ITIF | INFORMATION TECHNOLOGY & INNOVATION FOUNDATION

Understanding the U.S. National Innovation System, 2020

ROBERT D. ATKINSON | NOVEMBER 2020

The United States has no national, coordinated innovation policy system. In fact, its overall innovation system has been deteriorating. The country's economic future and national security will depend on rising to the challenge of addressing this problem.

KEY TAKEAWAYS

- The U.S. national innovation system is in crisis, and in need of thorough rejuvenation, especially through significant increases in federal funding.
- A strong national innovation system requires correctly structuring all three sides of the "innovation success triangle"—the business environment, the regulatory environment, and the innovation policy environment.
- While under threat, the United States still has reasonably good business and regulatory environments, but it has a weak innovation policy environment.
- Compared to other nations, the United States is trending downward in its funding for universities, federal labs, and other innovation inputs that policymakers have been unwilling to prioritize in the federal budget process.
- No nation has its innovation system entirely right, but a few come close. The challenge for the United States going forward is whether it can make the changes needed to meet the new global competition, especially vis-à-vis China.

INTRODUCTION

In the conventional view, innovation is something that just takes place idiosyncratically in "Silicon Valley garages" and research and development (R&D) laboratories. But in fact, innovation in any nation is best understood as being embedded in a national innovation system (NIS). Just as innovation is more than science and technology, an innovation system is more than those elements directly related to the promotion of science and technology. It also includes all economic, political, and other social institutions affecting innovation (e.g., the financial system; organization of private firms; the pre-university educational system; labor markets; culture, regulatory, and tax policies and institutions).

Indeed, as Christopher Freeman defined it, a national innovation system is "the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies."[1] Innovation systems matter because a nation's innovation success depends on its national innovation system working effectively and synergistically.

Better understanding of the origins, development, and operation of a nation's innovation system can help policymakers identify key strengths and weaknesses, and policy changes, needed to enhance a nation's innovation performance. Because of a variety of factors, no nation's innovation system is exactly the same as others. Each system is unique and needs to be understood in this context.

The U.S. national innovation system today is in crisis, and in need of thorough rejuvenation, especially through significant increases in federal government funding.

In the post-war period, the United States developed the world's most effective national innovation system. It was not called that—indeed it is referred to as the "hidden developmental state"—but through a set of policies, and most importantly, vast government investment in R&D, most of it focused on maintaining a technological and military advantage over the Soviet Union, the United States became the clear leader in technology. But the fall of the Soviet Union meant that policymakers no longer felt an urgency and presided over the gradual and inexorable shrinking of this once preeminent system. The rise of the ideology of market fundamentalism—which still dominates Washington economic thinking—saw this shift not as a problem but a solution, as markets—not government—should be privileged. As such, the U.S. national innovation system today is in crisis, and in need of thorough rejuvenation, especially through significant increases in federal government funding. Fortunately, as reflected by the growing realization of the China technology challenge and the resultant recent bipartisan congressional advanced technology legislation, there is a growing awareness of this need.

This report first briefly describes the historical evolution of the U.S. national innovation system. It then describes the broad elements of the national innovation system organized around what is termed the "innovation success triangle": the business environment, regulatory environment, and innovation environment. In addition, for each element, it provides a subjective and informal ranking of the U.S. strengths relative to other nations.

THE INNOVATION SUCCESS TRIANGLE

One way to conceptually organize all the factors determining innovation in a nation is to think of an innovation success triangle, with business environment factors along one side of the triangle; the trade, tax, and regulatory environment along another; and the innovation policy environment along the third. Success requires correctly structuring all three sides of the innovation triangle.

An effective business environment includes the institutions, activities, and capabilities of a nation's business community, as well as the broader societal attitudes and practices that enable innovation. Factors specific to business include high-quality executive management skills; strong IT (or as many other nations refer to it, ICT—information and communications technology) adoption; robust levels of entrepreneurship; vibrant capital markets that support risk taking and enable capital to flow to innovative and productive investments easily and efficiently; and a business investment environment that strikes the right balance between short- and long-term goals. Broader factors include a public acceptance and embrace of innovation, even if it is disruptive; a culture in which interorganizational cooperation and collaboration is embraced; and a tolerance of failure when attempting to start new businesses.

An effective trade, tax, and regulatory environment features a competitive and open trade regime, including serious efforts by government to protect its businesses against foreign mercantilist practices; support for competitive markets such that new entrants, including those introducing new business models, can flourish; processes by which it's easy to launch new businesses and bring innovations to market; transparency and the rule of law; a reasonable business tax burden, especially on innovation-based and globally traded firms; a strong and well-functioning patent system and protection of intellectual property (IP); regulatory requirements on businesses that are, to the extent possible, based on consistent, transparent, and performance-based standards; limited regulations on the digital economy, especially toward data privacy and emerging technologies such as facial recognition and artificial intelligence; limited regulations on labor markets and firm closures and downsizing; a balanced approach to antitrust policy that recognizes the benefits of both scale and competition; and government procurement based on performance standards as well as open and fair competition. To be sure, a good regulatory climate does not mean simply the absence of regulations. As we saw with the 2008 financial crisis, the right kinds of regulations are critical to ensuring markets work and innovation flourishes. But nations need a regulatory climate that supports rather than blocks innovators, and creates the conditions to spur ever more innovation and market entry, while at the same time providing more regulatory flexibility and efficiency for industries in traded sectors.

The final leg of the innovation triangle is a sophisticated and strong innovation policy system. While markets and businesses are key to innovation, without effective innovation policy, markets will underperform.[2] An innovation policy system includes generous support for public investments in innovation infrastructure (including science, technology, and technology transfer systems) and ideally targeting to specific technology or industry research areas; funding sector-based industry-university-government research partnerships; reshaping the corporate tax code to spur innovation and IT investment, including R&D and capital equipment and software incentives; a skills strategy, including high-skill immigration and support for science, technology, engineering, and math (STEM) education; encouraging private-sector technology adoption, including by small and mid-sized manufacturers; supporting regional industry technology clusters and regional technology-based economic development efforts; active policies to spur digital transformation in the private and nonprofit sectors, including in digital technology infrastructures (such as smart grids, broadband, health IT, intelligent transportation systems, e-government, etc.); and championing innovation in the public sector.

MAJOR DEVELOPMENT STAGES OF THE U.S. NIS

In order to better understand the U.S. innovation system, it's worth examining the history of the United States in terms of innovation and innovation policy. Clearly this brief overview cannot do justice to this enormously complex topic, but it can provide a basic outline.[3]

For the nation's first half century, there was a long policy conflict between Jeffersonians who advocated for a minimal role for the federal government and idealized a rural and small craftsperson economy, and Hamiltonians who advocated for a stronger role for the government in order to industrialize. The tension was never resolved, but the Hamiltonians did make progress, including funding internal improvements (canals and roadways) and supporting industrialization through tariffs and government expenditures for weapons development, such as the formation of the Springfield Armory in 1777. And since the founding of the Republic, the federal government had a robust patent system embedded in the Constitution.

With the emergence of the steel-based industrial revolution of the late 1890s, the United States joined the ranks of the world leaders, producing a host of leading-edge innovations.

The Civil War represented the transition to a second national innovation system. With the agrarian South no longer represented in Congress, the path was paved for significant legislation to move the nation forward technologically, including the building of the intercontinental railroad, and the passage of the National Bank Act. Congress also created a system of research-based land grant colleges through the Morrill Act. Funding for agricultural research helped power agricultural productivity, which freed up tens of millions of farm workers to power America's growing factories, and helped create larger markets for industrial producers.

Still, for the first 125 years after its founding, the United States was not at the global technology frontier—that advantage was held by select European nations, first the United Kingdom and then Germany. However, with the emergence of the steel-based industrial revolution of the late 1890s, the United States joined the ranks of the world leaders, producing a host of leading-edge innovations. As business historian Alfred Chandler showed, the large American market enabled U.S. firms to successfully enter new mass production industries, such as chemicals, steel, and meat processing, and later autos, aviation, and electronics.[4] Because scale mattered so much to innovation and firm competitiveness, U.S. firms such as DuPont, Ford, GE, GM, Kodak, Swift, Standard Oil, and others became global leaders.

Scale helped, but the United States had other advantages. One was the "greenfield" nature of development. Unlike Europe, which had to overcome a pre-industrial craft-based system, the American economic canvass was newer, enabling new forms of industrial development to be more easily established. Another advantage was the unrelenting commercial nature of the American culture and system, where commercial success was valued above all else. As President Calvin Coolidge famously stated, "The business of America is business."

Moreover, policy to spur competition—through the Sherman Antitrust Act of 1890 and the Clayton Antitrust Act of 1914—was used to ensure firms had the incentive to continue to innovate. And as Charles Morris's *The Dawn of Innovation: The First American Industrial Revolution* shows, wars (including the War of 1812, the Civil War, and WWI) energized government-funded technology and industrial development, including helping metal-industry innovation such as precision metal measurement and interchangeable parts. During WWI, the government played a key role in advancing aviation and also electronics, with the secretary of Navy, Franklin Roosevelt, taking the lead in the formation of the Radio Corporation of America (RCA). Notwithstanding these factors, by and large, America's industrial innovation prior to WWII was principally powered by private inventors and firms.

This changed dramatically after WWII with the emergence of a more science-based system of innovation (inspired in part by Vannevar Bush, director of the U.S. Office of Scientific Research and Development during WWII) which would become dominated by large firms and the federal government. The establishment—initially in the Great Depression and then after the war—of large, centralized corporate R&D laboratories helped drive innovation in an array of industries, including electronics, pharmaceuticals, and aerospace. On top of this, the massive federal support for science and technology in WWII helped develop the "arsenal of democracy" the Allies used to beat back the Axis powers' threat.

With WWII and the subsequent rise of the Soviet threat, the federal government constructed a new innovation system. The massive expenditures on weaponry and R&D in World War II positioned the United States as the global leader in a host of advanced industries, including aerospace, electronics, machine tools, and others. The response to the Soviet threat—exemplified by Sputnik—helped cement America's technology leadership. By the early 1960s, the federal government invested more in R&D than every other foreign government and business combined.

