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Why the United States Needs a National Advanced Industry and Technology Agency

ROBERT D. ATKINSON | JUNE 2021

With the rise of China, the U.S. economic and technology environment has fundamentally and inexorably changed. The most important step Congress and the Biden administration can take to meet the challenge is to create a dedicated national advanced industry and technology agency.

KEY TAKEAWAYS

- Economy-wide competitiveness policies, like enhancing the R&D tax credit, strengthening the country's STEM workforce, and bolstering digital infrastructure, are all necessary, but they are not sufficient.
- To compete effectively with China, the federal government needs an advanced industry and technology strategy—a set of policies and programs explicitly designed to support *specific* targeted industries and technologies.
- Congress should establish a National Advanced Industry and Technology Agency with the same sized budget as the National Science Foundation to manage an array of policies and programs designed to ensure long-term U.S. advanced industry leadership.
- The new agency should have five divisions: 1) data and analysis; 2) advanced industries; 3) emerging technologies; 4) innovation systems, and 5) cross-agency and cross-government coordination.

INTRODUCTION

With the rise of China and other economic competitors, the United States requires a national advanced technology strategy.[1] While there are many steps Congress and the Biden administration should take—steps the Information Technology and Innovation Foundation (ITIF) has detailed in numerous reports—the most important is the creation of a dedicated national technology agency.[2] Well over 50 nations have already established such bodies.[3] (See appendix A.) This new agency, ideally at least as large as the National Science Foundation (NSF), would lead a number of core tasks, including analyzing U.S. industry strengths, weaknesses, opportunities, and threats and responding with well-resourced solutions, including support for domestic research and development (R&D) and production partnerships and investment in advanced research facilities.

To be clear, we recognize the political difficulty of creating any new agency, given committee conflicts, a view that such reorganization is difficult, and resistance by some to larger government.[4] But doing so is critical. NSF and the academic science community play a key role in the advancement of basic science, but that is different than supporting technological innovation and value capture in the United States. While the Department of Defense (DOD) plays a key role in technology development, its focus will always be on defense needs. The Department of Energy (DOE) is either focused on basic science or energy technology. What the United States lacks and desperately needs is a free-standing federal entity whose sole mission is supporting advanced technology industry development in order to help America compete.

Such an agency should take the lead in crafting and regularly revising a national advanced industry and technology strategy (AITS). It should coordinate, along with the White House, an interagency process to help align federal, state, and international (allied nation) policies and programs with the goal of U.S. advanced industry competitiveness. And it should be the one place in government that funds activities explicitly focused on commercial competitiveness.

The Endless Frontier Act

Before discussing the outlines of a national technology agency, it's worth briefly mentioning the Endless Frontier Act (EFA), which was seen as the principal vehicle for the United States more effectively competing with China in advanced technology industries.

The drafters of the EFA understood the critical importance of increasing support for advanced technology and R&D. The original legislation established a set of well-funded programs, most of which were to be housed in a new directorate of technology within NSF, to support U.S. advanced technology research and commercialization.

However, almost immediately, there was pushback. The scientific community resisted the idea that government would be asking them to do work related to a critical national mission, and to hold them accountable for ensuring that their work helped accomplish that mission. They wanted more money, to be sure; but what they wanted even more was freedom.

As a result, the Senate legislation dropped the proposal to change the name of NSF to the National Science and Technology Foundation. But the revised legislation still maintained the new directorate of technology within NSF that would, after a few years, be funded even more generously than the existing science directorate. But in the final Senate bill (now the United

States Innovation and Competition Act—USICA), this funding was cut significantly, in part to fund the science side of NSF and to provide funding to DOE Labs.

Over the last year, scholars and others have criticized the EFA for a variety of reasons. For example, some have objected to the idea that U.S. technology policy should focus on U.S. interests, instead of supporting a vague and idealized vision of advancing global welfare. Melisa Flagg and Paul Harris of the Center for Security and Emerging Technology wrote, "America will be at its most competitive when it taps the broadest pool of global talent and ideas, and it will be increasingly important to find ways to maintain links even with countries with whom strategic relationships are difficult."[5] In other words, rather than compete with China, we should cooperate with China. Besides, even though U.S. funding for R&D as a share of gross domestic product (GDP) is lower than before Sputnik, more money for research is not needed, they argued.

The original version of the EFA was watered down in USICA, in part because Washington, D.C., is divided into three camps when it comes to the overarching goals for economic and technology policy: the flourishing camp, the freedom camp, and the fairness camp.

Others criticized the act, not because they did not believe a stronger federal mission for supporting commercial technology development was needed, but because they believed that NSF was not the right home and the insertion of a new technology mission risked diverting the core mission of NSF from peer-reviewed science.[6] In addition, some argued that any legislation had to go significantly beyond supporting research. Technology policy experts Pat Windham, Chris Hill, and David Cheney argued that "the idea that university research can and should be the key driver of US technology development and commercialization is a limited and outdated model."[7] This was a trenchant critique, but politics is the art of the possible, and the drafters of the EFA believed that their NSF-based approach was most likely the best path forward.

But it is looking like, at best, EFA is only a partial path forward. The original version of the EFA was watered down in USICA, in part because Washington, D.C., is divided into three camps when it comes to the overarching goals for economic and technology policy: the flourishing camp, the freedom camp, and the fairness camp.

The flourishing camp supports spurring faster per capita GDP growth, more innovation, and greater U.S. competitiveness, especially in advanced industries. This means an antitrust policy that enables large oligopolies to compete globally, a tax code that spurs business investment, and government investment in the building blocks of growth and innovation—especially R&D, new machinery and equipment, critical infrastructures, and worker skills. Flourishing doesn't mean rejecting markets and business, especially nonfinancial businesses. And it doesn't mean rejecting a larger and more strategic role for government. It does mean rejecting freedom and fairness as the overarching goals of economic policy. Virtually all members of this camp support the EFA, or at least its goals.

The freedom camp is focused on limiting the role of government. This means limiting taxes and regulation, keeping U.S. markets open to goods, services, and people, and ensuring that contracts are enforced. The fact that free-market conservatives claim that this is the best recipe for growth is largely irrelevant. Their goal is freedom. As Friedrich Hayek, the patron saint of economic conservatives, stated in his classic book *The Road to Serfdom*, "Personally, I should much prefer to have to put up with some such inefficiency than have organized monopoly control my ways of life."[8]

Some in the freedom camp oppose EFA because they see it as intruding in the free market and being a version of a reviled "industrial policy." These Republicans want any legislation to only focus on China, including spending any monies on the Defense Department, not for commercial technology development.[9]

The fairness camp is focused on ensuring that lower-income Americans have significantly more wealth, income, and access to government services. This means increased regulation, taxes, and spending. For at least a decade, the progressive left has argued that income inequality is out of control, and more recently, that racial and gender fairness should be the overarching political policy goal. One can dispute how much inequality has grown (not as much as most progressives assert) or wages have stagnated (median wages have increased, but not as fast as incomes for the top earners). But the real question is whether fairness should be the principal goal of U.S. economic policy. If it should be, then higher taxes on both companies and the wealthy, more regulation, breaking up big companies, and more government spending make sense. But if faster growth and increased competitiveness should be the overarching goal, then this strategy would be detrimental.

