AN INNOVATION CHALLENGE FOR THE UNITED STATES

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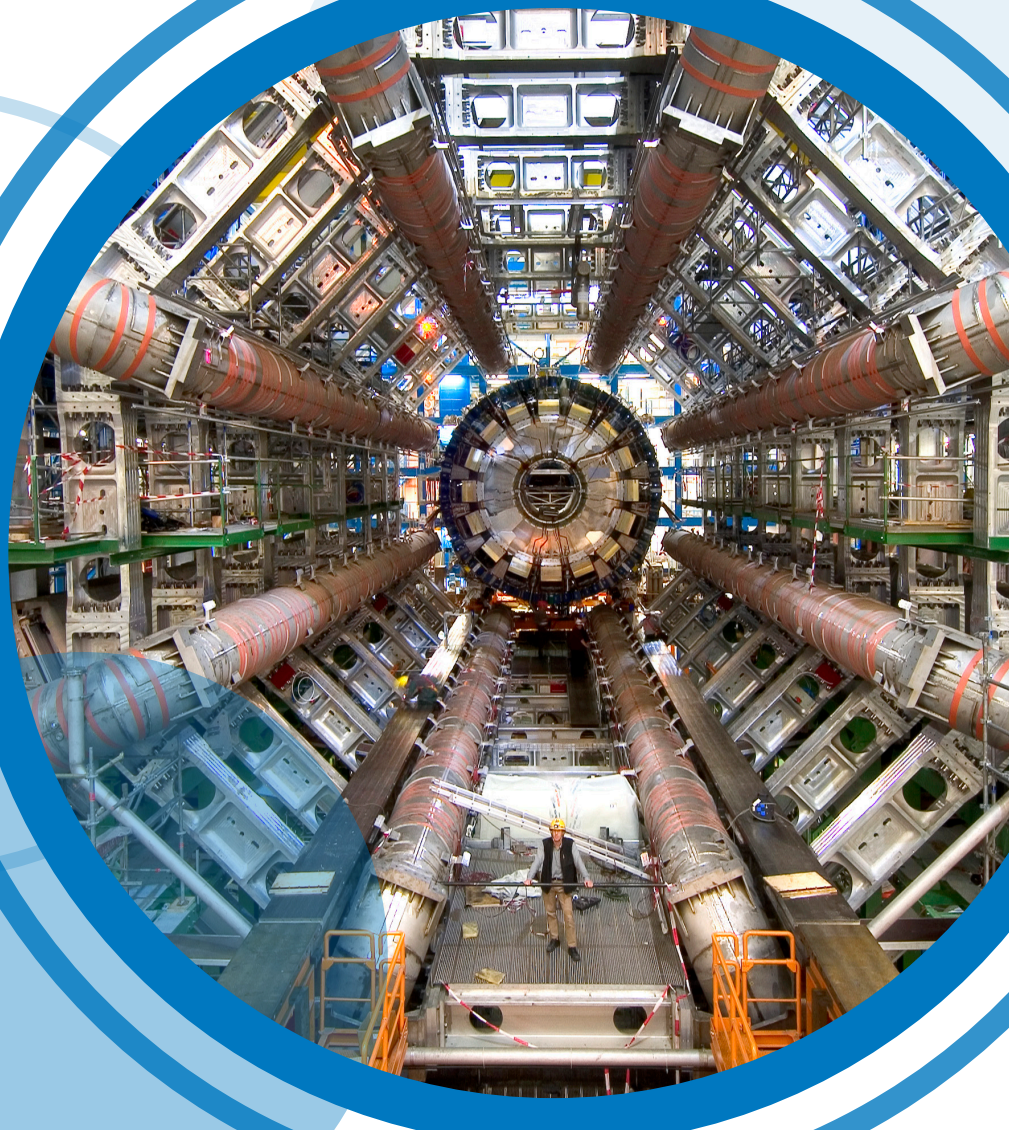

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INTRODUCTION

The United States became the undisputed global leader in innovation following World War II. From transistors to personal computers, from the development of the Internet to the evolution of the smart phone, America was at the frontier of the world's technological transformation. Multiple factors drove this advancement in the post-war era: consumer demand, Cold War competition, the relentless pursuit of advancement, and strong federal leadership. High risk tolerance, competition, and the insatiable appetite to create and improve technology forged an innovation culture that has benefited the United States and the world. That culture—and all the economic, security, and societal benefits that it brings—is now at risk.

