and has fallen since then to around 0.62 percent. (See figure 4.)

Congress should appropriate at least $90 billion more annually for research spending targeted to supporting innovation in national economic power industries. If over five years, congressional appropriations for federal research could increase from their current 0.67 percent of GDP to over 1 percent, that would mean an increase in federal funding from $189 billion to $282 billion, or an increase of $93 billion. After that, Congress should increase funding to maintain the same share of GDP investment.

Figure 4: U.S. federal R&D funding as a share of GDP, 1960–2023[21]



Target Increased Funding at National Economic Power Industry Needs

One place to start is to give engineering research a larger share of support. The imbalance between science and engineering support should be reduced, with **at least one-third of new funding going to engineering, up from around 15 percent.**[22]

At the same time, **new funding should be targeted to areas of science, engineering, and technology that have direct implications for national economic power industries.** The CHIPS and Science Act did that in identifying 10 key technology areas for investment. This was a good step, but winning advanced industries through research and innovation is not enough. We need to find ways to ensure more traditional, but critical, industries can also innovate—for example, research into new kinds of steel and chemicals, new ways of forging metals, or making circuit boards.

The imbalance between science and engineering support should be reduced, with at least one-third of new funding going to engineering, up from around 15 percent.

This means funding new kinds of institutional systems. It also should mean expanding the two main R&D efforts that have strong connections to commercial innovation: NIST and the Defense Advanced Research Projects Agency (DARPA). NIST funding was cut from 0.011 percent of GDP in 1995 to 0.004 percent in 2025.[23] At the same time, DARPA funding fell from around 0.027 percent of GDP in 1995 to about half of that, 0.014 percent, in 2025. **Congress should triple the NIST budget and double the DARPA budget over five years.**

Less Open Internationally, Especially to the Chinese

The current system and those who manage it see science as a global good, not a weapon in a techno-economic war. **The new system should work to limit the ability of China to access U.S. and allied STEM knowledge and capabilities.** As ITIF has documented in another report, there are a number of steps Congress and the administration should take to limit scientific and technical cooperation with China.[24] This includes requiring disclosure of U.S. faculty doing research with Chinese researchers in areas related to national power industries and restricting the U.S.-China Science and Technology Agreement, as discussed in a separate ITIF report on slowing China's advance to avoid losing the techno-economic trade war.[25]

More Focused Specialization With Scale

At the core, the U.S. research system is about projects, not sustained centers with scale.

China, in contrast, goes deep, and that makes innovation easier. For example, unlike the United States, where a research university may have just a few professors working on a particular area, China has established research institutes where a hundred researchers are working on the same topic. For example, China has close to 50 graduate programs that focus on either battery chemistry or the closely related subject of battery metallurgy. By contrast, only a handful of professors in the United States are working on batteries.[26]

This is similar to other Asian Tiger nations that have long supported large, specialized industrial research labs, such as ITRI in Taiwan focused largely on electronics and South Korea's Electrotechnology Research Institute.[27] In China, we see this with its SKL program, which, according to one report, is a "method of teaming researchers and developers as a strategy to tackle hard problems [and which] has long been hailed as a successful model, as was seen with Bell Labs in the United States."[28] The over 500 SKLs are usually located at universities, although in the last decade, the Chinese government has funded private companies to form SKLs, akin to Bell Labs.

The U.S. STEM research system is about projects, not sustained centers with scale.

We also see this focus on specialization in Chinese government efforts to form advanced technology regional clusters. A Center for Security and Emerging Technology report on SKLs notes that "to streamline the innovation process from basic to applied research, Beijing has co-located enterprises, universities, research institutions, and SKLs to form industry clusters."[29] One person told ITIF that there are universities in China that only focus on battery research. For example, China's SKL for Physical Chemistry of Solid Surfaces employs over 100 researchers at Xieman University.[30] In contrast, NSF funds 19 ERCs and a total of 79 ERCs since the program's inception—and only about half of these are focused on technologies that could be used in globally traded industries. A typical one, such as the Center for Innovative and Strategic Transformation of Alkane Resources, has only about 30 researchers, and only few of them work full-time at the center.