This strong federal role continued after the war, with substantial funding of a system of national laboratories and significantly increased funding of research universities. In 1945, the Army published a policy affirming the need for civilian scientific contributions in military planning and weapons production. In 1946, Congress created the Atomic Energy Commission and a system of national laboratories. The Department of Defense (DOD) established the first FFRDC (RAND) and University Affiliated Research Centers in 1947. Congress passed the Defense Production Act of 1950 and also created the National Science Foundation (NSF). Eisenhower pressed for the passage of the Interstate Highway Act. The Defense Advanced Research Projects Agency (DARPA) and NASA were established in 1958. And it provided the critical, although usually overlooked, inputs to America's key technology hubs, including Boston's Route 128 and Silicon Valley. Indeed, even in the late 1980s, Silicon Valley's Santa Clara received more DOD prime contract award dollars per capita than any other county.

Federal funding of research helped drive innovation and played a key role in enabling U.S. leadership in a host of industries, including software, hardware, aviation, and biotechnology. This funding enabled the development of a host of critical technologies we enjoy today, including jet aircraft, the Internet, GPS, LED lighting, microwaves, radar, networked computers, wireless communications, and many others.[5] For the most part, this research was funded through mission-based agencies seeking to accomplish a particular federal mission (e.g., Defense, Health, Energy) and through a system of peer-reviewed basic research funding at universities.

In fact, the explicit promotion of innovation and productivity as an economic goal was largely ignored and even rejected through most of the post-war period. To be sure, there were occasional efforts during the Kennedy, Johnson, and Nixon administrations, but these were small-scale and largely short-lived. The first major post-war federal effort to explicitly support industrial innovation was made by the Kennedy administration in 1963, with its proposal for a Civilian Industrial Technology Program (CITP). The administration proposed CITP to help balance the overriding focus of federal R&D on defense and space exploration, both of which had increased as the United States sought to counter the Soviet Union in the Cold War.[6] CITP was to provide funding to universities to do research helping innovation in sectors thought to help society, such as coal production, housing, and textiles. But despite the administration's efforts to launch the program, Congress did not approve it, in part because of industry opposition that feared disruptive technologies. For example, the cement industry opposed the program because it feared that innovation in housing technology might reduce the need for cement in construction.

Attempts by the federal government to explicitly support commercial innovation were at best made in fits and starts, and never really got off the ground.

Two years later, the Johnson administration was able to get a redesigned effort through Congress, but only after making a number of changes. The new program, the State Technical Services program, was to fund university-based technology extension centers in the states that would work with small and mid-sized companies to help them better utilize new technologies. But despite the program's success, the Nixon administration eliminated it, largely on the grounds that this was an inappropriate federal intervention into the economy. However, the Nixon administration proposed its own initiative, the new Technology Opportunities Program, again to support technology in solving pressing social challenges, such as developing high-speed rail and curing certain medical diseases. But again, the program was not funded by Congress.

These attempts by the federal government to explicitly support commercial innovation were at best made in fits and starts, and never really got off the ground. Moreover, they were not guided by any overriding vision or mission, unlike the government's efforts to develop defense and space technology, which were motivated by the need to respond to the Soviet threat. And they certainly were not linked to overall economic policy, which remained focused principally on reducing business-cycle downturns, and, depending on the political party in power, reducing poverty.

This system began to gradually change in the late 1970s with the emergence of competitiveness challenges from nations such as Japan and Germany. It was with the election of President Jimmy Carter in 1976 that the federal government began to focus in a more serious way on the promotion of technology, innovation, and competitiveness. The motivation for this was the major recession of 1974 (the worst since the Great Depression), the shift in the U.S. balance of trade from one of surplus to one of deficit, and the growing recognition that nations such as France, Germany, and Japan now posed a serious competitiveness challenge to U.S. industry.

These efforts were followed up by efforts by Congress and the Reagan and Bush I administrations. Indeed, policymakers responded with a host of policy innovations, including passage of the Stevenson-Wydler Act, the Bayh-Dole Act, the National Technology Transfer Act, and the Omnibus Trade and Competitiveness Act. They created a long list of alphabet-soup programs to boost innovation, including SBIR (Small Business Innovation Research), NTIS (National Technical Information Service—expanded), SBIC (Small Business Investment Company—reformed), MEP (Manufacturing Extension Partnership), and CRADAs (cooperative research and development agreements). They put in place the R&D tax credit and lowered capital gains and corporate tax rates. They created a host of new collaborative research ventures, including SEMATECH, NSF Science and Technology Centers and Engineering Research Centers, and the National Institute of Standards and Technology (NIST) Advanced Technology Program. And they put in place the Baldridge Quality Award and the National Technology Medal.

Moreover, it wasn't just Washington that acted. Most of the 50 states transformed their practice of economic development to at least include the practice of technology-led economic development. Many realized that R&D and innovation were drivers of the New Economy, and state economies prosper when they maintain a healthy research base closely linked to commercialization of technology. For example, under the leadership of Governor Richard Thornburgh, Pennsylvania established the Ben Franklin Partnership Program that provides matching grants primarily to small and medium-sized firms to work collaboratively with Pennsylvania universities.

But by the time Bill Clinton was elected in 1992, America's competitiveness challenge appeared to be receding. Japan was beginning to face its own problems, in part stemming from the popping of its property bubble and increasing value of the yen. And Europe was preoccupied with its internal market integration efforts. Moreover, with the rise of Silicon Valley as a technology powerhouse, and of the Internet revolution and companies such as Apple, Cisco, IBM, Intel, Microsoft, and Oracle, America appeared to be back on top, at least when it came to innovation. And most importantly, the collapse of the Soviet Union eliminated what had been a principle motivation for bipartisan cooperation and activity to ensure the United States was the world's leading technology power. Once that was gone, other priorities such as balancing the budget and increasing spending on social services soon trumped national innovation. As such, federal spending on innovation policy gradually shrank year after year, to the point where today as a share of gross domestic product (GDP) it is where it was before Sputnik

On top of that, the information technology entered into a new phase, with more powerful microprocessors, the wide-scale deployment of fast broadband telecommunications networks, and the rise of Web 2.0 social network platforms. As a result, it became clear to many policymakers that IT (or ICT) was now a key driver of growth and competitiveness, and that effective economic policy now had to get IT policy right.

Toward that end, the Bush II administration and Congress undertook a number of initiatives. Building on the Clinton administration's Internet Governance Principles, which argued that government should take a light touch toward regulating the Internet, the Bush administration took a number of steps to spur IT innovation, including deregulating broadband telecommunications (now that most American homes had access to at least two broadband "pipes"— cable and DSL), freeing up radio spectrum for wireless broadband, taking a light touch with respect to regulating online privacy, and using IT to transform government itself (e-government). The fact that the

United States was the clear leader in IT, including the emerging Internet economy, led many to believe all was well.

But while much of IT was thriving, U.S. industrial competitiveness was not. The United States lost over one-third of its manufacturing jobs in the 2000s, with the majority lost due to falling international competitiveness, not superior productivity.[7] The United States went from running a trade surplus in high-technology products in 2000 to around a $100 billion deficit a decade later. While the United States used to produce significant amounts of electronic products, including computers, much of that went to China. In fact, by 2017, the trade deficit with China in electronic products was $184 billion.[8]

There are three elements of a national innovation system: the business environment, the regulatory environment, and the innovation policy environment.

In any case, the state of U.S. industrial innovation and competitiveness has gained renewed attention after the losses of the 2000s, the Great Recession, and the emergence of robust new technological competitors—especially China. Because of this, the Obama administration proposed a number of initiatives, including the establishment of a National Network of Manufacturing Innovation (three centers have already been announced); an expansion in the research and experimentation (R&E) tax credit; increased funding for science agencies (including NSF, NIST, and Department of Energy (DOE)); policies to expand the number of STEM graduates; patent reform; and increased efforts to limit unfair foreign "innovation mercantilist" policies, among others. Congress has also introduced a variety of similar measures."

The Trump administration brought a new approach to dealing with the China challenge, but largely eschewed any formal technology policy, actually proposing cuts in overall federal R&D.[9] More recently, bipartisan efforts in Congress have led to the introduction of a number of major technology competitiveness bills to respond to the China technology challenge.

ELEMENTS OF THE U.S. NIS

As previously described, there are three elements of a national innovation system: the business environment, the regulatory environment, and the innovation policy environment. This section describes each, and the U.S. performance.

Business Environment

The business environment consists of three broad factors: market and firm structure and behavior; the system for financing business; and related social and cultural factors affecting how business operates.

Market and Firm Structure and Behavior

Managerial Talent

When it comes to managerial talent, it appears the United States is the world leader, and this factor has played a role in explaining past U.S. innovation leadership. As professor John Van Reenan and colleagues have shown, "[When] it comes to overall management, American firms outperform all others."[10] In part, this comes from environmental factors that force better management: more competition and more flexible labor markets. But it may also come from the fact that the United States developed the discipline of management (in the 1950s) and perfected it through its extensive system of business schools at universities.

Time Horizon and Risk Appetite of Firms

Despite the high quality of many U.S. managers, they increasingly find themselves in firms buffeted by pressures for short-term performance, which in turn reduces their ability to invest for the long term. For example, in a 2004 survey of more than four hundred U.S. executives, over 80 percent indicated that they would decrease discretionary spending in areas such as R&D, advertising, maintenance, and hiring in order to meet short-term earnings targets; and more than 50 percent said they would delay new projects, even if it meant sacrifices in value creation.[11] One recent study by the CFA Institute finds that while some progress has been made in the last 15 years, too many companies are still too short term in their orientation.[12] This focus on maximizing short-term returns means companies are effective in reducing waste and pulling the plug on poor investments. But at the same time, this pressure to achieve short-term profits all too often has meant sacrificing long-term investment, which is the majority of investment in innovation. As the Business Roundtable, the leading trade association for large American businesses, reported, "[T]he obsession with short-term results by investors, asset management firms, and corporate managers collectively leads to the unintended consequences of destroying long-term value, decreasing market efficiency, reducing investment returns, and impeding efforts to strengthen corporate governance."[13]

ICT Adoption

U.S. firms are among the world leaders in adoption of ICT (e.g., hardware and software). In 2000, U.S. firms invested more as a share of sales in capital investment in hardware, software, and telecommunications than only one other Organization for Economic Cooperation and Development (OECD) nation (Sweden).[14] But that lead has shrunk. OECD reported that in 2015, seven other nations saw more business investment in software and IT equipment as a share of GDP than the United States.