Some in the fairness camp are not thrilled with the idea of federal support for research focused on helping U.S. companies. And some take less seriously the China competitiveness threat and therefore do not believe that technology-based competitiveness should be the main goal of the EFA. Congresswoman and Chair of the House Science Committee Eddie Bernice Johnson (D-TX) exemplified this view when she stated,

> After many months of discussion with dozens of experts and thought leaders, we decided on a somewhat different approach than that taken in EFA.
>
> Andrew Schrank at Brown University … observes that "competitiveness is neither a necessary nor a sufficient basis for equity, sustainability, or security." He goes on to write, "China's industrial policy has improved neither equity nor sustainability. Russia's economic collapse has done little to erode its national security." A similar line of thinking on our part motivated us to reframe the conversation around a new Directorate for Science and Engineering Solutions at NSF that would focus not on developing technology for its own sake—or for the singular goal of competitiveness—but on advancing solutions that will help make people's lives healthier and safer, society more equitable, and the globe more resilient to a changing climate and other threats.[10]

As such, some in the fairness camp have proposed reorienting the EFA to support social policy goals, such as "hybrid learning tools and pedagogies to broaden access to high-quality education … energy technologies ... that align with communities' values and priorities and [technology for] neglected and hazardous infrastructure."[11] They have noted that they are not pushing these goals "just for the sake of not losing scientific leadership to China," which they see as some kind of jingoistic corporate competition. "What does outcompeting China in new technologies—as Senators Schumer and Young seek to do—mean if we fail to advance American ideals of equality, justice, and opportunity?"[12]

In other words, many liberal Democrats see America's new technology policy as one in which science must serve social equity goals, not competitiveness and growth goals.[13] Chairwoman Johnson wrote, "In charting a course for the future of US science and innovation, science policy makers must attend both to the contributions of other areas of research, and to the complicated social and economic aspects of emerging technologies that we have seen so starkly in the rise of the gig economy, and the consequences of pervasive social technologies."[14]

Science now principally is in service of equity and inclusion. She added, "If we do not reimagine an innovation future that is exponentially more inclusive, we will not lead."[15]

A second reason the Senate bill was not as ambitious as originally envisioned was interest group politics. Other federal departments, especially DOE, and members from states with DOE labs wanted a share of the funding.

To be sure, the university science community wanted more money, but not in the way the EFA would allocate it. Ever since the creation of NSF in 1950, the scientific community has resisted anything that smacks of direction and threatened to interfere with curiosity-driven research. Since the publication in 1945 of *Science, the Endless Frontier; A Report to the President on a Program for Postwar Scientific Research* by MIT's Vannevar Bush, the science-based framework has dominated. As Bush noted, "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." The report mentions science 119 times but technology just 5. In this view, innovation is a linear model, with science inputs going in at one end (defined by individual scientist) and innovation coming out the other.

The university science community uses the "Bush Bible" to resist any and all intrusions from the state to direct their work. As noted by former Rep. George Brown Jr. (D-CA), then chair of the House Committee on Science, Space, and Technology and a strong supporter of a national technology policy (including the establishment of a National Technology Foundation), the *Science, the Endless Frontier* report "has often been invoked by the academic research community as an almost biblical command for robust, no-strings-attached federal support of scientific research."[16]

A technology-based view of innovation argues that basic science is just one input, and that good policy means more than supporting investigator-led basic research.

That may have worked when the United States led the world technologically and few nations or foreign firms had the capability to use and build on our global public good investment in basic science. But it does not work now. Basic science spills over internationally much more than applied research and technology development do.

A technology-based view of innovation argues that basic science is just one input, and that good policy means more than supporting investigator-led basic research. It means links with industry. It means funding aligned with key national goals. It means directly supporting industry technology and production efforts. It means supporting engineering, not just science. And it means giving more support to areas of science critical to competitiveness, such as computer science.

Given this deep ideological divide and such strong interest-based opposition from the scientific community, how is it possible to advance an alternative approach, such as a new national technology agency? The answer is White House and business support. Strong White House support is critical to overcoming parochial and ideological recalcitrance in Congress. Business support is also critical. While some in the business community support the legislation, it has not been a top priority for U.S. industry, even technology-based industries and firms. If the White House and industry are willing to spend political capital for the establishment of a national technology agency, the odds of passage go up significantly.

Finally, the potential of China and the United States to "change places" technologically and economically—with the U.S. declining and China advancing—would generate stronger motivation for bolder action. At some point, the economic, technological, and military gap with China will likely become so large that it may provide enough impetus to overcome interest- and ideologically based opposition to a new approach and a new agency.

A NATIONAL ADVANCED INDUSTRY AND TECHNOLOGY AGENCY

An effective AITS would include robust generic technology policies (such as increased funding for science), a stronger R&D tax credit, STEM (science, technology, engineering, and math) workforce policies, and support for digital infrastructure. These and related policies, programs, and actions ultimately need to be governed by a "whole of government" approach, as a "whole of market" approach will not cut it. But these policies, while necessary, would not be sufficient. If America is to effectively respond to the China challenge, it will need to embrace targeted industry and technology policies.

While there are a multitude of different industry and technology policies and programs involved in an AITS, the most important is the establishment of a National Advanced Industry and Technology Agency (NAITA). Currently, there is no entity in the U.S. government with the support of advanced industries and technologies as its mission. As we see with the EFA debate, NSF's mission is about advancing science largely through supporting principal investigators. But technology innovation and commercialization are not part of its mission. Indeed, since NSF's founding, policymakers have occasionally tried to get NSF to focus on broader missions, such as spurring industrial innovation (the Engineering Research Centers program) or technical training (the Advanced Technological Education program). But NSF's leadership and culture have largely rejected these initiatives as foreign bodies, confining them to lesser status within the agency where they can do no harm to its core mission of funding basic science.

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DOE, particularly now with Advanced Research Projects Agency–Energy (ARPA-E), has long had a focus on innovation and commercialization. But its core mission has been on energy and also fundamental scientific research. While energy innovation is important, the U.S. challenge vis-à-vis China goes far beyond energy.

In some ways, DOD could take on the mission of spurring dual-use commercial technology development and commercialization. It knows how to fund research, development, and demonstration (RD&D) programs and bring technologies to the market (in this case, the DOD market for weapons systems). But the U.S. challenge is not limited to weapons systems—although there is considerable interplay between a strong advanced technology sector and national security capabilities. And it is inevitable that anything DOD is charged with related to AITS will be seen through and operationalized in relation to defense needs, not overall U.S. advanced industry and technology capabilities.

The Commerce Department (DOC) may seem the rightful home of such an initiative since it is the only U.S. agency whose mission is supporting U.S. industry and commerce. But DOC is an amalgam of unrelated activities, such as The National Oceanic and Atmospheric Administration (NOAA) and the Census. Its economic analysis functions, such as the Bureau of Economic Analysis (BEA), are focused on broad statistics, not industrial and technology analysis. And the International Trade Administration's focus is on trade issues—which is important, but is too narrow for what is needed.[17] The Bureau of Industry and Security has analytical capabilities, but they are focused narrowly on analyzing export controls. The Economic Development Administration's role is to help lagging regions.

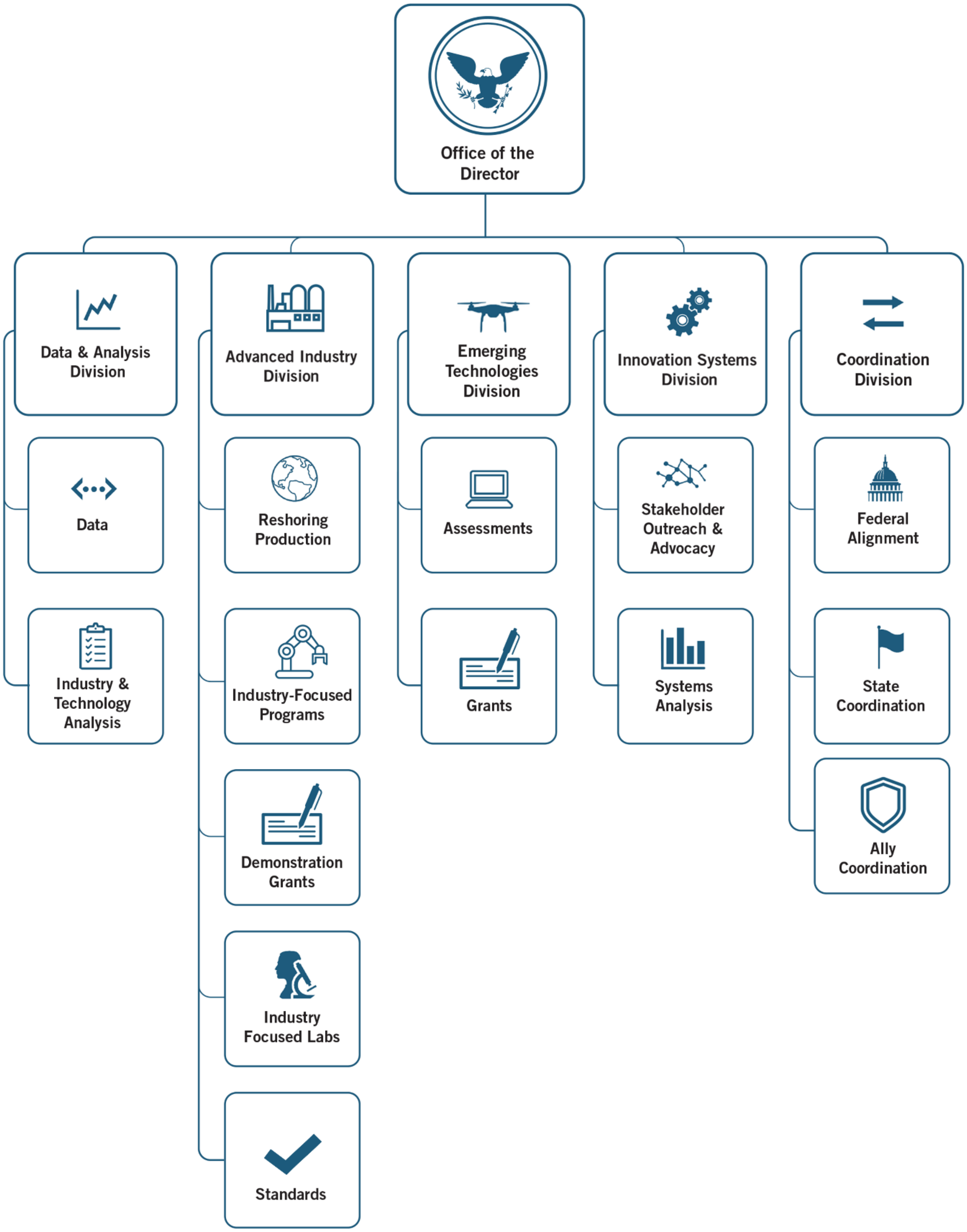
Other agencies that deal with industry, such as the Federal Trade Commission, see their job as that of regulation, not facilitation. Other entities touch on the issue of commercial technology competitiveness, but do not have as their core mission promotion of U.S. industrial competitiveness.[18]