It is easy to lose sight of the conditions that propelled the United States into such a strong position of innovative leadership. Many Americans reflexively assume that this status was preordained—a sort of "innovation manifest destiny." This ignores history. To be sure, the United States had many innate advantages, but American leadership in the post-war years grew out of a unique set of circumstances, many of which no longer exist and are unlikely to be seen again. Yet even with all those advantages, in the midst of our 20th century innovation boom, we needed a wakeup call: the Sputnik moment. On October 4, 1957, the Soviet Union launched the world's first satellite into orbit, and suddenly, the United States was publicly behind in the space race. Sputnik ignited a feverish pursuit for technological dominance, heralding decades of research and development, Neil Armstrong's first steps on the moon, and countless other advancements.

To maintain our global position, the United States—government, private sector, and academia—must chart a purposeful course to maintain our leadership while embracing the values that have long propelled American innovation. If not, we run the risk of squandering the many national advantages we still possess. We cannot wait for the next Sputnik moment—whether in quantum computing, artificial intelligence (AI), or some yet-to-be-discovered technology—to focus our national attention and efforts.

Much is at stake. Continued innovation leadership is essential to peace and economic prosperity for the United States and the global community. In the digital age, a free and open Internet strengthens free societies around the world. If the United States cedes leadership in innovation, there is a risk that new technologies will be developed and implemented by nations that do not share values of liberty and freedom.

ORIGINS OF AMERICAN INNOVATION LEADERSHIP

American innovation leadership—which bordered on dominance in the early post-war years—did not arise by accident. Nor was it solely the result of advanced planning, strong execution, and strategic investments. Instead, it was a mix of both and driven by several key factors:

- **Post-War Devastation:** As 1945 drew to a close, Europe had just emerged from six years of war; tens of millions were dead and scientific and manufacturing hubs across the continent were devastated. In the Pacific, Japan and East Asia lay in ruins. Yet the continental United States was left essentially untouched, equipped with an unprecedented manufacturing and scientific research base. Contemporary economists predicted economic disaster when millions of servicemembers were discharged into the workforce and massive orders for war-time materiel ended. Instead, scientific and manufacturing capacity, freed from wartime mandates, shifted toward consumer demands and inventions.[1]
- **High-Skilled Immigrants:** Well before World War II, some of Europe's greatest minds fled fascism and settled in the United States. In fact, the Manhattan Project relied heavily on these skilled immigrants. The war's physical, economic, and emotional toll in Europe and Asia helped make the United States a beacon for immigrants of all skill and education levels. Between 1949 and 1952 alone, 900,000 immigrants were admitted to the United States, providing a new pool of educated workers.[2] Even more sought refuge in the West as the Iron Curtain fell over Eastern Europe, further expanding the supply of immigrants—many highly educated—who made it to the United States.[3]
- **Educational Opportunities:** Sixteen million servicemembers returned to civilian life in the post-war years. While many immediately entered the workforce, others took advantage of the education provisions in the G.I. Bill (officially the Servicemen's Readjustment Act of 1944). Millions returned to school and attended universities and trade schools, and the U.S. workforce grew steadily more educated in the second half of the 20th century. In 1940, just one in four Americans completed high school. In 2000, a record 80% had done so. The number of college-educated Americans grew just as quickly. Less than five percent of Americans held bachelor's degrees or higher in 1940. In 2000, it was almost 25%.[4] Higher

[1] "Economic Recovery: Lessons from the Post World War II Period," Cecil Bohanon, *George Washington University*, Sept. 10, 2012, https://www.mercatus.org/publication/economic-recovery-lessons-post-world-war-ii-period.