However, in some areas, U.S. performance is better.[15] The United States ranks fourth in the share of businesses using cloud computing services.[16] And Van Reenan and Bloom found that U.S. firms appear to get more benefit out of IT investment than many other countries' firms. In part, this is because U.S. firms are more willing to use IT to fundamentally restructure production processes.[17]

Business Financing System

Venture and Risk Capital

With the establishment of the American Research and Development Corporation in 1946, the United States pioneered the venture capital industry—and remains a leader. Hundreds of private venture capital firms across the nation analyze and fund investment opportunities. The industry does more than invest funds; it also helps with key management functions such as serving on boards and advising on business strategy.

Over the last decade or so, the amount of venture investing has grown significantly, with the value of deal investment growing 4.6 times from 2006 to 2019, and the number of deals growing 3.6 times. Moreover, angel and seed funding deals grew 11 times to 5,207.[18] However, most venture capital placements are concentrated in a few states (e.g., California and Massachusetts, and to a lesser extent Colorado and Washington). However, from 2006 to 2019, venture capital funding grew slightly slower in New England and the West Coast than in the rest of the nation.

There is also a robust "angel capital" system in the United States made up of private individuals of high net worth who invest money in entrepreneurial, high-growth companies.[19]

Some state governments have also established programs to help with venture funding, particularly to smaller and earlier stage start-ups. Some have also created angel capital networks to help private funders better coordinate their efforts and find deals. And the federal government, through the Small Business Administration's Small Business Investment Company, provides capital subsidies to some private-sector venture firms, while the SBIR program provides modest research grants to small firms.[20]

Firm Finance (Debt and Equity)

Firms in the United States have access to a wide array of financing sources, the vast majority of which are provided by the private sector. While the initial public offering (IPO) market is smaller than it has been in the past, many growth-oriented innovation-based firms are able to obtain capital through IPO placements. In 2019, firms raised around $39 billion through IPOs, down from the boom years of the late 1990s, but generally greater than a decade ago.[21] Small, high-growth start-ups firms also use acquisitions by larger firms as an "exit" strategy, although some in the antimonopoly camp have recently argued that large firms should be limited in their ability to purchase start-ups

Government financing for firms is quite limited. Existing firms can raise additional money on highly traded and liquid equities markets. And corporate debt, either through bonds or loans, is widely available. At the federal level, the Small Business Administration provides some direct and indirect lending to small firms, but this is not targeted to innovation-based firms or firms in traded sectors—and in fact, the significant majority goes to local-serving industries such as dry cleaners, restaurants, and liquor stores. And many state governments provide modest financing for industrial expansion and early stage firms.

Cultural Factors

As scholars such as Francis Fukuyama, Raquel Fernandez, Lawrence Harrison, and Samuel Huntington have shown, cultural factors such as trust, group orientation, and risk taking have impacts on innovation and growth.[22]

Nature of Customer Demand

As Michael Porter's work on competitive advantage indicates, nations with demanding consumers are in a better position because it puts pressure on firms to innovate and be more efficient.[23] While there is little good data on this, it appears American consumers are more demanding than those in many other nations. Moreover, thanks to the Internet, and applications such as Yelp and others, most U.S. consumers have immediate access to a wealth of information about businesses. We see this in terms of comparing U.S industries to ones in Europe. For example, standard business traveler hotel quality in the United States appears to be far superior to Europe, in part because American consumers demand higher quality.[24] Columbia professor Amar Bhidé has also argued that the "venturesome consumption" nature of American consumers—that is, their eagerness to be early adopters of and experiment with new products and technologies—has played a role in supporting U.S. innovation success.[25] For example, a Microsoft survey found that

54 percent of customers in the United Kingdom, 53 percent in Japan, and 58 percent in Germany don't think their feedback to businesses is taken seriously, while only 45 percent of Americans think that way.[26]

Risk Taking and Entrepreneurship

The United States has long been seen as having a culture of "Yankee ingenuity," meaning a deep-seated interest in tinkering, inventing, and making things better. At the same time, in part because the United States is a nation of immigrants, who by definition took a major risk to move from their native country, the United States has a strong culture of risk-taking and entrepreneurship. Combine that with a distinct culture of individualism, and this makes it easier for people—whether they are a Steve Jobs or a worker on the shop floor—to question established ways of doing things.[27] Moreover, unlike many other nations, failure in starting a new business does not doom a professional career. (In fact, it's been said that some Silicon Valley venture capital firms don't want to see entrepreneurs' business plans until they're on their third start-up.) And compared with most other nations, Americans are more willing to take risks in terms of financing, and see the potential benefits as higher.[28]

In part because the United States is a nation of immigrants, who by definition took a major risk to move from their native country, the country has a strong culture of risk-taking and entrepreneurship.

Attitudes Toward Science and Technology

For much of its history, American culture was characterized by a general belief in the inevitability of social and economic progress. Historian Merritt Roe Smith discussed in a sampling of books from the period of the 1860s to the early 1900s with titles such as *Eighty Years of Progress*, *Men of Progress*; *Triumphs and Wonders of the 19th Century*, *The Progressive Ages or Triumphs of Science*, *The Marvels of Modern Mechanism*, *Our Wonderful Progress*, *The Wonder Book of Knowledge*, and *Modern Wonder Workers.*[29] As economist Benjamin Anderson wrote in the 1930s, "[O]n no account must we retard or interfere with the most rapid utilization of new inventions."[30] While America still largely tilts toward innovation, the anti-innovation forces in U.S. culture are stronger today than ever in American history. Whether it is fears of job loss from automation, privacy loss from the Internet, or environmental damage from nano-tech or biotech, anti-technology forces—in the media, "public interest" groups, and the public at large—continue to gain influence, making it harder for the U.S. economy to press ahead with innovation, and making it more likely to adopt precautionary principle-based regulations, if not outright technology bans.[31] Case in point: When MIT's project on the future of work calls for the federal government to "tax robots" to slow down automation, it's clear there has been a major shift in the American political economy toward innovation.[32]

Collaborative Culture

While innovation is about competition, it's also about "coopetition" and cooperation—in other words, groups working together to drive innovation. This has become more important to enabling innovation, especially as innovation has become more challenging, with more organizations embracing open innovation. As Fred Block found, the nature of the U.S. innovation system became more collaborative.[33] Using a sample of innovations recognized by *R&D Magazine* as being among the top 100 innovations of the year from the 1970s to the 2000s, they find that while in the 1970s almost all winners came from corporations acting on their own, in the 2000s, over two-thirds of the winners came from partnerships involving business and government, including federal labs and federally funded university research. The culture of collaboration in places such as Silicon Valley and Boston's Route 128 is one of the keys to their success. Likewise, the ability of some leading U.S. universities to work cooperatively with industry has been key to driving regional innovation hubs and clusters. These collaborative learning systems, especially in clusters, are supported in part by strong IP protections—people aren't afraid that if they talk and share they will lose proprietary IP.

Time Horizon and Willingness to Invest in the Future

For much of American history, Americans have been willing to sacrifice current consumption for future income by supporting high levels of private and public investment. Over the last three decades, this has become more challenging, as the focus of most voters and the overall political system has shifted toward current consumption, either in the form or lower taxes or greater spending. In the 1960s, when federal support for R&D amounted to 1.75 percent of GDP, this meant Americans were willing to invest 2.8 percent of their income in government R&D.[34] Today, with per capita incomes more than three times higher in real dollars, Americans are only willing to invest just 0.87 percent of their income in government R&D (just 17 percent of the 1960s level).

Trade, Tax, and Regulatory Environment

While the business environment plays the key role in determining innovation success, government policy plays a powerful enabling (or detracting) role, particularly through the broad areas of trade, tax, and regulatory policy that shapes the innovation environment.

Regulatory Environment

Industry Structure and the Nature of Competition

Generally, the United States has embraced an approach to competition and competition policy based on maximizing consumer welfare. In contrast to the "ordoliberal" tradition of EU antitrust policy which embraces both economic and social goals, and in particular focuses on preserving competition for its own sake, the U.S. approach until recently was oriented to maximizing consumer—as opposed to producer—welfare, and was focused on anti-competitive behavior more than on market power per se.[35] However, in the last several years, there has been an increasing push from "neo-Brandeisians" for a wholesale shift in U.S. antitrust policy to focus more on limiting firm size, regardless of conduct, and on limiting competitive effects on other businesses, especially small business.[36] The recent majority report from the House Judiciary Committee on digital maker competition reflects this trend.[37]

While there is considerable disagreement about exactly where antitrust policy should be on the continuum of more or less competition, one can make the case, as Robert Atkinson and Michael Lind do in *Big is Beautiful: Debunking the Myth of Small Business* that U.S. antitrust policy has been too stringent, limiting the emergence of the kind of scale needed to win in global competition, and too focused on consumer welfare rather than overall economic welfare.[38]

Moreover, in comparison with many other nations and regions, especially Europe, the U.S. NIS erects relatively few barriers to entry for firms to break into existing markets, thus ensuring robust competition and the constant threat of "Schumpeterian" creative destruction. We have seen this in industries as diverse as financial services, energy production, and transportation. In addition, the U.S. system attempts to create a level playing field with e-commerce competitors, enabling new entrants to disrupt existing markets and business for the advantage of the consumer. However, entrenched interests in industries such as real estate, car sales, taxi services, hotels, legal services, and others continue to seek to use laws and regulations to limit competition.

Combine this change in attitude with a very large national debt, and it becomes increasingly difficult for federal elected officials to ask American voters to pay more to support expanded financial support for innovation.