Given its close working relationship with industry and its existing programs for industrial support, such as the Manufacturing Extension Partnership Program and the Manufacturing USA program, the National Institute of Standards and Technology (NIST) is the government body closest to taking on this function. And while NIST performs its functions extremely well, its industrial technology functions are adjunct to its core mission of standards and metrology. (NIST used to be called the National Bureau of Standards before being renamed in 1988 and given new missions related to commercial competitiveness.)

As such, Congress should establish a new government agency—NAITA—to manage an array of policies and programs designed to ensure long-term U.S. advanced industry leadership. ITIF is not the only entity proposing such a new agency. The National Security Commission on Artificial Intelligence has also proposed a similar new technology agency, which they term a "national technology foundation."[19] Similarly, in recent House testimony, technology policy scholar Erica Fuchs has proposed a similar entity.[20]

NAITA should be composed of five major divisions, headed by a presidentially appointed and Senate-confirmed director. (See figure 1.) Advising the director would be a board of 15 to 20 members, with at least two-thirds of which from industry, with others including industrial strategy experts, venture capitalists, and leading engineers and scientists.

Figure 1: Organizational chart for a proposed National Advanced Industry and Technology Agency



Division 1: Data and Analysis

If the economic belief is that all industries are equal—potato chips, computer chips: What's the difference?—then there is no need for economic data or analysis, other than to keep track of output so the Fed can respond to the ups and downs of the business cycle. But if some industries and technologies are critical to America's future, then government has to have strong analytical capabilities.

Why not just rely on private sector analysis from investment firms, consulting firms, and think tanks? While NAITA should certainly be a consumer of these products, there are two main reasons why it needs its own analytical capabilities. The first is that these other organizations very seldom conduct analysis specifically addressing U.S. sector competitiveness and policy strengths, weaknesses, and opportunities. The second is that conducting its own analysis builds key skills and deeper understanding of the sectors and technologies NAITA would be focusing on.

Moreover, during the Cold War, there was virtually no risk to U.S. supply chains if the Soviets decided to take aggressive action against the United States. Our supply chain vulnerabilities were near zero. That, however, is completely different with China. Should we get into a conflict with China, or should China seek to exert leverage over the United States, it has vast capabilities in terms of cutting off needed exports. As such, it is now critical—like it has never been in the history of the Republic—that the federal government has deep, comprehensive insight into the state of U.S. supply chains, especially vulnerabilities vis-à-vis China.

Given these two factors, the paucity of data, much less analysis, on the state of U.S. advanced industries and supply chains is striking.

Notwithstanding the hundreds of millions of dollars spent every year and the thousands of economists working for the federal government, the exact nature of the challenges to U.S. capabilities with regard to the competitiveness of America's traded sectors is only weakly understood. At least since after the Great Depression, the federal government has never felt the need to develop strategic economic intelligence in order to fully understand the competitive position of its traded sectors.[21] To some extent, the intelligence community may have done some of this work; but since most is classified, it does not inform commercial policy and programs.

If some industries and technologies are critical to America's future, then government has to have strong analytical capabilities. Given that, the paucity of data, much less analysis, on the state of U.S. advanced industries is striking.

As George Washington University scholar Andrew Reamer has noted, the opaqueness and limitations of our national statistical system for measuring innovation, sources of productivity growth, and competitiveness make achieving the needed insight daunting.[22] Established after WWII, the system is designed to help facilitate fiscal and monetary policy in order to avoid another Great Depression, and as such, measures things such as the number of houses built and cars manufactured. It does not measure the competitiveness of the electronics industry or auto industry or any other number of important matters (the assumption being that those things take care of themselves).[23] Moreover, other nations and regions such as the EU collect much more detailed data, on firm and industry innovation activities, that can be used to understand key sectors.[24] To be clear, the EU suffers from many significant drawbacks that keep its economy from being more innovative, but data collection is not one of them.

If the U.S. federal government is going to develop more effective policies to spur traded sector competitiveness, including in manufacturing, it will need to get much smarter. The very existence of government policies (tax, trade, regulation, spending, etc.) means government inevitably influences innovation—sometimes for good, sometimes for ill, but almost always by happenstance. Government would be much better positioned to effectively support competitiveness, including how to ensure that regulations do limited harm to U.S. competitiveness, if it were more strategic and knowledgeable. It should be able to understand the U.S. competitive position vis-à-vis other nations on key technologies and industries, as well as key strengths and weaknesses and where specific policies are needed.

Closing Data Gaps

As such, the NAITA analysis division should be charged with identifying data gaps, work closely with other statistical agencies (especially the Census Bureau) to fill those gaps, and then engage in detailed analysis of advanced industry and technology competitiveness issues.

Unfortunately, years of budget constraints have meant that U.S. statistical agencies lack the resources needed to effectively measure key elements of the traded economy.[25] There are numerous examples:

- The Census Bureau could do a better job of measuring data on imports and exports in its Annual Survey of Manufacturers.
- BEA no longer measures manufacturing foreign direct investment and can't distinguish between "greenfield" new plant investment in the United States and foreign purchases of existing U.S. establishments.[26]
- The International Labor Comparisons Program of the Bureau of Labor Statistics (BLS), which used to produce timely, high-quality international comparisons of labor force, productivity, hourly compensation, and prices for many industrialized countries, was terminated.
- BLS reporting of state-level data on manufacturing property, plant, and equipment data ended in 2007.
- BEA could improve its existing annual surveys and five-year benchmark surveys of companies with facilities overseas to identify the types of products manufactured abroad and the number of employees at those facilities.

As such, a portion of the NAITA budget should go toward providing other statistical agencies funding to either conduct special surveys or expand the coverage of existing ones. This improved data would not only help policy analysts inside and outside of government do better analysis, it would provide a new basis for academic research on technological innovation and policy.

Industry and Technology Analysis

It's not enough for the federal government to just collect better data; it needs to analyze it and add value to it. Unfortunately, the federal statistical agencies, with perhaps the exception of the Center for Economic Statistics at the Census Bureau and BLS, do little to interpret their own data. The result is much of it goes unused. One problem is no federal agency has been tasked with performing competitiveness analysis. This explains the recent widespread calls for the Biden administration to step up its analytical capabilities when it comes to trade and industrial competitiveness, to at least close the gap between the country's economically oriented analytical capabilities and its national security–oriented analytical capabilities.[27] Indeed, the closest America has to that now is in DOD's Office of Industrial Policy, but its focus, as expected, is defense oriented.