[2] "Displaced Persons Act of 1948," *Immigration to the United States*, http://immigrationtounitedstates.org/464-displaced-persons-act-of-1948.html.

[3] "Immigration to the United States after 1945," Xiaojian Zhao, *Oxford Research Encyclopedias*, July 2016, http://oxfordre.com/americanhistory/view/10.1093/acrefore/9780199329175.001.0001/acrefore-9780199329175-e-72.

[4] "Chapter Ten: Education," *United States Census Bureau*, https://www.census.gov/population/www/cen2000/censusatlas/pdf/10_Education.pdf.

education opportunities rose to fill the growing demand. Existing universities expanded, and new ones sprang up.[5]

- **Cold War Build-Up & Scientific Competition:** It is difficult to overstate the importance of an external driver for government investment in scientific research. Indeed, government research and development (R&D) funding that began during World War II and continued into the Cold War was a foundation of American innovation in the latter half of the 20th century. It may not have been stated as such, but during the Cold War, the United States was determined to out-innovate the Soviet Union. Military, civilian, and even athletic competition drove scientific innovation and the creation of a deep and wide pool of highly-educated Americans. Great power competition was not limited to the military sphere; the Space Race led to numerous inventions and innovations. It also drove policy in the United States. The 1957 launch of Sputnik led to a variety of science initiatives in the United States, including the creation of the Defense Advanced Research Projects Agency (DARPA) and the passage of the National Defense Education Act of 1958, which funded scientific and technical studies and led to a proliferation of advanced placement courses in high schools.[6]

[5] "The Worldwide Expansion of Higher Education in the Twentieth Century," Evan Schofer and John W. Meyer, *American Sociological Review*, Dec. 2005, https://www.jstor.org/stable/4145399?seq=1#page_scan_tab_contents.

[6] "The Impact of Sputnik on Education," *Physics Today*, Oct. 14, 2017, https://physicstoday.scitation.org/do/10.1063/PT.5.021570/full/.

THE WORLD TODAY

The factors described above allowed the United States to dominate the global innovation landscape in the immediate post-war years, and the long tail of some factors preserved that lead for the latter half of the 20th century. But most of these structural advantages have diminished with time or vanished entirely, with the United States falling behind in some areas.

Today, America's physical infrastructure is aging and in many cases failing. Europe and Japan rebuilt, and Korea, China, and other emerging nations have invested heavily in their own modern infrastructure. Investment in the United States has not kept pace. In 2017, the American Society of Civil Engineers graded the United States as a D+ on infrastructure and suggested that nearly $10 trillion will be required in the next ten years to restore infrastructure integrity.[7] Our digital infrastructure is more modern, but is at best on par with much of the world. According to the Federal Communications Commission, broadband download speeds in the United States were ranked 10th among developed nations in 2016.[8]

Aging, outdated, and unreliable infrastructure takes a toll. Entrepreneurs, researchers, and academics who want to take advantage of cloud computing or data analytics to advance their work need to move vast amounts of data quickly—and therefore need high-speed, reliable connectivity. In the United States, such access is expensive and geographically concentrated. Similarly, cutting-edge research requires advanced research tools. If we do not invest in modernizing our academic and research centers, we risk losing ground to newer institutions around the world.

The United States is still a favored destination for high-skilled, highly-educated immigrants, though this advantage is diminishing. Immigrants were the driving force behind many recent innovative technology companies, including eBay, Intel, Yahoo, and Google. But the competition for talent is global, and restrictive immigration laws are one reason that many innovators are not coming to the United States or staying after receiving an education here. People around the world still aspire to come to the United States, but we can no longer sit back and assume that the best and brightest want to come here—or that they will be able to should they so desire.

The nature of innovation has also changed. In 1957, a scientific leap forward was easy to understand, sometimes frighteningly so in the case of Sputnik. Today many breakthroughs are not singular, observable events and do not make the front page of every newspaper or feature at the top of most social media feeds. Instead, important innovations in recent history – e.g.,

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[7] "2017 Infrastructure Report Card," https://www.infrastructurereportcard.org/.