Regulatory System for Entrepreneurship

Academic research shows that delays caused by entry regulations are associated with lower rates of firm entry.[39] In 2020, the United States ranked sixth on the World Bank Index of ease of starting a business, behind nations including Denmark, Korea, New Zealand, and Singapore.[40] This is down from number 1 in 2004.[41] Moreover, it is not only relatively easy to start a new business, but it is also easy to close one or lay off workers, at least in the non-unionized, non-governmental share of the economy.[42] The latter is important, for if entrepreneurs cannot easily close or downsize businesses, and if investors cannot obtain reasonable capital recovery rates, the incentives for entrepreneurship are reduced.[43]

Role and Form of Regulation

The U.S. system of regulations, many of which affect innovation, begins with Congress passing legislation and sometimes requiring executive branch agencies to promulgate regulations. These agencies go through an extensive public notice and comment period in which individuals and organizations can submit written comments that the agencies are required to review. In addition, the Office of Information and Regulatory Affairs (OIRA) within the White House Office of Management and Budget also conducts cost-benefit reviews of some proposed regulations, particularly those with high expected costs. To the extent OIRA finds a "significant" federal regulation inconsistent with its cost-benefit analysis, it can return the regulation to the promulgating agency (which can then revise or withdraw it). Although OIRA's analysis does not always trump that of the agency, it does dominate. And of course, if agencies do not change their regulatory decision, Congress can also act and change the law. And this process is generally quite transparent. For example, the Clinton administration inserted greater transparency into the OIRA review process by requiring, inter alia, public disclosure of all communications between OIRA personnel and individuals not employed by the executive branch.

While regulation is not always performance based, in the last two decades, there has been a greater awareness among regulators of the importance of focusing regulations more on what the government wants to achieve, while leaving the means by which to achieve it up to the regulated entities. There is some recognition that this form of regulation is more efficient and spurs more innovation than regulation that prescribes the means.

However, it appears that the U.S. regulatory burden on innovation, both in extent and orientation, grew in the 2000s until the election of President Trump in 2016. Trump made it a key focus to reduce regulations in a wide array of areas. However, in areas such as agricultural biotech, AI, privacy, and others, the pressures for stronger regulation continue to grow. Moreover, most regulatory agency budgets have been cut or limited, making it harder for them to both modernize technologies and processes and expand staff so that they can respond quickly to firms seeking regulatory approval.

Transparency and Rule of Law

Regulations have less of a negative effect on innovation and growth when they are transparent and backed up by the rule of law so that they are consistently applied. This has generally been a strength of the U.S. system, which enjoys a well-developed, independent judiciary and a legislative framework (e.g., the Administrative Procedures Act) that works to hold government executive agencies accountable for obtaining public input and basing rules on evidence. However, the Trump administration has at times intervened—often through the president's "bully pulpit" of Twitter—to put pressure on companies and administration agencies to act in certain ways.

Tax, Trade, and Economic Policy

Macroeconomic Environment

Macroeconomic policies can provide an overall supportive policy for innovation. U.S. macroeconomic policy has been predicated on monetary stability, focused on limiting inflation. Some have argued that in its efforts to limit inflation the Federal Reserve Board has placed too little relative emphasis on full employment, especially since the late 1970s. At least since the 1980s, U.S. macroeconomic policy has relied principally on monetary policy, rather than fiscal policy, to adjust cyclical growth rates. But the 2008 American Recovery and Reinvestment Act and the 2020 COVID recovery packages suggest that fiscal policy tools may be relied upon more going forward, especially if Democrats gain more political power and Modern Monetary Theory gains adherents.[44] In addition, because of the overriding focus on consumer as opposed to producer welfare, as well as a belief that markets should determine prices, U.S. policy toward its currency (and that of other nations) is largely non-interventionist—and to the extent it is interventionist, it is to defend a strong dollar (which helps consumers but hurts most producers, especially in traded sectors).

Tax Policy

While the prevailing view about U.S. tax policy is that it should be neutral vis-à-vis various economic activities, the reality is that it is somewhat interventionist, sometimes for good policy reasons (e.g., R&D tax credit, accelerated depreciation, etc.), and other times because of special-interest pressures for particular tax provisions.[45] But most policymakers strive for a tax code that does not favor particular industries over others, even if it means some traded sectors exposed to international competition pay more than some non-traded sectors, and functions such as R&D with significant positive externalities are not adequately supported through the tax code.[46] After the tax reform act of 2018, the U.S. corporate tax rate was lowered from 35 percent to a more competitive rate of 21 percent.[47] Moreover, companies were allowed to expense for tax purposes investments made in capital equipment. However, the R&D credit is scheduled in 2022 to be reduced in value. This is on top of the fact that tax incentives for R&D are quite minimal compared with most OECD and BRIC (Brazil, Russia, India, and China) nations.[48] And the United States is also one of the very few nations that does not use a border-adjustable value added tax (VAT). Finally, there is increasing pressure from Democrats to raise taxes on business, especially corporations.

Trade Policy

For decades, U.S. trade policy was based on the belief that nations have a comparative advantage, and that an open and market-based trading system enables nations to achieve that advantage to the benefit of their consumers. This has led the United States to focus mostly on signing new trade agreements and being somewhat blasé toward trade enforcement. The Obama administration took some steps to remedy this, establishing an Interagency Trade Enforcement Center based on the belief that the benefits from trade will be less if other nations are not playing by the rules developed by the World Trade Organization. Nevertheless, funding for trade-enforcement efforts is relatively anemic, with the Office of the United States Trade Representative (USTR), Department of Commerce's (DOC) International Trade Administration (ITA), and State Department trade efforts significantly underfunded. The Trump administration's approach to trade has been fundamentally different than the prior Washington consensus, focused much more on bilateral (rather than multilateral) trade deals and being willing to take much tougher actions against foreign mercantilists, especially China. At least in rhetoric, the Trump administration has embraced a "results-oriented" approach to trade, rather than the prior "rules-based" one, and has used tariffs and the threat of tariffs to try to get desired results from foreign nations, especially China.

When it comes to trade promotion, the United States does very little compared with other nations. Funding authority for the Ex-Im Bank is limited compared with many other nations.[49] The same is true for USAID Trade and Investment programs.[50]

Most policymakers strive for a tax code that does not favor particular industries over others, even if it means some traded sectors exposed to international competition pay more than some non-traded sectors.

Intellectual Property

The U.S. system of IP protection has its roots in the U.S. Constitution, which gives Congress the powers to promote "the progress of science and useful arts" by providing inventors with the limited but exclusive right to their discoveries. This applies to copyrights and patents, with trademarks similarly protected by Congress under the Commerce Clause (Article I, Section 8, Clause 3). The view then, as well as now, was that without reasonable protection for their IP, inventors and creators (e.g., individuals or companies) would innovate and create less. Patents and trademarks are governed by the U.S. Patent and Trademark Office (PTO) in DOC. Copyright is governed by the Librarian of Congress. And of course, Congress writes the laws under which these agencies must function, and mostly objective courts can rule on their decisions.

While there is some disagreement within the United States over exactly how strong IP protection should be, the differences are largely at the margin (with some arguing for slightly stronger protection and some for slightly weaker), or over particular issues regarding implementation (e.g., the debate over the proposed Stop Online Privacy Act (SOPA) legislation regarding how to identify and limit access to foreign infringing websites). Part of this overall debate has stemmed from the fact that there is some evidence that during the late 1990s and early 2000s, the U.S. Patent and Trademark office was perhaps too liberal in issuing patents, in part from a large patent backlog and from the development of novel applications (e.g., business methods patents). However, after passage of patent legislation that allowed an increased budget for the PTO, some of these problems appear to have receded. However, there is still a challenge from what some refer to as "patent trolls," a pejorative term used for a person or company that enforces its patents against one or more alleged infringers in a manner considered unduly aggressive or opportunistic, often with no intention to manufacture or market the product.

Standards

The U.S. commercial standards system (as opposed to standards for health, safety, and the environment) is characterized by a voluntary, consensus-based global system. By and large, the government itself does not get involved in picking particular industry standards. For example, in the dispute between HD and Blu-ray high-definition video players, the government did not pick a standard, instead letting cooperation and competition between industry and the emergence of consumer choice determine the winning standard. These standards processes are coordinated by industry trade associations and the American National Standards Institute (ANSI). ANSI facilitates the development of American National Standards (ANS) by accrediting the procedures of standards developing organizations (SDOs). These groups work cooperatively to develop voluntary national consensus standards. ANS are usually referred to as "open" standards. In this sense, "open" refers to a collaborative, balanced, and consensus-based approval process. The content of these standards may relate to products, processes, services, systems, or personnel. ANSI has served in its capacity as administrator and coordinator of the United States private-sector voluntary standardization system for more than 90 years. Initially funded by five engineering societies and three government agencies, ANSI remains a private, nonprofit membership organization supported by a diverse constituency of private- and public-sector organizations. ANSI and other SDOs also work with their counterparts around the world to develop voluntary, consensus-based global standards. While NIST is a federal laboratory, its work largely involves metrology (measurement), not private-sector standard setting.

Innovation Policy Environment

Innovation policy refers to policies specifically designed to spur technological innovation, as opposed to other policies that shape the overall environment for innovation. In general, U.S. innovation policy is less sophisticated and less well thought out than it is in many other nations. This is due in part to the dominance of the neoclassical economic consensus in the United States, which eschews these kinds of policies as inappropriate intervention into the economy, and in part to the "Hertz syndrome" (we think we are number one and therefore do not try harder).[51]

Research and Technology

Support for Research in Universities and Research Labs/Research Institutes

The U.S. system for supporting scientific research is based on two fundamental aspects: support for mission-oriented research (e.g., defense and health) largely to federal labs, and support for basic, curiosity-directed research through university funding. The federal government financed approximately $129 billion of R&D activity in 2018.[52]

Relative to private-sector R&D funding trends, federal support for R&D has fallen substantially as a share of GDP from its high levels in the 1960s (during the Cold War and the race to the moon). To match levels of the 1980s as a share of GDP, funding would need to increase by about 80 percent, or $100 billion, per year.[53]

There have been occasional efforts to increase funding. In the late 1990s and early 2000s, funding for the National Institutes of Health (NIH) was doubled in order to accelerate health innovation, but as a share of GDP, NIH funding has since fallen by 25 percent.[54] In response to the war on terror and the Iraq and Afghanistan wars, federal funding for defense and homeland security R&D was significantly increased. And there was a temporary bump up in response to the economic recession in 2008. However, since then, and with the budget sequester, federal support for R&D has fallen.[55] Moreover, fiscal challenges facing the federal government may make future increases difficult. However, bipartisan legislation such as the Endless Frontiers Act, which would allocate $100 billion in funding to R&D, shows promise of reversing the slide.