The federal government needs an economy-wide equivalent of DOD's "net assessment" structure and process, which is a "a framework for strategic analysis" involving quantitative and qualitative information, to assesses current and future military power of the United States and its adversaries.[28] The United States needs the same in-depth practice to assess the commercial power and capabilities of itself and its adversaries. As such, a core task for NAITA should be to conduct competitiveness analysis of key advanced sectors and technologies, including SWOT (strengths, weaknesses, and opportunities) analysis.

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In addition, this should involve working with key stakeholders, including other government agencies, industry, and organized labor, to develop strategic roadmaps of how the federal government can promote the competitiveness of key sectors and technologies. It should incorporate a number of different industry analysis rubrics, such as Pisano and Shih's "Modularity-Maturity Matrix," classifying industries by modularity and maturity, the Porter competitiveness diamond, as well as others, such as type of production (process vs. product, customized vs. mass, etc.).[29] (See appendix B.)

Federal agencies work to advance their own particular missions and are largely unwilling to take into account the impact of their actions on innovation competitiveness, or to coordinate with other agencies. Medical devices are a good example. The Food and Drug Administration reviews the safety and effectiveness of medical devices. The Department of Health and Human Services sets reimbursement schedules. DOD and the Veteran's Administration procure such devices. But there is little to no coordination across agencies to develop a unified strategy to orient government policies to support the competitiveness of the U.S. medical device industry, even though it is a high-value-added sector in which the United States still retains competitive advantage—albeit one that is at risk.

Accordingly, this NAITA division should develop strategic roadmaps and guide interdepartmental efforts to ensure that the regulatory policies and activities of disparate government agencies are, wherever possible, aligned to promote the global competitiveness of strategic sectors of the U.S. economy. It should also assess the nature of U.S. supply chains, particularly in advanced technology industries. The unit should also be charged with identifying and tracking foreign industrial policies, both to provide learning for the United States and to understand better what our competitors, particularly China, are doing. Finally, because there is a need to coordinate advanced industry and technology strategies and programs with allies, this division should also work with close allies on industry and firm data alignment, coordination, and analysis.

Finally, there is a serious human capital gap. Few U.S. universities, including those with economic and public policy programs, provide a grounding in the kinds of skills needed to conduct in-depth industry analysis. While there are a few bastions, such as the Industry Studies Association, many more are needed. As such, one role of NAITA would be to fund scholars committed to this kind of analysis and to support expansion of graduate-level programs with this focus. The data and analysis division should also work to provide training to other government agencies that have industry analysis as part of their mission.

Division 2: Advanced Industry

NAITA's second division would operate a variety of programs focused on boosting the overall competitive position of the United States and key industries.

Reshoring Production

Congress should give NAITA responsibility for programs such as the CHIPS (Creating Helpful Incentives to Produce Semiconductors) Act that, if funded, will provide subsidies to firms to build semiconductor fabrication facilities in the United States. Congress should also enact a program similar to Japan's and Taiwan's, which are providing reshoring grants for companies that have moved production from China back to those either of those two nations.[30]

Cooperative Industry-Focused Programs

Cooperative ventures by firms represent an important process in boosting industry competitiveness. This is why Congress passed the Cooperative Research and Development Act in 1984 to allow firms to seek Department of Justice approval for R&D partnerships. But more should be done.

With the 2014 Revitalizing American Manufacturing Innovation (RAMI) Act, Congress put into statute the Manufacturing USA program, currently run by NIST and made up of 15 industry or technology-specific R&D institutes co-funded by the federal government and industry.[31] To enable more centers to be created, Congress should expand the funding for this and, just as importantly, provide long-term government funding for these centers, just as the Germans do for their long-standing and successful Fraunhofer Institutes, which receive a considerable share of funding from the national and state governments. This is important because China has a network of 15 institutes (which in fact almost exactly replicate the first 15 institutes the United States stood up), on its way to 40, which are being funded at considerably higher levels than U.S. centers. In addition, if Congress were to fund the CHIPS Act to provide research funding for semiconductor companies, NAITA could manage such a program.

Congress could provide funding for industry-focused skills alliances. These alliances would involve partnerships by firms in similar industries or with similar skill requirements. The firms in the industries would have to lead the effort and contribute at least one-quarter of the total funding, with NAITA (and possibly state governments) contributing the remainder.

Congress should also implement a proposal from the early 1990s by economist Paul Romer for the creation of self-organizing industry research boards, similar to agricultural marketing boards, wherein members tax themselves to support programs to benefit the entire industry. Romer highlighted both the importance of collective action and the risk of free riders making collective action difficult. As a case in point, it might be rational for all the firms in an industry to invest collectively in a workforce training program, but because of free riders, the effort never gets made, as everyone seeks to benefit without paying. Romer's proposal would work as follows:

> [Firms] would start by petitioning [NAITA], giving the argument for provision of an industry-specific public good. The [agency] would then hold a hearing to certify that the proposal for collective action addresses a genuine public need. If the proposal passes this test, an election would be held in which all widget manufacturers vote whether to levy, say, a 1 percent tax on widget sales. If a large enough fraction of the industry (measured as a fraction of total sales, as a fraction of the total number of firms, or some combination of the two) votes in favor of this initiative, a tax backed by the full force of law would be imposed on the entire industry. The proceeds from the tax would not, however, go to the government.[32]

The proceeds would go to industry investment boards overseen by NAITA but governed by industry itself. Some industries already engage in similar action, with, for example, such activities being common in agriculture. The cable TV and broadband industry also does this, funding the nonprofit CableLabs to help the industry with new technology and standards.[33] These new boards could be managed by NAITA and loosely overseen by the Department of Justice under the 1984 Cooperative Research and Development Act procedures.

Grants for Demonstrating Key Advanced Technologies at Scale

Companies can be slow to adopt many new production technologies for several reasons, including the risk of going first being high and some of the learning invariably spilling over, making it easier for followers to learn from the mistakes of the leaders and adopt. As such, NAITA should operate a competitive grant program for first-stage pilot programs. Any company in the United States could apply for matched funding to demonstrate an advanced technology production process in a U.S. facility. In exchange, it would have to agree to exchange best practices and lessons with other firms in the United States.

Establish Government Industry-Focused Labs

As a group, the U.S. government labs, including the DOE National Labs, are highly technically competent and sophisticated organizations. But perhaps with the exception of NIST, none are focused on commercial industry. This is in contrast to a number of other nations such as Germany, Japan, South Korea, and Taiwan that have established dedicated national industry-focused labs to work on earlier-stage research and transfer to either existing industry firms or start-ups.

A case in point is Taiwan's Industrial Technology Research Institute (ITRI), which plays a key role in enabling advanced technology innovation. (See box A.) With the loss of large corporate labs, such as Bell Labs and others, that played key roles in funding strategic research (early-stage research, but directed at a solving a particular problem), the U.S. system is lacking such institutions. NAITA should be charged with establishing and funding one or more such labs.

Help Industry Compete Against China in Standards Setting

China is supposedly developing a China Standards 2035 plan to enable it to lead in the shaping of global technology standards.[34] If it can succeed in this task, it will give its firms a significant leg up in global technology competition. But it would be one thing if Chinese technology firms could have their standards adopted internationally because they are the best standards as determined through a fair and open industry-led standards-setting process. But China is not content to do that fairly. The Chinese government pressures Chinese companies to support Chinese proposed standards, even when they might prefer a foreign standard. And China uses its Belt and Road program to pressure other countries and companies to support Chinese standards.[35] NAITA would work with other governments and U.S. companies to better support and enable the voluntary, industry-led standards process.