[8] "Sixth International Broadband Data Report," *Federal Communications Commission*, Feb. 2, 2018, https://www.fcc.gov/document/sixth-international-broadband-data-report.

Hadoop, digital mapping, deep learning, or genetic sequencing – occurred with little fanfare and even less widespread understanding of their import. It is far harder to predict when competitors will surpass the United States or even have confidence that one will know it when they do.

Perhaps the biggest change from the latter half of the 20th century is the end of the Cold War. Today, there is no external, existential pressure driving R&D budgets in the United States, no geopolitical rival to focus and unify the government and the American people. At least in the technology sector, at times the opposite seems to be true—many citizens do not trust their government. The next time American leaders ring the alarm, they may well find an American public without a shared sense of urgency or even an understanding of the technological race they are losing.

TOWARDS A NATIONAL RESEARCH & DEVELOPMENT AGENDA

> ***"[T]he Federal government has an important role in funding R&D in areas that industry does not have a strong incentive to invest in and in areas of critical importance to national and economic security."***
>
> – The White House, Analytical Perspectives: Budget of the U.S. Government, Fiscal Year 2018[9]

Innovation requires research. As Vannevar Bush, who is often described[10] as the father of the National Science Foundation, wrote in 1945:

> New products and new processes do not appear full-grown. They are founded on principles and new conceptions, which in turn are painstakingly developed by research in the purest realms of science. A nation which depends upon others for its new basic scientific knowledge will be slow in its industrial progress and weak in its competitive position in world trade.[11]

Apple did not build the iPhone in a vacuum. Rather, the smart phone was the result of decades of research in numerous disciplines—generalized, curiosity-driven foundational research, as well as focused, purpose-driven research. *Both* are fundamental to innovation leadership

Foundational, "curiosity" research is the bedrock of innovation. The National Science Foundation defines it as "activity aimed at acquiring new knowledge or understanding without specific immediate commercial application or use."[12] It fosters discovery that informs and strengthens the application of new technologies down the road. The success of foundational research is not always immediately tangible nor is it guaranteed; it is by design an exploration of the unknown. Yet as Vannevar Bush understood, basic research is essential if the United States is to remain the global innovation leader.

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[9] "Analytical Perspectives: Budget of the U.S. Government, Fiscal Year 2018," *Executive Office of the President of the United States, Office of Management and Budget*, Feb. 2018, https://www.whitehouse.gov/wp-content/uploads/2018/02/ap_18_research-fy2019.pdf, p. 233.

[10] "How America Risks Losing Its Innovation Edge," Walter Isaacson, *Time*, Jan. 3, 2019, http://time.com/longform/america-innovation/.

[11] "Science: The Endless Frontier," Vannevar Bush, *Transactions of the Kansas Academy of Science (1903-)*, 1945, pp. 231–264, www.jstor.org/stable/3625196.

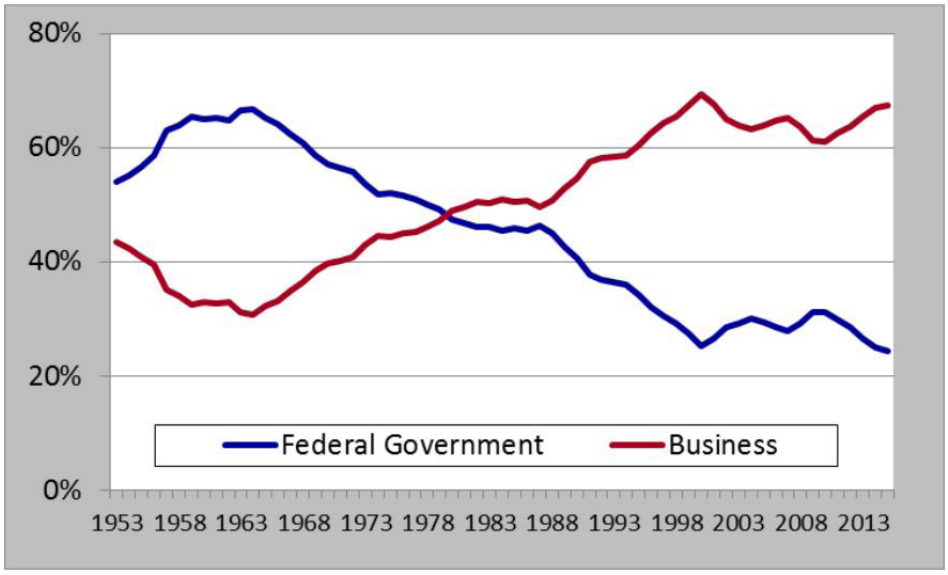
[12] "Data check: U.S. government share of basic research funding falls below 50%," Jeffrey Mervis, *Science*, Mar. 9, 2017, https://www.sciencemag.org/news/2017/03/data-check-us-government-share-basic-research-funding-falls-below-50.