As such, **federal STEM research policy needs to focus more on specialized centers than on individual awards. The funding for the centers needs to be sustained, at least for 10 years, contingent on performance. And funding needs to be sizeable enough to gain real scale.**

NSF has recently taken a step in this direction with the announcement of its new request for proposal for its Tech Labs programs. This is an "initiative designed to launch and scale a new generation of independent research organizations. These organizations will focus on technical challenges and bottlenecks that traditional university and industry labs cannot easily solve on their own."[31] Funding appears to be around $200 million a year; a reasonable amount, but no enough to adequately respond to the China challenge.[32]

More Funding of Mid-Level TRL Research

While some additional funding should go to early-stage basic research (e.g., TRLs 1 and 2), significant funds should go to TRLs 3 to 5 (proof of concept demonstrated experimentally to test the feasibility of your innovation, technology validated in a lab environment, and technology validated in a relevant environment).[33] And research proposals should demonstrate interest and commitment to having this research commercialized in the United States or with allies that have reciprocal programs with the United States. **This needs to be required by Congress, otherwise the science agencies will revert to form to satisfy their clients.**

The lion's share of mid-level TRL research is from the Department of War (DOW). As such, Congress should triple DOW's funding for university-based industrial research. Most of the funding for manufacturing-related research at universities comes from DOW. Indeed, if there is a manufacturing technology agency in the United States it is DOW. Much of what it funds has dual-use implications, such as R&D in composites, digital production systems, materials, and prototyping. Various parts of DOW have long experience and established relationships with R&D centers across the nation. These programs, however, need to be significantly expanded to pursue more R&D focusing on dual-use capabilities. For example, the University of Delaware Composites Research Center, founded in 1974, has been funded by the U.S. Army Research Laboratory (ARL), the U.S. Army Tank and Automotive Command, the Office of Naval Research, and DARPA. Similarly, Penn State University's Electronics Manufacturing Center is one of seven Navy Manufacturing Technology (ManTech) Centers of Excellence. Similarly, the Missouri University of Science and Technology's Center for Aerospace Manufacturing Technologies is funded by the U.S. Air Force Research Labs and Boeing Research.

A variety of DOW offices fund this kind of applied research and engineering development including the Under Secretary of Defense for Research & Engineering and the ManTech program. Service research programs include the Army Research Laboratory, Office of Naval Research, Air Force Research Laboratory, and AFWERX. DOW also sponsors several of the 16 Manufacturing USA institutes. However, as a share of GDP, basic, applied, and advanced-technology research funding at DOW (budget activities 6.1, 6.2, and 6.3, respectively) declined from 0.096 percent of GDP in 2006 to 0.078 percent in 2024.[34] **Congress should double 6.1, 6.2, and 6.3 funding from around $21 billion to $42 billion.**

Congress should also **create a "civilian DARPA" to co-invest with industry on research and application of key technologies needed for dual-use national security leadership** in the commercial sector. Funded by year five with at least $20 billion per year, such an entity could be administered by NIST.[35]

Increase Industry Involvement

Most of this **new additional funding should not go to university individual investigators pursuing basic research** and seeking to publish their findings. Rather, **it should go to institutional models that engage much more deeply with industry.**

One path is to create **new kinds of research universities**.[36] For example, the Chinese government has supported research universities that are focused on a few narrow technology areas, such as robotics, but do so at enormous depth. There is no reason the United States could not do that—for example, creating graduate universities focused on materials, optics, and robotics and autonomy. Congress should provide NSF with at least a one-time appropriation of $1 billion to award to around five or so entities that seek to create specialized research universities.