Relative to private-sector R&D funding trends, federal support for R&D has fallen substantially as a share of GDP from its high levels in the 1960s.

Federal Labs

The United States funds a system of between 80 and 100 government research laboratories (some are government operated, while some are private contractor operated). The largest labs are funded by the departments of Defense, Energy, and Health. For the most part, research is funded to help agencies better achieve mission goals.[56] While not part of the National Labs system, the Defense Advanced Research Projects Agency (DARPA) and Advanced Research Projects Agency-Energy (ARPA-E) have also played an important role in the development of cutting-edge technologies initially designed to support core agency missions (e.g., defense or energy efficiency) that over time have yielded substantial technology spin-offs to the U.S. and global economy (e.g., the Internet, lasers, etc.).

University Research

University research is supported through a number of agencies, including DOD, DOE, and NIH, to help them achieve mission goals. However, NSF funds university research largely unrelated to agency mission goals. While the system is based on the conception of the linear model of research (first proposed by White House science advisor Vannevar Bush in the post-war period and based on the notion that funding for investigator-directed basic research will lead to valuable outcomes automatically), some argue that federal funding for university research should take a more explicit account of the needs of the commercial economy and promote tech transfer. However, in part because of cuts at the state government level and more recently federal funding cuts, university R&D levels relative to GDP in the United States lag behind many nations. In fact, the United States ranks 28th out of a representative group of 39 industrialized nations in government funding for university research as a share of GDP, with 12 governments among the higher-ranked nations investing more than double the U.S. investment. Between 2011 and 2017, U.S. government funding for university research as a share of GDP fell by nearly a quarter—0.06 percentage points. On average, nations decreased 0.03 percent of GDP during that time.[57]

Technology Transfer Systems

Prior to the 1980s, technology transfer (from universities or federal labs to the commercial marketplace) was largely an afterthought, at least as far as federal policy was concerned. To be sure, some institutions, such as MIT and Stanford, had long played an important role in working with industry and supporting new business spin-offs. But such efforts were largely due to unique institutional factors and were not widely adopted by publicly supported research institutions. However, since the 1980s, a range of policies have been put in place to help better commercialize research. Congress passed the Stevenson-Wydler Technology Innovation Act in 1980, which stated that "technology and industrial innovation are central to the economic, environmental, and social well-being of citizens of the United States." The Act made a number of changes to better enable the transfer of technology from federal laboratories to commercial use. Likewise, the Bayh Dole Act changed the IP rules governing federally funded research at universities, allowing universities to retain the IP rights, giving them more incentive to commercialize research. Congress also passed the Federal Technology Transfer Act of 1986, the National Defense Authorization Act for FY1991, the Technology Transfer Improvements and Advancement Act, the Technology Transfer Commercialization Act, and the Omnibus Trade and Competitiveness Act in 1988 (which, among other things, created the Technology Administration in DOC, reorganized the National Bureau of Standards into NIST, and created a number of programs to help industry with innovation, including the Malcolm Baldrige Quality Award, the Advanced Technology Program, and the Boehlert-Rockefeller State Technology Extension Program). In addition, some agencies, such as NSF and NIH, have begun pilot programs such as I-Corps, to better link their funded research to commercialization outcomes.[58] Overall, while policies have been put in place to help spur commercialization, the only federal agency explicitly focused on commercial innovation is NIST.

Support for Research in Business

In the United States, most commercial activities are conducted by private, for-profit firms. The United States generally does not support R&D directly in firms, unless that R&D is related to achieving a core mission, especially defense. In part, this is because of an aversion toward anything that might smack of heavy-handed industrial policy. But it also reflects a belief that firms are often better positioned to identify the technology areas of most commercial promise. However, the federal government does support an array of policies to help firm-level innovation. For example, in 1981, Congress established a tax credit for business R&D expenditures. In addition, the SBIR program (which requires federal agencies to allocate a small share of their R&D budgets to small business research projects related to agency mission goals) was established in 1984. However, the SBIR program could be reformed to make it a more effective tool for innovation.[59] Likewise, Congress passed the Cooperative Research and Development Act in 1984 which allows companies to gain an antitrust exemption for participating in pre-competitive R&D consortia.

On a per-GDP basis, Korea invests 89 times more than the United States on industrially oriented research, with Germany 43 times more, and Japan 15 times more.

All of these measures are largely technology and firm agnostic, supporting innovation itself (e.g., the R&D credit). However, the federal government has supported some industry-specific efforts related to industry R&D. For example, SEMATECH and the StarNet program have supported advanced R&D in the semiconductor industry—the latter program with industry and government funds a number of university research centers focused on advanced semiconductor research.[60]

The Obama administration established a network of Manufacturing USA Institutes, modeled in part on efforts like those of the German *Fraunhofer* centers.[61] The first center established was a

DOD center for additive manufacturing (named "America Makes") that brings together firms, universities, and several government agencies in a unique public-private partnership. A total of 15 have been established, with much of the government funding coming from DOD and DOE.[62] However, the funding levels are relatively limited, especially when compared with what other nations are committing. For example, on a per-GDP basis, Korea invests 89 times more than the United States in industrially oriented research, with Germany 43 times more, and Japan 15 times more.[63] And Chine purportedly has proposed a system of 45 such centers funded on a significantly larger scale than the United States'.

Systems of Knowledge Flows

Innovation Clusters

The concept of innovation clusters has been long understood by regional planners (harkening back to "Marshallian" manufacturing learning districts in the early 1900s). However, it was not until Harvard Business School professor Michael Porter popularized the notion of clusters in the 1990s that many governments in the United States began to focus more explicitly on spurring innovation clusters. Of course, the emergence of a few high-profile clusters such as Silicon Valley and North Carolina's Research Triangle Park (RTP) lent credibility to the notion that innovation clusters can power innovation and growth. Despite this, the federal government has not played an explicit role in the development of innovation clusters. To be sure, funding from the federal government (especially DOD in Silicon Valley and Boston's Route 128 and NIH in RTP) has played a key role in the development of some U.S. innovation clusters. But explicit innovation-cluster policies have been the province of states and sub-state regions, in part because these units of governments are "closer to the ground" and have a better sense of which clusters are important. Toward that end, many U.S. states have innovation-cluster programs and policies.[64] There is also a growing concern that technology has become too concentrated in just a few leading hubs and that the federal government should step in to help more regions thrive.[65] Both the Endless Frontier Act and legislation introduced by Senators Coons (D-DE) and Durbin (D-IL) contain provisions to do that.[66]

For every MIT or Stanford, there are 10 universities wherein commercialization is more haphazard and less effective.

Industry Collaboration Systems (With Academia and Research Institutes)

Compared with many nations, the United States has a highly developed and successful industry-research institute collaboration system. Universities such as MIT, Cal Tech, and Stanford are models the rest of the world, and indeed, other universities in America, look to for inspiration. There is no single reason for U.S. success at university-industry collaboration; rather, a number of factors play a role. One factor is culture. A long tradition of John Dewey-like pragmatism has dominated U.S. universities, leading them to view collaboration with industry not as something that sullies the purity of basic research, but rather as something that is useful and can advance knowledge. In addition, the U.S. system, with a diversity of kinds of universities and ownership (with a large number of world-class private universities), has created a more competitive environment wherein universities innovate and compete to work with industry. On top of this, U.S. universities are much less hierarchical than universities in many other nations, where faculty must wait until they become full professors to work with industry or start new companies.

Finally, in many states, public colleges and universities are encouraged and supported by state and local governments in their efforts to work more closely with industry.

Despite this overall positive record, it's important to note that there is still great diversity in commercialization performance. For every MIT or Stanford, there are 10 universities wherein commercialization is more haphazard and less effective.[67] NSF's Engineering Research Center (ERC) and Industry/University Cooperative Research Center (I/UCRC) programs have also played a role in facilitating university-industry collaborative research into complex engineered systems. However, both programs receive limited funding, and the ERC program has limited industry engagement.

Acquiring Foreign Technology and Exporting U.S. Technology

In part because the U.S. economy is so large and is generally at the leading edge of technology development, there has been little explicit policy directed at acquiring foreign technology. The general policy approach has been to welcome inward foreign direct investment (FDI) because of the technology transfer that it brings. To the extent that government supports inward FDI attraction, that support has been at the state and local levels. For example, in the 1980s and 1990s, states aggressively courted Japanese automobile company investment in part for the jobs they provided, but also because of the technology transfer that occurred as U.S. auto firms were more easily able to learn the Japanese system of auto production. However, more recently, the Obama administration has established Select USA, a small initiative in DOC designed to work with the states to help attract foreign investment. However, according to DOC data, less than 1 percent of all foreign investment to the United States is in the form of greenfield investment in new manufacturing facilities.

In addition, the United States monitors foreign acquisitions of U.S. companies through the Committee on Foreign Investment in the United States (CFIUS). CFIUS is an inter-agency committee authorized to review transactions that could result in control of a U.S. business by a foreign entity ("covered transactions"), in order to determine the effect of such transactions on the national security of the United States. Most foreign acquisitions of U.S. companies do not even trigger a CFIUS review, and few transactions are rejected. In part, this reflects a belief that foreign acquisitions of U.S. firms can in many cases provide needed injections of capital, know-how, and market access that can help the U.S. establishment become more competitive. However, because of the increasing worry about predatory acquisitions by China, Congress passed the Foreign Investment Risk Review Modernization Act of 2018, which gave more resources to the administration and more tools to limit foreign investment in the United States, especially by U.S. adversaries. Since then, Chinese investment has fallen significantly.