The U.S. economy relies on federal R&D investment to support foundational research while industry directs its R&D resources into applied research where payoff is more likely. This is precisely why the United States government has historically funded foundational research, leading to significant technological advances benefitting the nation and the world. It is foundational research and early-stage applied research that fuels innovation, laying the groundwork for new products and services.

A close look at recent technological advances reveals how federal funding often leads to radical technological change. Federal investment played a critical role in developing GPS, supercomputing, and the Internet. These inventions began as government projects before blossoming into whole commercial industries. In other cases, smaller and more strategic funding from the federal government supported key advancements in the private sector, such as Google's search algorithm and visible LEDs. The iPhone's core technologies, including capacitive sensors, solid-state memory, the click wheel, cellular communications, Siri, microchips, and the touchscreen originally derived from U.S. government and military research efforts.

Unfortunately, federal R&D funding—which encompasses foundational research—as a percentage of GDP has fallen steadily since the 1960s. In the 1980s, industry began outspending the federal government in R&D, and that gap has steadily widened ever since, creating a reliance on private investment for research.

Federal and Business Shares of U.S. R&D Expenditures, 1953-2015



Source: CRS analysis of National Science Foundation, National Patterns of R&D Resources: 2015-2016 Data Update.[13]

Private sector R&D is essential to the U.S. economy and the success of its businesses. Yet it is not a substitute for long-term, foundational research that the government has historically funded—the very research that the private sector often eschews in favor of purpose-driven research.

[13] "U.S. Research and Development Funding and Performance: Fact Sheet," John F. Sargent Jr., *Congressional Research Service Report*, June 29, 2018, https://fas.org/sgp/crs/misc/R44307.pdf.

Although industry R&D investment continues to rise, dwindling federal government investment is troubling. If the United States wants to lead the world in innovation, this must change.[14]

The case for government R&D funding—particularly foundational research—is simple: no one else will do it at scale. Foundational research frequently does not reward the original spender. Investing in technological innovation is risky, and long-term research often fails to yield profits.[15] In the private sector, it is difficult to make a business case to support theoretical research that might not lead to a marketable product even after years of effort.

As a result, the private sector often gets involved in such investment at the tail stages of research, when the likelihood of profit is much higher.[16] Private sector reluctance to support foundational research has increased in recent decades, particularly since the mid-1980s.[17] This is entirely reasonable—investors and the stock market do not reward near-misses or discoveries that power a competitor's widget. But this hesitance can also lead to big misses. Take, for instance, immunotherapies. Relying in part on two grants from the National Institutes of Health, cancer researcher Jim Allison achieved a monumental breakthrough in immunotherapy.[18] Yet as he searched for follow-on funding to turn his discovery into a workable therapy, he was repeatedly turned down by "skeptical" leading companies.[19] Today, immunotherapy is perhaps the most promising field of cancer treatment.

Without foundational research there will be far fewer end-stages in which to invest. While one company sees little immediate benefit from another company's successful research, society as a whole benefits through economic growth, better jobs, improved quality of life, and stronger national security. The government should include these factors in determining where and when to invest its R&D funding and use them to measure the success of its investment in foundational research. The government must have a tolerance for risk—and for failure of some endeavors—that the private sector often cannot afford.