Another path is the to **establish five national industrial research institutes focused on key, dual-use industries and technologies**—modeled after Tawain's Industrial Technology Research Institute, an industry-government advanced technology lab focused largely on IT technologies, with a long track record of working on technologies in what is referred to as the "middle Technology Readiness Levels" beyond what universities work on and earlier than most companies work on.[37]

In the CHIPS Act, Congress provided $11 billion for R&D. This included establishment of the National Semiconductor Technology Center, a public-private consortium to be operated by a new nonprofit called Natcast. It was to serve as a shared sandbox wherein start-ups, universities, and giant companies could access expensive chip design tools and prototyping capabilities without having to build their own billion-dollar facilities. The legislation also created the National Advanced Packaging Manufacturing Program to fund research into "heterogeneous integration"—basically the Lego-like stacking of different chiplets to make computers faster and more energy efficient. Unfortunately, the Trump administration is ideologically opposed to this kind of industry-led technology policy and so cut most of the funding for Natcast.[38] However, going forward, the Natacast model should be used not only for semiconductors but also other technology areas where industry is really to step forward with funding and commitment.

Congress should also **significantly expand the Manufacturing USA centers' public-private pre-competitive research institutes**.[39] There are currently 18 institutes; there should be at least 36. These centers should be selected by industry, with them coming to NIST with proposals and providing a share of the funding. Funding could also go to nonprofit service providers/manufacturers for key technologies such as ultra high-density interconnect circuit boards or other technologies for which the United States is highly dependent on China.

Congress should **create a "civilian DARPA" to co-invest with industry on research and application of key technologies needed for dual-use national security leadership** in the commercial sector. Funded by year five with at least $20 billion per year, such an entity could be administered by NIST.[40]

Some of the increased funding should go to states that agree to increase their own funding for R&D centers focused on research related to national economic power industry technology needs, as Georgia has with its Georgia Research Alliance.

Congress should modify the collaborative R&D credit to boost the credit rate from 20 percent to 50 percent for industry funding of university or federal lab research or industry-led collaborative research. This would provide a powerful incentive for companies to support more extramural research in areas critical to industry needs and be more oriented toward helping industry solve key challenges.

More Industry-Focused Graduate Programs

Most U.S. university Ph.D. programs are designed to turn out academic researchers/professors. That needs to change. **We need more experimentation with different kinds of programs that are more focused on industry needs**. For example, the Danish Agency for Science, Technology and Innovation oversees an industrial Ph.D. Program designed to produce STEM Ph.D.s with more industry-relevant skills. (See box 3.)

In China, the Harbin Institute of Technology (one of the Seven Sons of National Defense) is now rewarding students with a Ph.D. based on real solutions they build—such as creating vacuum laser welding tech for the military.

In the United States, Olin College of Engineering requires students to study design, business entrepreneurship, and engineering. And it has no faculty tenure.[41] Alfred Kettering University in Michigan provides immersive co-op experience for a variety of engineering disciplines.[42]

In China, the Harbin Institute of Technology is now rewarding students with a Ph.D. based on real solutions they build—like creating vacuum laser welding tech for the military.

Congress should provide funding for grants to higher education institutes that want to develop new institutional approaches for training scientists and engineers. Ideally, this would be funded not by NSF, which has shown little interest in "rocking the academic boat," but rather NIST or a new national technology agency.

Box 3: Denmark's Industrial Ph.D. Program

Beginning in 1971, Denmark's Industrial Ph.D. program became one of the first programs of its kind designed to train researchers with industrial research and workforce applications in mind.[43] With the goal of increasing knowledge sharing between universities and the private sector while also promoting research with commercial applications, the program enables a student to enter a Danish university while simultaneously working for a Danish company for a three-year period. While in the program, the student splits their time between the company and the university, completing a single research project that has direct benefits for their company while also completing the traditional requirements of the university's Ph.D. program (coursework, doctoral thesis, teaching, etc.). While enrolled, the student is paid an annual salary by the firm, which is partially subsidized by the university, while the Danish Agency for Science, Technology and Innovation pays the full tuition to the university.