With regard to exporting technology, there are few limits on exporting U.S. commercial technologies to other nations, unless those technologies have potential benefits for current or potential military adversaries. As a result, DOC's Bureau of Industry and Security oversees the transfer of certain sensitive U.S. technologies to some foreign nations. But again, the number of technologies covered is relatively small. Moreover, in the past decade, there has been increasing pressure from industry and others to reduce the restrictions in order to boost U.S. innovation competitiveness. At the same time, the growing concern that China is acquiring too much U.S. technology, coupled with the growing interest of the Trump administration to hamstring some Chinese technology firms, especially those with ties to the Chinese military, has made export controls a more widely used tool. In addition, the Bureau of Industry and Security (BIS) was charged by Congress with coming up with a list of Emerging and Foundational Technologies that should be limited in terms of exports.[68]

Technology Diffusion and Adoption

In the United States, there are several policies and programs related to diffusion and adoption. For over a century, the U.S. Department of Agriculture has supported a system to help farmers and ranchers adopt the best production technologies. These include a system of agricultural land grant colleges, agricultural research stations, and a county-wide system of agricultural extension agents. In 1989, Congress created a similar, albeit much smaller, system to help small and medium-sized manufacturers adopt new technologies. The program, the Manufacturing Extension Partnership (MEP), is run by NIST and administrated by over 60 regional centers. There are also other much smaller systems in place run by other agencies to help firms with issues such as energy efficiency and worker safety. However, relative to many other nations (e.g., Germany and Japan), U.S. support for these systems is quite modest.[69]

Human Capital System

Education/Training (K-12)

The United States' K-12 education system is largely operated at the state and local level, with thousands of local school districts. Unlike many other nations, the United States has not established federal control of the K-12 system. However, the development by the states (and supported by the federal government) of the "Common Core" standard is a move to bring more interstate uniformity.

Compared with many other nations, the performance of U.S. K-12 students on internationally comparable standardized tests such as PISA and TIMMS is generally lacking. Some argue that the poor performance reflects a lack of national curriculum standards, while others argue that it is more structural in nature (teachers' unions resistant to change, or too little school choice). However, it is generally not a result of lack of funding, as U.S. funding per pupil is above the OECD average. In part, this poor performance is because of the higher share of students in the United States from socioeconomically disadvantaged families.

One feature of the U.S. K-12 system that is different from that of many other nations is the increased diversity of kinds of schools. Since the 1980s, the growth of "charter" schools (publicly funded, but privately operated) has been significant, with many of the charters focusing on unique pedagogical approaches. In addition, the United States has a higher share of students in private (religious and non-denominational) schools than most other nations. Finally, despite the relatively mediocre test scores, the U.S. K-12 education system does appear to do a better job than many other national education systems in encouraging independence and creative thinking among students. In many schools, students are encouraged to not just engage in rote learning (e.g., "drill and kill") but in more creative activities and independent thinking. This appears to play a supportive role in U.S. innovation and entrepreneurship. However, with the rise of the standards movement, such activities may have diminished. In addition, the gradual movement to add more required courses to the U.S. high school curriculum has meant students have less choice of classes that may interest them. These changes may be why only around 40 percent of high school students report being satisfied with their school.[70]

Higher Education
The American higher education system is diverse and distributed in nature. As previously described, states manage public universities and colleges while private universities are funded though tuition and charitable donations. For private schools, some students can afford high tuitions while others receive financial aid from the universities. Public state schools are subsidized, but with the fiscal problems of state governments, tuition rates have increased significantly as public funding has been cut. This is one reason the United States has fallen behind many other nations in higher education enrollment rates.

In addition, there is little national or state effort to guide students in their choice of what to study. On the one hand, this helps students choose majors in response to market forces; but it also means there is an undersupply of graduates in STEM.

There is also increasing evidence of low levels of learning in U.S. colleges and universities. Sociologists Richard Arum and Josipa Roksa administered the Collegiate Learning Assessment to several thousand college students at over two dozen institutions when they began college and again at the end of both their sophomore and senior years. They found that, if the test were scaled on a 0-to-100 range, 45 percent of the students would not have demonstrated gains of even one point over the first two years, and 36 percent would not have shown such gains over four years.[71]

Because of COVID and the rise of online learning, it is possible the U.S. system will move more to massive open online courses (MOOCS) with a significant increase in higher education productivity as more students take more classes online. In addition, President Trump's executive order to no longer require the U.S. Office of Personnel Management OPM to include college degree requirements in job announcements (relying instead on actual capabilities), could help disrupt the higher education system.[72]

Finally, an increasingly large share of students participating in master's or Ph.D. programs in STEM fields at U.S. universities are foreign born, reflecting both the global quality of U.S. research universities and the difficulty in developing a pipeline of U.S. students studying toward STEM degrees.[73] However, many of these students are from China, and there is increasing concern that some of them may be using that access to steal IP for China.

Skills/Technical Training
In the United States, skills training is largely seen as a private-sector responsibility. As such, there is no national system for employer-based skills training. In the old economy, employers played a stronger role in skills training, with some industries and firms taking the lead with the establishment of training institutes and industry-wide apprenticeship programs. But over the past three decades, most of these efforts have ended as firms have seen such investments in "public goods" as something they can no longer afford. As such, overall private-sector investment in skills training has declined by about one-third as a share of GDP in the last decade.[74]

To the extent that there is a federal role (through the Department of Labor), it is focused largely on helping disadvantaged individuals obtain skills. However, the National Skill Standards Act of 1994 created a National Skill Standards Board (NSSB) responsible for supporting voluntary partnerships in each economic sector that would establish industry-defined national standards leading to industry-recognized, nationally portable certifications. The vision was that each industry would define and validate national standards for the skills it was seeking, and credential individuals against those skills. One key reason for doing this was so companies would have a better way to assess the skills of prospective and current workers, and workers would have a better way to identify and gain the skills they needed to be successful. But the federal government failed to provide matching funding to establish this standards-based system. Moreover, in the 2000s, the national sectoral approach was abandoned in favor of a regional approach.

However, a number of states have established skills training programs. For example, Wisconsin and Georgia have strong youth apprenticeship programs. Some states and local school districts have established career academies within high schools. Several have established regional skills alliances—industry-led partnerships that address workforce needs in a specific region and industry sector. For example, Michigan has provided competitively awarded start-up grants and technical assistance to 25 industry-led regional skills alliances. Pennsylvania's $15 million Industry Partnerships program brings together employers and workers (or worker representatives, when appropriate) in the same industry cluster to address overlapping human capital needs. Other states have established tax credits for company investments in workforce development. California has a deduction for training expenses if a company has spent a certain share of sales on training. Firms in Rhode Island can deduct up to 50 percent of training costs on their corporate income taxes.

At least eight studies have examined the role of immigrants in launching new companies in the United States, and all conclude that immigrants are key actors in this process.

Moreover, a core component of the U.S. skills training system is the system of community colleges the nation enjoys. The community college system is a critical partner in training the current and future workforce. Community colleges play a vital role in training job seekers with the skills to obtain a good job, while simultaneously helping employers obtain the workers they need to stay competitive. For example, more than half (55 percent) of the 1,600 community colleges in the United States offer specialized training in manufacturing skills. In addition, there has long been interest in expanding apprenticeship education, most recently by the Trump administration. But funding for such programs has been limited.

Immigration Policy

More than many nations, the United States has relied on high-skill immigration to support its innovation system. This has paid off to date. At least eight studies have examined the role of immigrants in launching new companies in the United States, and all conclude that immigrants are key actors in this process, creating from 15 to 26 percent of new companies in the U.S. high-tech sector over the past two decades.[75] Another study found that more than one-third (35.5 percent) of the most important U.S. innovators were born outside the United States, even though this population makes up just 13.5 percent of all U.S. residents.[76] Some U.S. states have seen even greater beneficiaries: Nearly 40 percent of the engineering and technology firms founded in California and New Jersey between 1995 and 2005 were founded by foreign-born immigrants.[77]

Overall, in comparison with many other nations, including Canada, the U.S. system is not focused on high-skill immigration. However, until the Trump administration, its overall liberal immigration policy meant that many STEM workers could immigrate to the United States. The United States also has a temporary employer-sponsored work visa system, the H1b visa program. However, the Trump administration has worked to limit immigration overall, and H1b workers in particular.

FUTURE EVOLUTION OF THE U.S. INNOVATION SYSTEM

There is no national, coordinated innovation policy system in the United States. While some nations have developed national innovation strategies (e.g., Germany, Sweden, and Finland), the United States generally has not. This reflects in part a belief that innovation is best left to the market, and that the role of government, to the extent there is one, is to support "factor inputs," such as knowledge creation and education.

However, that may be changing in response to the economic, technological and military challenge from China. Indeed, national innovation systems are evolutionary, not static. Moreover, the innovation environment itself evolves, which can change the relative strength of an NIS or individual components, as they either reflect a better or worse fit with the new environment. As such, a nation's overall innovation system, as well as individual components, can improve or degrade. For the U.S. innovation system, it appears that the direction of change has been toward relative worsening, especially when compared with some other national systems whose governments are putting in place a suite of policies designed to win in the global race for innovation advantage.[78]

Clearly the United States has important strengths in a number of areas, including managerial talent, enterprise use of ICT, and business cultural factors such as demanding customers and a collaborative culture.