Box A: Taiwan's Industrial Technology Research Institute

Founded in 1973, ITRI is a nonprofit institute that conducts R&D in applied technologies to advance private-sector growth. Over the past three decades, ITRI has helped Taiwan establish innovative science and technology industries, assisted traditional industries in technology upgrading, provided training for industrial technology talent, and blazed trails for many advanced and critical industries along Taiwan's journey of industrial development. ITRI has played an instrumental role in both transforming Taiwan from a labor-intensive to high-tech economy and building Taiwan's international economic competitiveness. Many of Taiwan's most successful high-tech companies, including the semiconductor titans Taiwan Semiconductor Manufacturing Corporation (TSMC) and United Microelectronics Corporation (UMC), can trace their origins to ITRI.[36]

ITRI has 5,728 personnel, 75 percent of whom hold master's or doctorate degrees. ITRI focuses on six core technology areas: Information and Communications Technology (ICT); Electronics and Optoelectronics; Materials, Chemicals, and Nanotechnology; Biomedical and Medical Devices; Mechanical and Systems; and Green Energy and Environment. ITRI personnel have played an important role in the development of countless next-generation technologies, including WIMAX wireless broadband, solar cells, radio frequency identification technology (RFID), light electric vehicles, flexible displays, 3D ICTs, and telecare technologies. Several ITRI labs, including the Flexible Electronics Pilot Lab and the Nanotechnology Lab, provide international-level research platforms on which R&D can be conducted jointly with global partners. ITRI also focuses on service innovation—in particular, leveraging ICTs to bolster the competitiveness of Taiwan's services industries.

ITRI focuses heavily on the development of applied technologies that can bolster the competitiveness of Taiwan's increasingly technology-based economy. ITRI holds more than 14,571 patents and its personnel produce an average of five new patents every day. In 2010, ITRI filed 2,004 national and international patent applications, of which 1,368 were approved, with 940 of them in foreign countries. In fact, ITRI ranked number 53 in terms of entities receiving U.S. patent grants in 2009, and was the leading patent applicant in China from 2008 to 2009, applying for 490 patents.[37]

But for ITRI, it's not just about creating new technology; it's about taking that technology and spinning it off into viable enterprises. Thus, ITRI has cultivated 70 CEOs and assisted in the creation of over 165 start-up and spin-off companies.[38] In other words, ITRI is about directly creating both new technology and innovative new companies. But ITRI also assists existing companies/industries in technological research and technological upgrading projects. In 2010, ITRI completed 15,139 such "industrial services" cases, with small and medium-sized enterprises (SMEs) accounting for 74 percent, and larger enterprises 26 percent, of firms assisted. ITRI further provided support to 1,189 RD&I (research, development, and innovation) projects at Taiwanese firms in 2010, totaling NT$28.5 billion ($951 million). Of this, 28 percent were in the ICT sector; 24 percent in Mechanical and Systems; 17 percent in Green Energy and Environment; 15 percent in Materials, Chemicals, and Nanotechnology; 9 percent in Biomedical and Medical Devices; and 8 percent in Electronics and Optoelectronics.

Taiwan's experience shows that government support can be crucial in helping a country achieve rapid technological catch-up. ITRI was founded under the direction of Minister of Economic Affairs Sun Yun-suan and the leadership of its first president, Chao Chen Wang. A driving motivation was to transform Taiwan's existing export industries—which were developed in the 1960s and centered on textiles, shoes, plastic toys, and agriculture—to the more sustainable fields of petrochemicals, machine tools, and electronics. ITRI has played a key role in both facilitating synergy and linkage among government, industry, and universities and the successful commercialization of innovative products and services. ITRI has also helped SMEs absorb and assimilate existing technologies they cannot invest in by themselves.

Put simply, ITRI has proven to be instrumental in creating the semiconductor and electronics industry in Taiwan. UMC, spun off from the ERSO division of ITRI, was launched in 1980 in Hsinchu Science Park. It was Taiwan's first mainstream semiconductor company. UMC was followed by TSMC in 1986, the Taiwan Mask Corporation in 1988, and the Vanguard International Semiconductor Corporation in 1994. TSMC's first semiconductor wafer fabrication plant was set up on the ITRI campus in 1985.

Metrics and measures ITRI uses to evaluate its impact include the number of patents granted, licensing income/contracts, the number of spin-off companies, income generated by industrial and research contract services, and the amount of induced investment through incubation operation.[39]

NAITA would scan and assess important emerging technologies; identify what other nations, including adversaries such as China, are doing in these spaces; assess overall U.S. efforts to support the technologies; and, where necessary, fund R&D in them.

Division 3: Emerging Technologies

It is clear that there are a number of emerging technologies that are only partially in the marketplace but hold significant potential for U.S. welfare. These include, among others, artificial intelligence (AI), quantum computing, cybersecurity, robotics, genomics and personalized medicine, high-performance computing, next-generation semiconductors, nano technology and other materials, and advanced clean energy technologies. While there is some coordination of federal efforts in support of these efforts, principally by the Office of Science and Technology Policy, there is no agency in the federal government charged with advancing these and related technologies overall. NAITA would scan and assess important emerging technologies; identify what other nations, including adversaries such as China, are doing in these spaces; assess overall U.S. efforts to support the technologies; and, where necessary, fund R&D in them.

NAITA should be charged with an Emerging Technology Program wherein it puts out calls for proposals for grants in particular technology areas. Funding could go to universities that work with industry, start-ups, and larger companies that commit matching funds. It might also fund programs or policies to help encourage existing technology funders to take a longer-term view in order to counter Chinese venture funders that seek to invest in U.S. firms with more generous terms.

Division 4: Innovation Systems

Many innovation policy analysts focus on firms—with some on industries as a whole, and even fewer on innovation systems. With regard to the health system, take, for example, Kaiser Permanente. The hospital firm itself is considered part of the industry, while the entire health care network (e.g., labs, doctors' offices) is the "innovation system." A systems focus is important because maximizing innovation in many firms or industries requires complementary innovations. Looking only at industries runs the risk of missing system components needed for overall innovation.

There are many aspects of our economy, including transportation, construction, health care, finance, manufacturing, and education for which a systems analysis is key. (See box B.) NAITA would develop core competencies in a number of such key systems, and work with stakeholders to better understand key policy interventions in order to boost innovation in the entire system. In certain cases, this might entail support of precompetitive applied industrially relevant research. In others, it might involve competitive grant programs to help demonstrate certain technology systems, such as smart cities. In others, advocacy for regulatory changes, including streamlining or alignment, will be needed—or funding demonstration projects will be required. In still others, it might be working with government agencies to align government procurement to these goals.

Box B: Innovation in the Construction System

The U.S. construction industry accounts for about 4.5 percent of GDP, but the construction system (lumber and wood products, architecture services, real estate sales, etc.) is much larger.

Over the last 40 years, U.S. construction industry productivity has declined.[40] Many aspects of the industry limit productivity improvement. First, the industry lacks scale. According to the National Academy of Sciences, in 2009, 98 percent of U.S. construction firms averaged fewer than 100 workers each, yet employed 79 percent of all construction workers. In part because of that lack of scale, the industry invests little in R&D, about 1/25th the rate of the broader manufacturing sector.[41] Not only are firms small, they are also generally not horizontally integrated: Different firms deal with different aspects of the system (design, planning, development, engineering, construction management, construction operations), with even more subspecialization. This makes developing and deploying shared tools difficult. For example, as much of the industry involves communication among designers, contractors, suppliers, and construction workers, added costs and delays can be significant, as construction managers often have to wait for crews, materials, or supplies that are stored in the wrong place. A National Academy of Sciences report cites "25 to 50 percent waste in coordinating labor and in managing, moving, and installing materials."[42] Another study finds that "interoperability, the goal of which is to seamlessly integrate systems capable of exchanging and interpreting data among members of the design and construction teams, causes losses of between $15.6 and $36 billion per year."[43] However, emerging technologies such as the Internet of Things could play a key role by enabling everyone in the industry to know where everything is at any time.

Because, however, these inefficiencies occur at both the industry and system level, as opposed to just the firm level, the market is at best a weak mechanism to address these issues. As one study notes, "Once the industry begins to recognize how everyone in the process pays a price for permitting incomplete and uncoordinated design documents, we can start to address the imminence of how new technology will bring greater efficiency and profitability to the entire industry."[44] Taking full advantage of these technologies, though, would require interoperable standards and overcoming chicken-or-egg issues. Why, for example, would construction managers and workers have devices such as wireless tablets if none of their materials can be kept track of electronically?