The fields of inquiry for the Industrial Ph.D. Program include several areas of emerging and critical technology, including green research, technology and innovation, life sciences and welfare technology, robotics and AI, and space technology.[44] To be sure, participating Danish companies are involved in knowledge-intensive industries, particularly IT, chemicals, pharmaceuticals, medical equipment, and advanced manufacturing. The majority of companies expect patents, and at least half expect higher corporate incomes as a result of participating in the program.

In 2011 and 2013, over 1,200 projects, including 430 Industrial Ph.D. students at 270 companies, were surveyed and compared with a control group of companies and students that did not participate in the program. Among the companies that participated in the program, they generally experienced a doubling of the number of patent applications, higher gross profits, an increase in total employment, and an increase in total factor productivity compared with the control group. Additionally, the companies reported new knowledge, new market opportunities, and a bolstered network to the academic world.

Industrial Ph.D. students found that they earned about 10 percent more than conventional Ph.D. students did and were also three times as likely as conventional Ph.D.s to hold senior leadership positions in a company. The surveys also found that industrial Ph.D.s who went into the public sector earned the same as those in the private sector, but conventional Ph.D.s earned less.

An additional survey conducted in 2013 concluded that the Ph.D. program created value for students, businesses, and universities. Students were enriched by the combination of practical experience and research. Companies found concrete results with increased revenue; new products and services; and an increase in patent applications and licensing. Universities got a better sense of the research needs for business, not to mention a supply of highly qualified and motivated Ph.D. students. All parties enjoyed the benefit of networking. Finally, the Danish society was served by a program that delivered value for money, increased national competitiveness, and increased employment.

The Industrial Ph.D. is not a substitute for fundamental research in the sciences, but rather is a valuable supplement to academic, corporate, and national research agendas.

Harness AI to Transform, Not Just Optimize, Scientific Discovery

U.S. science policy should prioritize the large-scale integration of AI and advanced digital infrastructure into the core of the scientific enterprise. DOE’s Genesis Mission provides a compelling model. It aims to build an integrated national discovery platform that connects supercomputers, AI systems, scientific instruments, and vast federal datasets into a single, AI-driven research engine.[45] By training scientific foundation models, automating research workflows, and enabling AI systems to generate and test hypotheses, the initiative is designed to double the productivity and impact of American science within a decade. This approach reflects a critical shift: AI for science is not merely about improving efficiency or stretching research dollars, but also about fundamentally modernizing how discovery occurs. Evidence shows that AI can enhance the novelty and impact of research—especially in complex domains—while countries such as China are already leveraging these capabilities at scale to gain advantage in frontier research. As one recent study finds, “China has taken the lead in AI-driven research, outpacing both the US and the EU, not just in sheer output, but also in terms of scientific novelty and impact.”[46] To remain globally competitive, the United States should treat AI-enabled science as a strategic national capability, embedding it into research infrastructure, funding models, and institutional design across all federal research agencies.

More Tracking of China’s Efforts

It is not enough for the U.S. STEM research system to focus more on supporting U.S. national economic power industries. The federal government also needs to do a better job of tracking Chinese directions and progress.

Current intelligence and policy frameworks are heavily focused on applied technologies and commercial developments, often reacting to Chinese innovations only after they have materialized. Using procurement power to accelerate the development of anticipatory models that look at early-stage research, patents, and funding trends would enable the United States to better predict and prepare for technological shifts driven by Chinese scientific advancements.

THE FEDERAL GOVERNMENT CAN'T RELY ON INTEREST GROUPS FOR CHANGE

Bold institutional change is hard. But in the case of U.S. STEM research policy, continuing with the status quo will lead to the United States losing the techno-economic war with China. And relying on interest group pressures for needed change will mean little change.