But there are a number of other factors wherein the U.S. position is clearly trending down, especially in relation to other national innovation systems. These include funding support for universities and federal labs and other innovation inputs as federal policymakers continue their unwillingness to prioritize investment in the federal budget process. Indeed, this is a component of a broader factor of the unwillingness of American society to invest in the future and collective goods. There is little evidence that American voters are willing to sacrifice additional current income and consumption for investments in the future. At the same time, this pressure for immediate gratification reflects itself in the investment decisions by publicly traded corporations. Again there is little evidence that the pressures from equities markets for immediate returns will abate any time soon. Even more, there is a disturbing turn to "neo-Luddism" in America as so-called "public interest" groups, the media, pundits, and other elites adopt an anti-innovation attitude, whether it relates to genetically modified organisms, the use of data and AI, or automation. Given the complicity of the media in this process, which increasingly adopts the view that "fear grabs eyeballs," the likelihood is neo-Luddite, anti-progress forces will strengthen, particularly among liberals, making the overall innovation environment more problematic.[79]

For similar reasons, reform of the regulatory system as it affects innovation is equally problematic. Most Democrats look at any efforts here as an attempt to gut needed protections, and therefore view even simple common-sense reforms as opening up the floodgates of deregulation. Moreover, most liberal Democrats believe that business, especially large businesses, are regulated too lightly. At the same time, most Republicans are reluctant to increase funding for regulatory agencies, believing that it would simply empower them to regulate more, rather than regulate more smartly and expeditiously.

There are a number of areas wherein policy may make a significant difference. One is high-skill immigration. While there is a general bipartisan consensus in favor of liberalizing high-skill immigration, opposition from the left and the Trump wing of the Republican Party right make future progress problematic.[80] There are a number of other areas where there is reasonable bipartisan consensus for action, including STEM education, manufacturing technology support programs, FDI attraction programs (e.g., Select USA), funding for technical skills training, and increased resources for trade enforcement. Indeed, recent legislative proposals around the semiconductor industry, increased R&D funding, support of technology hubs, and a wide array of other steps believed to be needed to help the United States stay ahead of China in the technology innovation race suggest that perhaps the United States will turn around its long-term decline in innovation policy factors.

The nation that can put together all three sides of the innovation success triangle most effectively is likely to be the nation that wins the race and reaps the rewards in greater economic vitality and prosperity.

In summary, as nations compete to win the global innovation race, some will sprint out ahead, others will remain stuck in the middle of the pack, and still others will struggle just to get out of the starting gate. Nations face different challenges in the race. No nation has it entirely right just yet, although a few come close. While some nations—such as Japan and much of Europe—have strong innovation policy systems, many of them suffer from limited regulatory and business environments. In contrast, the United States has reasonably good business and regulatory environments (although, as noted, many important factors are trending downward), but a weak innovation policy environment. The nation that can put together all three sides of the innovation success triangle most effectively is likely to be the nation that wins the race and reaps the rewards in greater economic vitality and prosperity. Thus, the challenge for the United States going forward is whether it can make the needed changes to its innovation system to meet the new competition. Our economic future and national security will depend on the answer.

Acknowledgments

The author wishes to thank the following individuals for providing input to this report: Stephen Ezell and MacKenzie Wardwell. Any errors or omissions are the author's alone.

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), 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, and a master's degree in urban and regional planning from the University of Oregon.

About ITIF

The Information Technology and Innovation Foundation (ITIF) is a nonprofit, nonpartisan research and educational institute focusing on the intersection of technological innovation and public policy. Recognized as the world's leading science and technology think tank, 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.

ENDNOTES

1. Christopher Freeman, *Technology and Economic Performance: Lessons from Japan* (London: Pinter, 1987).
2. Robert D. Atkinson, Stephen J. Ezell, and Luke A. Stewart, "The Global Innovation Policy Index" (ITIF, March 2012), 17, http://www.kauffman.org/~/media/kauffman_org/research%20reports%20and%20covers/2012/03/globalinnovationpolicyindex2012.
3. For some broader and deeper views, see Michael Lind, *Land of Promise: An Economic History of the United States* (New York: HarperCollins, 2012), and Charles R. Morris, *The Dawn of Innovation: The First American Industrial Revolution* (New York: PublicAffairs, 2012).
4. Alfred Chandler, *The Visible Hand* (Cambridge, MA: Harvard University Press, 1977).
5. Ibid, 38.
6. Robert D. Atkinson, "Innovation policy making in a federalist system: Lessons from the states for U.S. federal innovation policy making," *Research Policy*, 20, no. 6 (December 1991): 559–577, http://www.sciencedirect.com/science/article/B6V77-45D0R95-43/2/2bb90d167270cfa32c758d21507349a1.
7. Robert D. Atkinson et al., "Worse Than the Great Depression: What Experts are Missing About American Manufacturing Decline" (ITIF, March 2012), http://www2.itif.org/2012-american-manufacturing-decline.pdf.
8. "China," United States International Trade Commission, https://www.usitc.gov/research_and_analysis/trade_shifts_2017/china.htm.
9. Robert D. Atkinson et al., "Trump vs. Biden: Comparing the Candidates' Positions on Technology and Innovation" (ITIF, September 2020), https://itif.org/publications/2020/09/28/trump-vs-biden-comparing-candidates-positions-technology-and-innovation.
10. Nicholas Bloom et al., "Why American Management Rules the World," *HBR Blog Network*, June 13, 2011, http://blogs.hbr.org/cs/2011/06/why_american_management_rules.html.
11. Dean Krehmeyer, Matthew Orsagh, and Kurt Schacht, "Breaking the Short-Term Cycle: Discussion and Recommendations on How Corporate Leaders, Asset Managers, Investors and Analysts Can Refocus on Long-Term Value" (CFA Institute and Business Roundtable Institute for Corporate Ethics, 2006), http://www.corporate-ethics.org/pdf/Short-termism_Report.pdf.
12. Matthew Orsagh, Jim Allen, and Kurt Schacht, "Short-termism Revisited: Improvements made and challenges in investing for the long-term" (CFA Institute, September 2020), https://www.cfainstitute.org/en/advocacy/policy-positions/short-termism-revisited
13. Ibid.
14. "Innovation, Applications and Transformation, Figure 5.2" in *OECD Digital Economy Outlook 2017*, (Paris: OECD Publishing, 2017), http://dx.doi.org/10.1787/888933586027.
15. "Innovation, Applications and Transformation, Figure 5.1" in *OECD Digital Economy Outlook 2017*, (Paris: OECD Publishing, 2017), http://dx.doi.org/10.1787/888933586008.
16. "ICT Access and Usage by Business," OECD.Stat, October 23, 2020, https://stats.oecd.org/Index.aspx?DataSetCode=ICT_BUS.
17. Ben Miller and Robert D. Atkinson, "Raising European Productivity Growth Through ICT" (ITIF, June 2014), http://www2.itif.org/2014-raising-eu-productivity-growth-ict.pdf.
18. PitchBook and NVCA, *Venture Monitor* (July 2020), https://pitchbook.com/news/reports/q2-2020-pitchbook-nvca-venture-monitor.
19. Robert D. Atkinson and Adams Nager, *The 2014 State New Economy Index* (ITIF, June 2014), http://www2.itif.org/2014-state-new-economy-index.pdf.

20. Robert Rozansky, "Becoming America's Seed Fund: Why NSF's SBIR Program Should Be a Model for the Rest of Government" (ITIF, September 2019), https://itif.org/publications/2019/09/26/becoming-americas-seed-fund-why-nsfs-sbir-program-should-be-model-rest.
21. Jay R. Ritter, "Initial Public Offerings: Updated Statistics," October 6, 2020, Warrington College of Business, University of Florida, https://site.warrington.ufl.edu/ritter/files/IPOs2019Statistics.pdf.
22. *See*, Francis Fukuyama, *The End of History and the Last Man* (New York: Avon Books Inc, 1992); Raquel Fernandez, "Does Culture Matter?" in *Handbook of Social Economics*, by Jess Benhabib, Matthew O. Jackson, and Alberto Bisin (North-Holland: Elsevier B.V., 2011), 481–510; Lawrence Harrison and Samuel Huntington, *Culture Matters: How Values Shape Human Progress* (New York: Perseus Books Group, 2000).
23. Michael Porter, *Competitive Advantage of Nations* (New York: The Free Press, 1980).
24. For example, in the United States, rooms are larger, more likely to be air conditioned, and have better quality beds. U.S. hotels are more likely to provide room service. They are also more likely to have electronic keys.
25. Amar Bhidé, *The Venturesome Economy: How Innovation Sustains Prosperity in a More Connected World* (Princeton: Princeton University Press, 2008).
26. Andrea Stojanović, "What do Customers Want? – 37 Customer Service Statistics," *Smallbizgenius*, August 10, 2020, https://www.smallbizgenius.net/by-the-numbers/customer-service-statistics/#gref.
27. Roxana Mihet, "Effects of Culture on Firm Risk-Taking: A Cross-Country and Cross-Industry Analysis" (working paper, International Monetary Fund, August 2012), http://www.imf.org/external/pubs/ft/wp/2012/wp12210.pdf.
28. Maria Ferreira, "Cross-country differences in risk attitudes towards financial investment," *Vox EU CEPR*, September 21, 2018, https://voxeu.org/article/cross-country-differences-risk-attitudes-towards-financial-investment.
29. Merritt Roe Smith, *Does Technology Drive History? The Dilemma of Technological Determinism* (Cambridge, MA: MIT Press, 1996).
30. Quoted in Amy Sue Bix, *Inventing Ourselves Out of Jobs?: America's Debate over Technological Unemployment,* 1929–1981 (Baltimore: Johns Hopkins University Press, 2000), 166.
31. Ben Miller and Robert D. Atkinson, "Are Robots Taking Our Jobs, or Making Them?" (ITIF, September 2013), http://www2.itif.org/2013-are-robots-taking-jobs.pdf.
32. Robert D. Atkinson, "How MIT's 'Work of the Future' Project Gets It Wrong: Raising Taxes on Machinery and Software Would Kill Jobs and Hamper Wage Growth," Innovation Files, October 5, 2020, https://itif.org/publications/2020/10/05/how-mits-work-future-project-gets-it-wrong-raising-taxes-machinery-and.
33. Fred Block and Matthew Keller, "Where Do Innovations Come From? Transformations in the U.S. National Innovation System, 1970–2006" (ITIF, July 2008), http://www.itif.org/publications/where-do-innovations-come-transformations-us-national-innovation-system-1970-2006.
34. Personal income is about 70 percent of GDP.
35. Robert D. Atkinson and David B. Audretsch, "Economic Doctrines and Approaches to Antitrust" (ITIF, January 2011), http://www.itif.org/files/2011-antitrust.pdf.
36. Robert D. Atkinson, "Big Business Is Not the Enemy of the People," *National Review*, October 10, 2019, https://www.nationalreview.com/magazine/2019/10/28/big-business-is-not-the-enemy-of-the-people/.
37. House Committee on the Judiciary, "Judiciary Antitrust Subcommittee Investigation Reveals Digital Economy Highly Concentrated, Impacted By Monopoly Power," press release, October 6, 2020, https://judiciary.house.gov/news/documentsingle.aspx?DocumentID=3429.