Today's state of investment does not bode well for the United States. The combination of two trends—declining federal funding of R&D and increased private sector focus on late-stage research—is a recipe for an innovation wasteland in the United States. The risks are serious. Business expert Greg Satell concluded that "[t]his puts the U.S. . . . at risk of falling behind in key growth sectors such as renewable energy, nanotech and space exploration."[20] One researcher

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[14] "Federally Supported Innovations: 22 Examples of Major Technology Advances that Stem from Federal Research Support," Peter L. Singer, *The Information Technology & Innovation Foundation*, Feb. 2014, http://www2.itif.org/2014-federally-supported-innovations.pdf.

[15] *The Entrepreneurial State: Debunking Public vs. Private Sector Myths*, Mariana Mazzucato, Anthem, 2013.

[16] "Federally Supported Innovations," Singer, 2014 and *Entrepreneurial State*, Mazzucato, 2013.

[17] "Federally Supported Innovations," Singer, 2014.

[18] "CD28 and CTLA-4 Have Opposing Effects on the Response of T cells to Stimulation," Matthew F. Krummel and James P. Allison, *Journal of Experimental Medicine*, Aug. 1995, pp. 459-465, http://jem.rupress.org/content/jem/182/2/459.full.pdf.

[19] "The T-Cell Army," Jerome Groopman, *The New Yorker*, Apr. 16, 2012, https://www.newyorker.com/magazine/2012/04/23/the-t-cell-army.

[20] "4 Government Programs That Drive Innovation," Greg Satell, *Forbes*, July 2, 2013, https://www.forbes.com/sites/gregsatell/2013/07/02/4-government-programs-that-drive-innovation/#7285d5913978.

from the Massachusetts Institute of Technology found that "[o]ver the long term, cuts in federal spending on research and development will result in lower long-term GDP growth and potentially an end of the historic trend of exponential growth."[21]

While the Trump administration does recognize "the continued importance of R&D spending to support innovation," recent data is troubling. U.S. government investment continues to decline, while other nations are increasing federal investment and strengthening foundational research. In fact, the White House's proposed budget for 2020 decreases foundational research funding by 10% and applied research by 14% from the last fiscal year.[22] By contrast, China doubled its foundational research funding in the last five years and spent a record $254 billion on R&D in 2017, narrowing the gap between it and the United States in R&D spending.[23] If measuring R&D spending as a percentage of GDP, Japan, South Korea, Israel, and Finland all outcompete the United States.[24] Stagnant R&D funding is not unique to the current administration. Except for the first year of the Obama Administration when the American Recovery and Reinvestment Act of 2009 provided a one-time surge in R&D spending, federal funding decreased during his two terms. In fact, most science agencies operated below funding levels of previous administrations.[25] If the United States wants to lead in innovation, particularly with respect to critical technologies, then the federal government must invest more in R&D. The solution to this problem begins with a national research and development agenda.

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[21] "Federally Supported Innovations," Singer, 2014.

[22] "A Budget for a Better America: Analytical Perspectives," *Executive Office of the President of the United States, Office of Management and Budget*, Mar. 11, 2019, https://www.whitehouse.gov/wp-content/uploads/2019/03/spec-fy2020.pdf, p. 271.

[23] "Surging R&D Spending in China Narrows Gap with United States," Dennis Normille, *Science*, Oct. 10, 2018, https://www.sciencemag.org/news/2018/10/surging-rd-spending-china-narrows-gap-united-states.

[24] "How Much Does Your Country Invest in R&D," UNESCO Institute for Statistics, http://uis.unesco.org/apps/visualisations/research-and-development-spending/.

[25] "Science and Technology Funding Under Obama: A Look Back," Matt Hourihan, American Association for the Advancement of Science, Jan. 18, 2017, https://www.aaas.org/news/science-and-technology-funding-under-obama-look-back.

ENABLING INNOVATION

Investment is essential for innovation, but it is not the only factor that enables it. So what policies should the United States pursue to encourage those innovation enablers? First, innovation thrives in a free and open society, and we must promote policies that are consistent with our core values to create equal opportunities to succeed. These values encourage the competition that drives individuals and businesses to optimize performance and seek improvement. More broadly, the United States continue must maintain strong trade, encourage immigration, provide affordable education, and value a diverse workforce.