The core political economy problem with federal STEM research policy is that industry largely relegates it to a minor issue that it doesn't lobby for while the core lobby is the recipient community—in this case, to take a page from Eisenhower, the NSF-scientist-university complex.

And the last thing the science lobby wants is change. In fact, most actively oppose change. The only change they want is more money. We can see that in the science lobby responses to a recent Office of Science and Technology Policy request for comments on science policy. In response to the first question, "What policy changes to Federal funding mechanisms, procurement processes, or partnership authorities would enable stronger public-private collaboration and allow America to tap into its vast private sector to better drive use-inspired basic and early-stage applied research," the most-answered response was predictable: more money.

The American Council on Education, representing 16 higher-ed organizations, said in its response to this question that "we encourage the administration to work with Congress to deliver on sustained and consistent federal funding for the research enterprise."[47]

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When asked, "What reforms will enable the American scientific enterprise to pursue more high-risk, high-reward research that could transform our scientific understanding and unlock new technologies, while sustaining the incremental science essential for cumulative production of knowledge?" the council's response was don't change anything other than give DARPA more money.[48]

In response to, "How can the Federal government support novel institutional models for research that complement traditional university structures and enable projects that require vast resources, interdisciplinary coordination, or extended timelines?" they essentially said that this was not a good idea. Rather, they said that the federal government should allow more indirect costs to qualify for research grants.

"How can the federal government leverage and prepare for advances in AI systems that may transform scientific research?" Answer: more money.

Overall, the university community will also say that it is basic research that produces the largest improvements, not later-stage applied research and certainly not development. Even assuming that this is true, it misses the point. If the U.S. science system keeps producing basic knowledge discoveries that Chinese firms also use and that do not do enough to strengthen U.S. techno-economic power industries, then the United States will be dependent on China.

Many free-market enthusiasts will object that this is inappropriate government intervention in the market. Only basic research is where there is a market failure. And many progressives will oppose giving money that might help business. Nonetheless, it is hard to see how companies in the United States will be able to compete with Chinese advanced companies without such an initiative.

Some will decry industry funding of research universities as somehow corrupting them and turning them away from their true mission of knowledge discovery for its own sake.[49] However, as North Carolina State Professor Denis Gray has documented, industry-university partnerships have no negative effects on academic freedom.[50] It is simply not the case that industry funding comes at the price of high-quality, independent research. If it did, then institutions such as Stanford and MIT should be worse than second-tier universities in their research quality, given how much money they receive from industry. In those and many other cases, high-quality, independent research attracts industry support. The key is not independence or even the phase of research, but rather the orientation. Universities focused more on what Princeton Professor Donald Stokes termed "Pasteur's quadrant" research—basic research directed at a specific challenge or problem—appear to be ones that are more likely to receive industry funding.[51]

If the U.S. science system keeps producing basic knowledge discoveries that Chinese firms also use and that do not do enough to strengthen U.S. techno-economic power industries, then the United States will be dependent on China.

However, many in industry will support this change, although most industry leaders will not be likely to place such change high on their priority list, in part because of the broad national—as opposed to firm—benefits of such a program. Many state governments will support it because of the economic development benefits. And many in the national security community will support it for obvious reasons.

This clearly will make change hard. In this case, the normal process of change in Washington wherein interest groups push changes and Congress and the White House respond will fail to produce needed change. In this case, national economic security interests require that Congress and the White House need to largely ignore status quo interests and recognize that virtually all will oppose needed change.

CONCLUSION

Federal support for STEM research is a key to enabling the United States to not lose to China. But the old Vannevar Bush linear model coupled with a narrow mission-driven model that excludes commercial technology development for national economic power industries is a path to losing.

Bold institutional changes in how the Untied Stats funds research are needed. None of the proposals here are all that complicated, at least in terms of implementation. All they require is the willingness to expand funding and devote it to new kinds of research institutions and programs.

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