Second, the industry has relatively weak incentives to improve productivity, in part because customers tend to be relatively unsophisticated, buying buildings only infrequently. As Barry LePatner wrote in *Broken Buildings, Busted Budgets*,

> Contractors have every incentive to bid low on a project to get the job. Because the business is highly competitive at the bid stage, most firms know that their low bid will not return an adequate profit. But after a contractor is awarded a contract, the situation changes radically. The contractor then becomes a monopolist, who will attempt to recoup through change orders the profits denied it by the bid process. This explains the pervasiveness of mutable-cost (open-ended) contracts. Owners realize that, even with a seemingly straightforward fixed-price contract, once they are embroiled in construction, they have few good options but to pay up in order to keep the project moving ahead so as not to incur even greater delays and costs. The industry is caught in this unvirtuous cycle.[45]

Finally, there is significant variation in building codes, permitting processes, and construction-related regulations, usually at the state and local levels. This variation makes it difficult to develop products and solutions that can gain national scale, including more use of prefabrication.

But this is not Baumol's string quartet industry, wherein productivity gains are difficult.[46] In fact, opportunities for productivity improvements that firms are not now taking advantage of appear to be ample. The National Academies of Sciences identified five key areas for improvement, including widespread deployment and use of interoperable technology applications; improved job-site efficiency through more effective interfacing of people, processes, materials, equipment, and information; greater use of prefabrication, preassembly, modularization, and off-site fabrication techniques and processes; innovative, widespread use of demonstration installations; and effective performance measurement to drive efficiency and support innovation.[47] Indeed, given advances in information technology, the industry is ripe for transformation. It is easy to imagine a system whereby architectural plans are prepared using computer-aided design software and sent to various factories where the parts are made with automated machines and partially assembled, then shipped to a site on a just-in-time basis, and finally assembled by workers using highly automated equipment.

Without a construction system productivity agenda, however, system productivity will lag behind potential productivity. Government can play a key role in helping to increase construction system productivity with three main policy approaches: using public procurement to drive competition and change, supporting precompetitive industry R&D, and streamlining and aligning regulation.

Any construction productivity effort should start with a national construction productivity strategy. For example, in response to anemic productivity growth in the industry, the United Kingdom established its Government Construction Strategy in May 2011.[48] In the United States, no national government entity has the mission to examine and then work to improve construction system productivity. If NIST were given a new, more proactive mission—as well as additional funding—it could play this role.

Division 5: Cross-Agency and Cross-Government Coordination

For the United States to meet the China challenge, it will need not only a whole-of-government approach but a whole-of-governments approach, enlisting both U.S. subnational governments and allied national governments in cooperative efforts.

First, there needs to be more alignment within the federal government. While virtually every federal agency takes actions that impact U.S. advanced technology competitiveness, concerns over competitiveness rarely even get a seat at the table. NAITA would have that seat, and just as the U.S. Small Business Administration's Office of Advocacy is charged with being a voice for small business within the entire federal enterprise, NAITA would be charged with being a voice for advanced technology industries and technological innovation. Among other actions, it would do deep-dive assessments of key industries and technologies and how various government agency actions (or lack thereof) affect their competitiveness.

For the United States to meet the China challenge, it will need not only a whole-of-government approach but a whole-of-governments approach, enlisting both U.S. state governments and allied national governments in cooperative efforts.

NAITA would also advise federal agencies and state governments on procurement and investment decisions that might favor Chinese firms. Often, agencies only prioritize their own agency interests when making procurement or investment decisions and are all-too willing to accept the savings that come from buying Chinese technology products that have been unfairly subsidized by the Chinese government. We see that with U.S. metropolitan areas buying Chinese rail cars, and with the United States Postal Service potentially buying a new fleet of vehicles from a company that is partly invested in a Chinese state-backed battery company.[49]

NAITA would also work with other agencies to encourage and assist them in establishing their own innovation strategies and programs. It could help them ensure that procurement and other policies are innovation focused.

In addition, as the State Science and Technology Institute has documented, all states have their own technology-based economic programs.[50] But they are generally underfunded relative to, and often lack alignment with, national needs and goals. NAITA could co-fund state technology initiatives and seek more alignment. In addition, if Congress funds a competitive program to establish regional technology hubs, responsibility for implementation could be shifted to NAITA.[51] And if Congress funded a program like the CHIPS Act, which includes incentives for building semiconductor fabrication facilities in the United States, NAITA could manage the program while also funding projects that states also provide incentives for. Ideally NAITA would manage this program in a way that provides incentives for states to engage less in zero-sum, beggar-thy-neighbor activities such as paying for domestic firms to relocate from one state to another.

Finally, U.S. technology and competitiveness programs should, wherever possible, be aligned with our allies. Given the complexity of both the existing and emerging technology systems, even an economy as large as that of the United States cannot hope to be a global leader in all key technologies. But it can hope that, collectively, America and its allies are leaders. In this sense, the United States needs not just a national industrial strategy but an allied industrial strategy in order to ensure, as a group, allied, democratic nations have the ability to produce innovative products at competitive prices in a set of key areas. Among other things, this means U.S. firms entering into reciprocity agreements with allies such that U.S. firms gain access to their technology policy support programs in exchange for their companies being permitted to participate in U.S. programs. For example, there is no reason U.S. firms could not participate in Canada's Superclusters programs, or Canadian firms to participate in Manufacturing USA center programs.[52]

If its annual budget were the same as NSF's $8.5 billion, NAITA could spend $400 million for staff, office space, travel, and other expenses, and still have over $8 billion leftover for direct funding of the kinds of programs previously listed.

Size and Budget

How large should NAITA be? There are several ways to assess this. One is to benchmark against other national technology agencies. For example, five national technology agencies in other nations sampled employ, on average, 149 staff per million population.[53] To be equivalent, NAITA would need to employ around 50,000 workers. Clearly, this is far too many. But it does suggest that if NAITA were as large as NSF, which employs around 2,500 workers (regular and contract workers), it would still be only modest in size relative to other nations.

If its annual budget were the same as NSF's $8.5 billion, NAITA could spend $400 million for staff, office space, travel, and other expenses, and still have over $8 billion for direct funding of the kinds of programs previously listed. Funding should be multi-year so both NAITA and the organizations it funds could plan for longer-term programs.

If Congress is looking for revenue to fund NAITA, it need look no farther than taxing dividends as normal income instead of at the much lower current rate. The Treasury Department has estimated that the tax break on qualified dividends costs the government $384 billion over 10 years—more than four times the proposed budget for NAITA.[54]

Finally, Congress should design NAITA such that it has more flexibility than most federal agencies, especially with regard to personnel. NAITA will need to be able to hire the best individuals and fire poor performers. In addition, it should have individuals from academia, think tanks, and industry join NAITA for limited periods before moving back to their home organization.

CONCLUSION

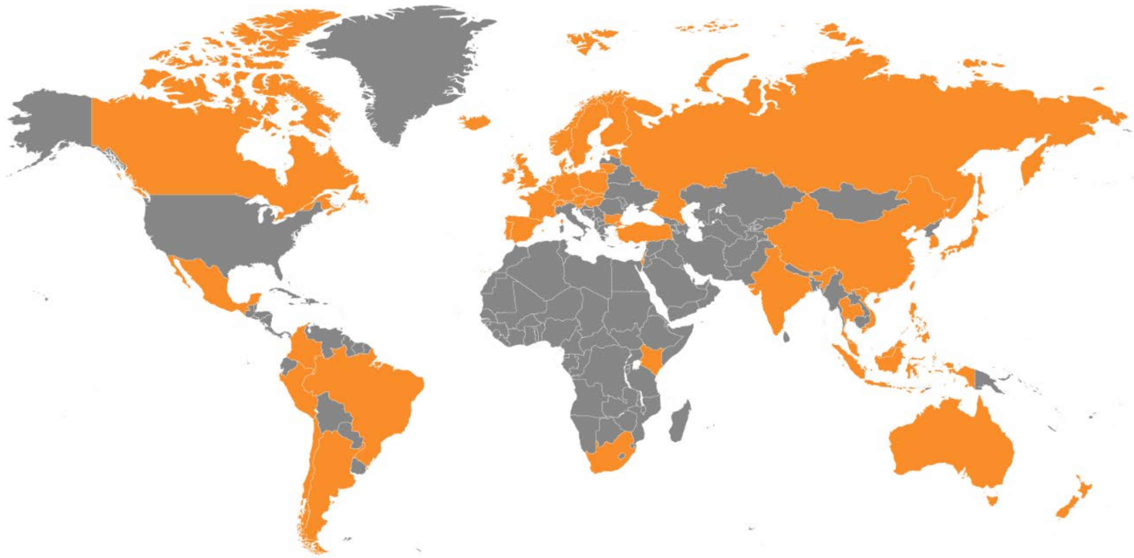
In the first Kennedy-Nixon presidential debate in 1960, John Kennedy highlighted the nature of the challenge facing the country:

> The Chinese Communists have always had a large population but they are important and dangerous now because they are mounting a major effort within their own country; the kind of country we have here, the kind of society we have, the kind of strength we build in the United States will be the defense of freedom. If we do well here, if we meet our obligations, if we're moving ahead, then I think freedom will be secure around the world. If we fail, then freedom fails. Therefore, I think the question before the American people is: Are we doing as much as we can do? Are we as strong as we should be? Are we as strong as we must be if we're going to maintain our independence, and if we're going to maintain and hold out the hand of friendship to those who look to us for assistance, to those who look to us for survival?[55]

Those were the right questions then, and while the world is no longer like it was in 1960, they are the right questions now. If the United States wants to maintain its global leadership in technology and technology industries, especially in the face of the threat that is China, policymakers will need to cast off old attitudes of free markets and limited government as a best recipe, as those will no longer cut it. And policymakers will need to understand that advancing needed goals of equality and broad societal progress will be much more difficult if the United States is a weakened power economically, technologically, and militarily.

There is no entity in the federal government with U.S. advanced technology competitiveness as its core mission. After 9/11, Congress made the decision that the threat of global terrorism was severe enough to reorganize parts of the federal government into a newly created Department of Homeland Security. Many now see the economic, technological, and military threat in a similar light. Surely, if we take that threat seriously, that also warrants spending political capital to reorganize our government to create a NAITA. The federal government needs a national advanced technology strategy, the central pillar of which should be a robustly funded NAITA.

APPENDIX A: GLOBAL MAP OF NATIONS WITH NATIONAL INNOVATION OR TECHNOLOGY AGENCIES[56]



Nations with agencies are shown in orange.

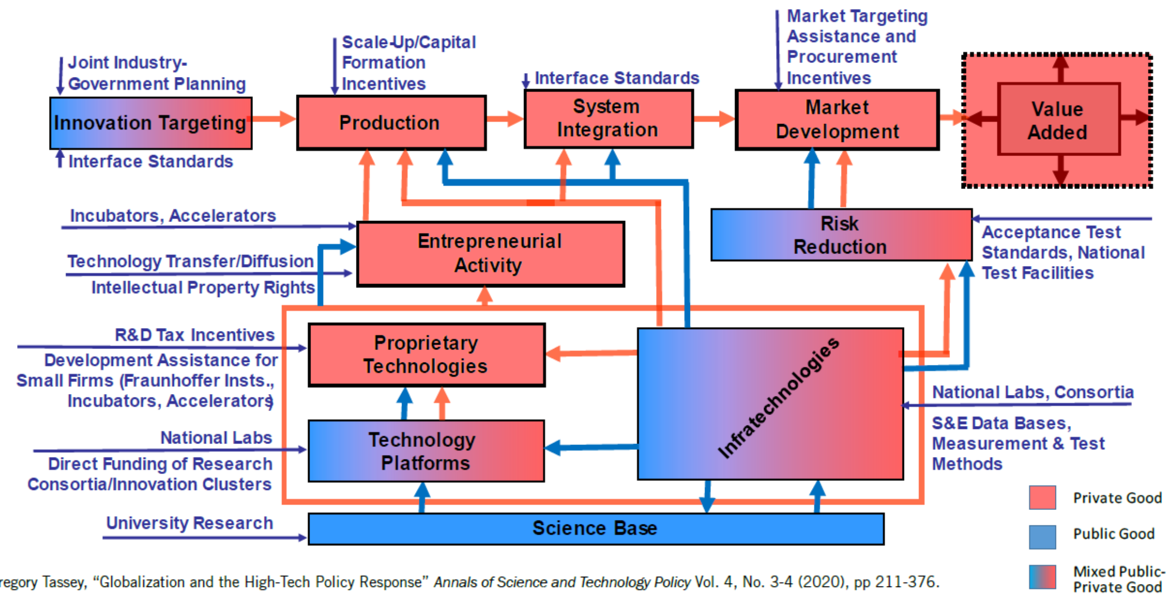
APPENDIX B: CONCEPTUAL FRAMEWORKS FOR INNOVATION AND PRODUCTION SYSTEMS

It is difficult to adequately develop a comprehensive and effective AITS without a proper conception of how advanced innovation and product systems work because individual policy initiatives can and should be designed for particular aspects of the system.

There are a number of conceptual models. Some, such as Tassey's technology element model (figure 2) and that of the Organization for Economic Cooperation and Development's (OECD) conception of national innovation systems, attempt to map the overall advanced innovation and production system and technology life cycle.

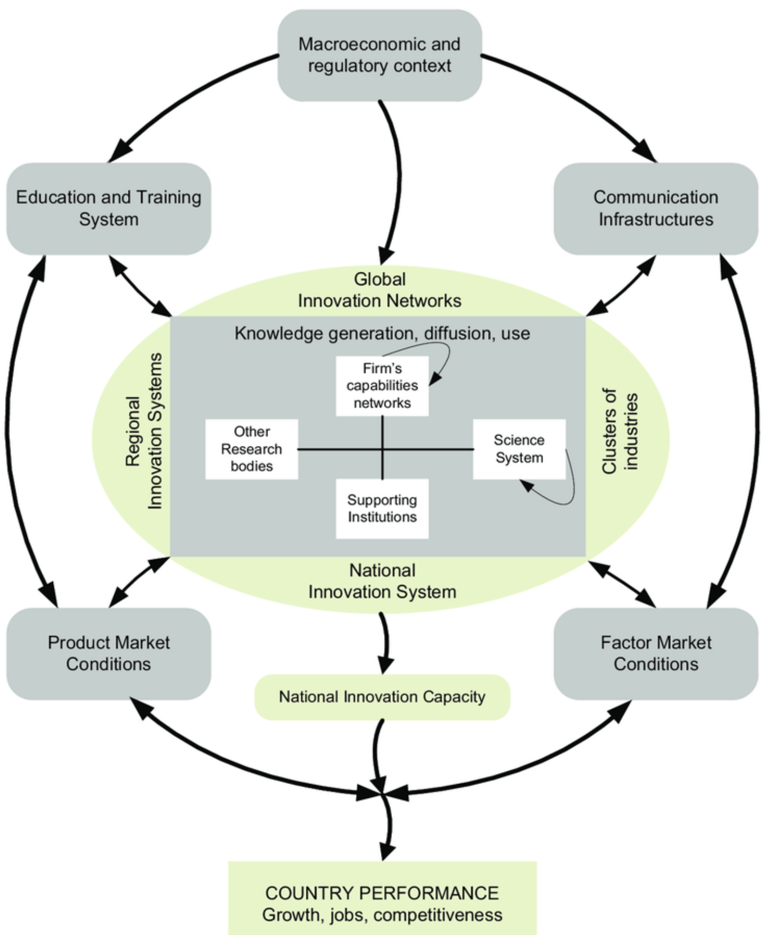
A critical attribute of the policy element model in figure 2 is the disaggregation of an industrial technology into its major elements based on their public-good content and hence public policy requirements. This "technology-element" policy model replaces the "black-box" model that has driven innovation policy for decades, in which industrial technology is asserted to be a totally private good. As previously described, entrenched and outdated philosophies have not recognized the needed roles of government in supporting the development of new technology platforms (crossing the "Valley of Death") and a wide range of infratechnologies that constitute an essential infrastructure, without which emerging technologies cannot be developed and commercialized.