38. Robert D. Atkinson and Michael Lind, *Big is Beautiful: Debunking the Myth of Small Business* (Cambridge, MA: MIT Press, 2018).
39. Leora Klapper, Luc Laeven, and Rhguram Rajan, "Entry Regulation as a Barrier to Entrepreneurship," *Journal of Financial Economics*, 82, no. 3 (December 2006): 591–629, http://faculty.chicagobooth.edu/raghuram.rajan/research/papers/entry.pdf.
40. "Ease of Doing Business rankings," The World Bank, https://www.doingbusiness.org/en/rankings.
41. Doing Business, "Doing Business in 2004," The World Bank (September 2003), https://www.doingbusiness.org/en/reports/global-reports/doing-business-2004.
42. Robert D. Atkinson, Stephen Ezell, and Luke A. Stewart, *Global Innovation Policy Index* (ITIF, March 2012), http://www2.itif.org/2012-global-innovation-policy-index.pdf.
43. Stephen Ezell and Robert D. Atkinson, "The Indian Economy at a Crossroads" (ITIF, April 2014), http://www2.itif.org/2014-indian-economy-at-crossroads.pdf.
44. Deborah D'Souza, "Modern Monetary Theory (MMT)," *Investopedia*, October 10, 2020, https://www.investopedia.com/modern-monetary-theory-mmt-4588060.
45. Robert D. Atkinson, "U.S. Corporate Tax Reform: Groupthink or Rational Debate?" (ITIF, July 2011), http://www.itif.org/files/2011-corporate-tax-reform.pdf.
46. *Incentives for Capital Investment and Manufacturing: Hearing on Tax Reform Options Before the Senate Finance Committee* (2012) (written testimony of Robert Atkinson, ITIF).
47. Joe Kennedy, "Assessing U.S. Corporate Tax Reform in an Age of Global Competition" (ITIF, March 2014), http://www2.itif.org/2014-corporate-tax-reform-global-competition.pdf.
48. John Lester and Jacek Warda, "Enhanced Tax Incentives for R&D Would Make Americans Richer" (ITIF, September 2020), https://itif.org/publications/2020/09/08/enhanced-tax-incentives-rd-would-make-americans-richer.
49. Stephen J. Ezell, "Understanding the Importance of Export Credit Financing to U.S. Competitiveness" (ITIF, July 2011), http://www.itif.org/files/2011-export-credit-financing.pdf.
50. "Trade and Investment," USAID, https://www.usaid.gov/what-we-do/economic-growth-and-trade/trade-and-regulatory-reform/trade-and-investment.
51. Robert D. Atkinson and David B. Audretsch, "Economic Doctrines and Policy Differences: Has the Washington Policy Debate Been Asking the Wrong Questions?" (ITIF, September 2008), http://www.itif.org/files/EconomicDoctrine.pdf.
52. Christopher Pece, "Federal R&D Obligations Increase 8.8% in FY 2018; Preliminary FY 2019 R&D Obligations Increase 9.3% Over FY 2018" (National Science Foundation, January 2020), https://www.nsf.gov/statistics/2020/nsf20308/.
53. Caleb Foote and Robert Atkinson, "Federal Support for R&D Continues Its Ignominious Slide," *Innovation Files*, August 12, 2019, https://itif.org/publications/2019/08/12/federal-support-rd-continues-its-ignominious-slide.
54. Robert D. Atkinson et al., *Leadership in Decline* (ITIF, May 2012), http://www2.itif.org/2012-leadership-in-decline.pdf.
55. Justin Hicks and Robert D. Atkinson, "Eroding Our Foundation: Sequestration, R&D, Innovation and U.S. Economic Growth" (ITIF, September 2012), http://www2.itif.org/2012-eroding-foundation.pdf.
56. Matthew Stepp et al., "Turning the Page: Reimagining the Nationals Labs in the 21st Century Innovation Economy" (ITIF, June 2013), http://www2.itif.org/2013-turning-page-national-lab-innovation-economy.pdf.
57. Robert D. Atkinson and Caleb Foote, "U.S. Funding for University Research Continues to Slide" (ITIF, October 2019), https://itif.org/publications/2019/10/21/us-funding-university-research-continues-slide.

58. Andre W. Marshall and Ruth M. Shuman, "Innovation Corps - National Innovation Network Teams Program (I-CorpsTM Teams)" National Science Foundation, https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=504672#:~:text=The%20NSF%20I%2DCorps%20Teams%20Program%20purpose%20is%20to%20identify,attract%20subsequent%20third%2Dparty%20funding.

59. Robert Rozansky, "Becoming America's Seed Fund: Why NSF's SBIR Program Should Be a Model for the Rest of Government" (ITIF, September 2019), https://itif.org/publications/2019/09/26/becoming-americas-seed-fund-why-nsfs-sbir-program-should-be-model-rest.

60. "Semiconductor Technology Advanced Research Network," on the Semiconductor Research Corporation website, accessed June 18, 2014, https://www.src.org/program/starnet/.

61. David M. Hart, Stephen J. Ezell, and Robert D. Atkinson, "Why American Needs a National Network for Manufacturing Innovation" (ITIF, December 2012), http://www2.itif.org/2012-national-network-manufacturing-innovation.pdf.

62. Robert Atkinson, "Manufacturing innovation is key to boosting growth," *The Hill*, April 15, 2014, http://thehill.com/blogs/congress-blog/economy-budget/203366-manufacturing-innovation-is-key-to-boosting-growth.

63. National Science Foundation, "Cross-National Comparisons of Government R&D Priorities" (Appendix Table 4-39; accessed June 18, 2014), http://www.nsf.gov/statistics/seind14/index.cfm/chapter-4/c4s7.htm.

64. Robert D. Atkinson and Luke A. Stewart, *The 2012 State New Economy Index* (ITIF, December 2012), http://www2.itif.org/2012-state-new-economy-index.pdf.

65. Robert D. Atkinson, Mark Muro, and Jacob Whiton, "The Case for Growth Centers: How to Spread Tech Innovation Across America" (ITIF, December 2019), https://itif.org/publications/2019/12/09/case-growth-centers-how-spread-tech-innovation-across-america.

66. "Sens. Coons, Durbin announce legislation to expand federal R&D, extend tech economy to more cities across America," press release, Senator Chris Coons, August 19, 2020, https://www.coons.senate.gov/news/press-releases/sens-coons-durbin-announce-legislation-to-expand-federal-randd-extend-tech-economy-to-more-cities-across-america.

67. Peter Singer, "Federally Supported Innovations: 22 Examples of Major Technology Advances that Stem from Federal Research Support" (ITIF, February 2014), http://www2.itif.org/2014-federally-supported-innovations.pdf.

68. Stephen Ezell and Caleb Foote, "How Stringent Export Controls on Emerging Technologies Would Harm the U.S. Economy" (ITIF, May 2019), https://itif.org/publications/2019/05/20/how-stringent-export-controls-emerging-technologies-would-harm-us-economy.

69. Stephen J. Ezell and Robert D. Atkinson, "International Benchmarking of Countries' Policies and Programs Supporting SME Manufacturers" (ITIF, September 2011), http://www.itif.org/files/2011-sme-manufacturing-tech-programss-new.pdf.

70. John Geraci, et al., *What Teens Want From Their Schools: A National Survey of High School Student Engagement* (Thomas B. Fordham Institute, June 2017), https://fordhaminstitute.org/sites/default/files/publication/pdfs/%2806.27%29%20What%20Teens%20Want%20From%20Their%20Schools%20-%20A%20National%20Survey%20of%20High%20School%20Student%20Engagement.pdf.

71. Richard Arum and Josipa Roksa, *Academically Adrift: Limited Learning on College Campuses* (Chicago: University of Chicago Press, 2011).

72. Joseph Kennedy, Daniel Castro, and Robert D. Atkinson, "Why It's Time to Disrupt Higher Education by Separating Learning From Credentialing" (ITIF, August 2016), http://www2.itif.org/2016-disrupting-higher-education.pdf.
73. Robert D. Atkinson and Merrilea Mayo, *Refueling the U.S. Innovation Economy: Fresh Approaches to STEM Education* (ITIF, December 2010), http://www.itif.org/files/2010-refueling-innovation-economy.pdf.
74. Author calculations using data from *Training Magazine*, October–November issues, 2000–2012.
75. David Hart, Sultan Aces, and Spencer Tracy, Jr., "High-tech Immigrant Entrepreneurship in the United States" (technical report, Small Business Administration, Washington, D.C., July 2009), http://www.sba.gov/advo/research/rs349tot.pdf.
76. Adams Nager et al., "The Demographics of Innovation in the United States" (ITIF, February 2016), https://itif.org/publications/2016/02/24/demographics-innovation-united-states.
77. Antony Davies, "Costs and Benefits of High Skilled Immigration" (presentation, Foreigners Welcome? The Economics of High Skilled Immigration, Washington, D.C., March 31, 2009), 12, http://mercatus.org/events/foreigners-welcome-economics-high-skilled-immigration.
78. Robert D. Atkinson and Stephen J. Ezell, *Innovation Economics* (New Haven: Yale University Press, 2012).
79. Robert D. Atkinson, "Can the Left Overcome its Technopessimism?" *American Compass*, October 20, 2020, https://americancompass.org/the-commons/can-the-left-overcome-its-technopessimism/.
80. Hal Salzman, Daniel Kuehn, and B. Lindsay Lowell, "Guestworkers in the High-Skill U.S. Labor Market" (Economic Policy Institute, April 2013), http://www.epi.org/publication/bp359-guestworkers-high-skill-labor-market-analysis/.