Figure 2: Managing the entire technology life cycle: policy roles in response to market failures



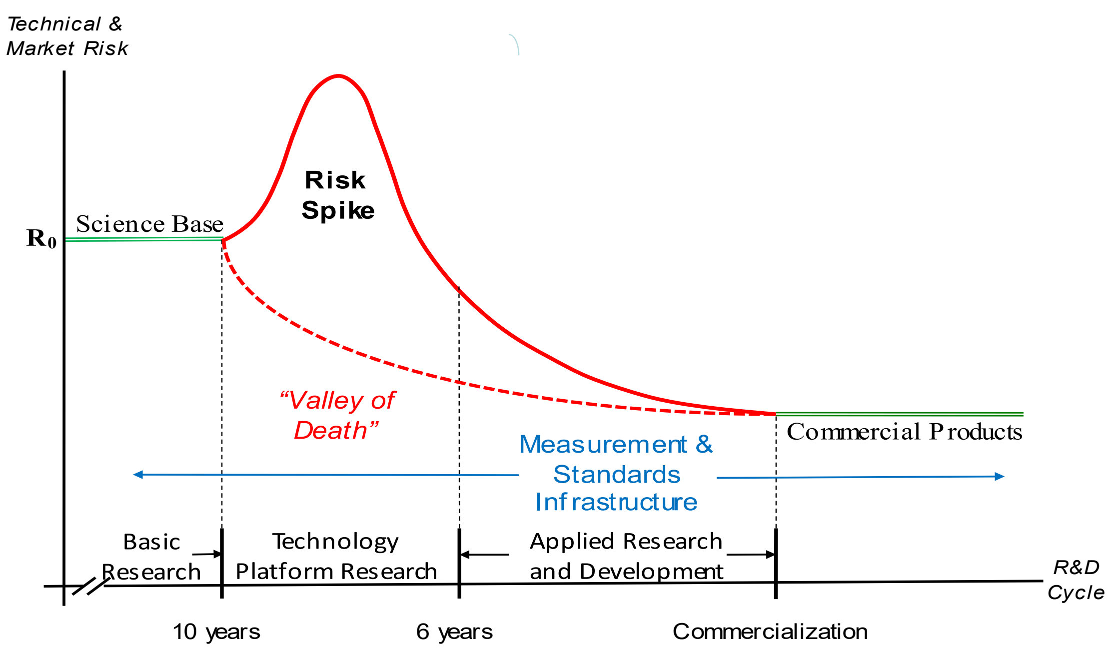
Gregory Tassey, "Globalization and the High-Tech Policy Response" *Annals of Science and Technology Policy* Vol. 4, No. 3-4 (2020), pp 211-376.

Figure 3: OECD framework of actors and linkages in the national innovation system[57]



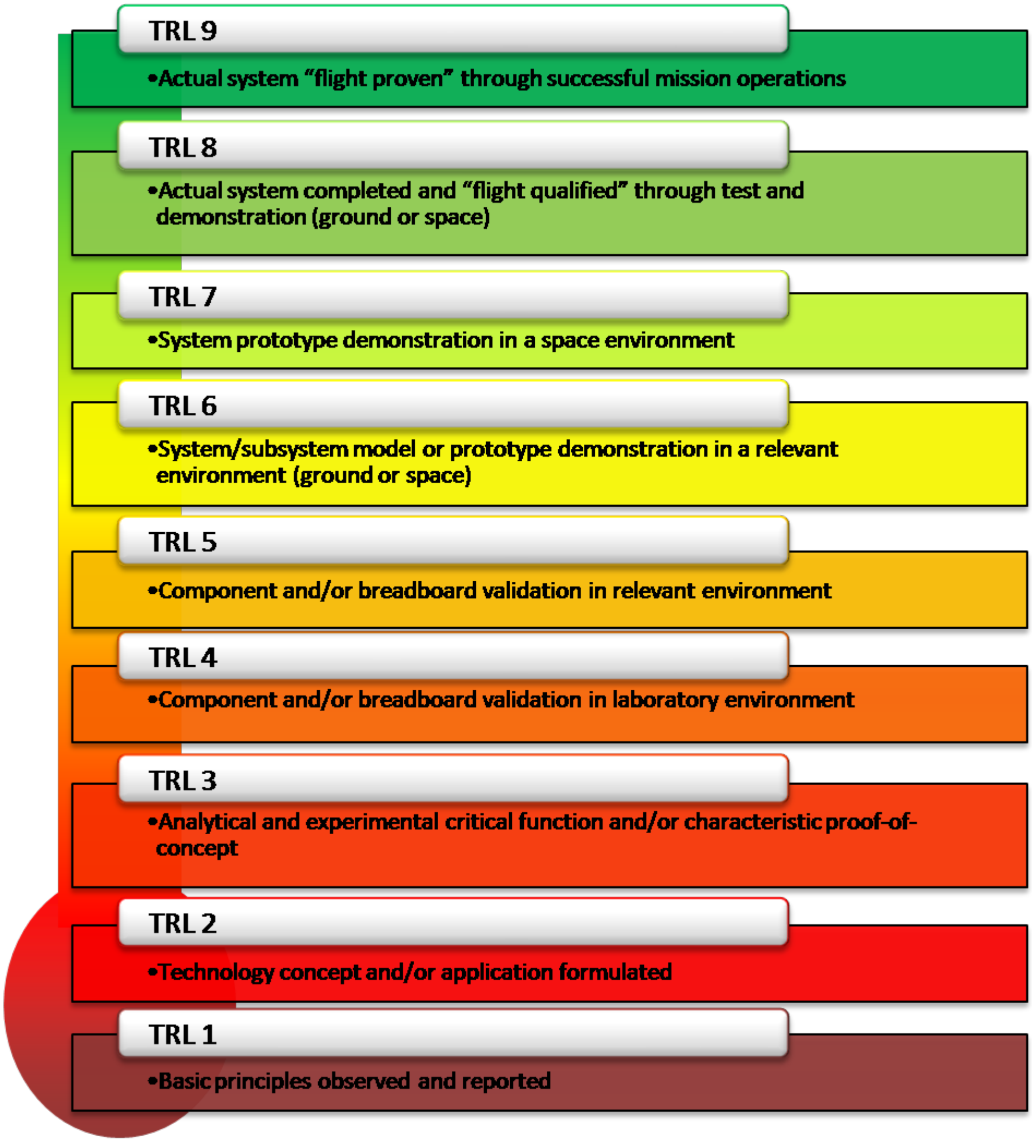
Although there are many feedback loops, technological progress and commercialization procedes in a series of steps from early-stage research to final production. Some of these steps are made more difficult by rather large barriers. In particular, drawing on science to develop a new technology concept/platform can be complicated by severe market failures, as indicated by Tassey's conception of a "risk spike" associated with early-phase technology development (also referred to as the Valley of Death), wherein the progression of innovation can fail to proceed to market (figure 4); and technology readiness levels (figure 5) map the kind of work needed at each stage of technological development. These kinds of linear models could help policymakers and program managers identify where public support is needed and the nature of that support at each phase.

Figure 4: Technology platforms: overcoming the R&D risk spike



Gregory Tassey, "Globalization and the High-Tech Policy Response", *Annals of Science and Technology Policy*: Vol. 4, No. 3–4 (2020), pp 211–376.

Figure 5: NASA technology readiness levels[58]



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About the Author

Robert D. Atkinson (@RobAtkinsonITIF) is the founder and president of ITIF. Atkinson's books include *Big Is Beautiful: Debunking the Myth of Small Business* (MIT, 2018), *Innovation Economics: The Race for Global Advantage* (Yale, 2012), *Supply-Side Follies: Why Conservative Economics Fails, Liberal Economics Falters, and Innovation Economics Is the Answer* (Rowman Littlefield, 2007), and *The Past and Future of America's Economy: Long Waves of Innovation That Power Cycles of Growth* (Edward Elgar, 2005). Atkinson holds a Ph.D. in city and regional planning from the University of North Carolina, Chapel Hill.

About ITIF

The Information Technology and Innovation Foundation (ITIF) is an independent, nonprofit, nonpartisan research and educational institute focusing on the intersection of technological innovation and public policy. Recognized by its peers in the think tank community as the global center of excellence for science and technology policy, ITIF's mission is to formulate and promote policy solutions that accelerate innovation and boost productivity to spur growth, opportunity, and progress.

For more information, visit us at www.itif.org.

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