Policies that promote trade can foster innovation by growing markets and enhancing efficiency through competition. More competition, specialization, and efficiency in turn encourage and increase the value of innovation. Specialization can increase the value of R&D investment by amplifying the amount of knowledge produced from individual investments. Moreover, larger markets yield higher profits for a given level of innovation, and therefore raise the incentive to innovate. Finally, trade can expose firms to the global flow of ideas, best practices, and new tools and techniques that make companies more productive and efficient.[26]

Immigration also drives innovation. It offers businesses access to a larger, more diverse marketplace of human capital and talent, as well as to new ways of thinking and differing approaches to solving common problems. Innovation requires a risk-taking ecosystem, and many immigrants are by their very nature willing to take risks to change and improve their lives, having relocated to a foreign land often with no native language skills. Restrictions on immigration, especially for those who are highly educated and bring unique skills, will severely damage America's ability to innovate, compromising the country's technological edge and economic growth.[27]

The ties between immigration and innovation are not new. A recent paper quantified the contributions of immigrants to American technological progress by matching United States patent data to local Census data during the "golden age of innovation" between 1880 and 1940. It found that "immigrants fueled regional inventiveness, bolstered creative momentum within their industries, and drove long-term technological growth."[28] This "immigrant effect" continues into the present day. A 2018 Stanford Business School study found that immigrants are responsible for more than 30% of combined American innovation since 1976, despite

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[26] "Trade, Innovation, and Economic Growth," Jason Furman, *The White House, President Barack Obama*, Apr. 8, 2015, https://obamawhitehouse.archives.gov/sites/default/files/docs/20150408_trade_innovation_growth_brookings.pdf.

[27] "How Immigrants Changed the Geography of Innovation," Tanvi Misra, *CityLab*, Feb. 8, 2017, https://www.citylab.com/life/2017/02/how-immigrants-influenced-the-geography-of-innovation/515901/.

[28] "Immigration and the Rise of American Ingenuity," Ufuk Akcigit, John Grigsby, and Tom Nicholas, *Harvard Business School*, Jan. 26, 2017, https://www.hbs.edu/faculty/Publication%20Files/17-064_50573c08-d0ca-4092-9f51-b079ed33c26b.pdf.

comprising only 16% of inventors.[29] Immigrants "with big ideas flock to places and fields where their ideas are in demand" and "when many of them work together, they influence each other, compounding the ingenuity in their own field and others," creating a "spillover effect" in places such as Silicon Valley.[30]

Table: Nineteen Immigrant Founders of U.S.-Based Companies

COMPANY	FOUNDER OR CO-FOUNDER(S)	ESTIMATED VALUATION OR MARKET CAP
Alphabet	Sergey Brin (Russia)	$827.6 billion
Uber	Garrett Camp (Canada)	$55.6 billion
Capital One	Nigel Morris (United Kingdom)	$40.7 billion
Ebay	Pierre Omidyar (France)	$33.8 billion
SpaceX	Elon Musk (South Africa)	$33.3 billion
Stripe	John Collison (Ireland), Patrick Collison (Ireland)	$22.5 billion
Crowdstrike	Dmitri Alperovitch (Russia)	$17.1 billion
Palantir	Peter Thiel (Germany)	$11.0 billion
Robinhood	Vlad Tenev (Bulgaria)	$7.6 billion
Instacart	Apoorva Mehta (Canada)	$7.6 billion
Slack	Stewart Butterfield (Canada), Serguei Mourachov (Russia), Cal Henderson (UK)	$7.1 billion
Unity Technologies	Joachim Ante (Denmark)	$6.0 billion
Credit Karma	Kenneth Lin (China)	$4.0 billion
Tanium	David Hindawi (Iraq)	$3.5 billion
Cloudflare	Michelle Zatlyn (Canada)	$3.2 billion

Source: "Immigrants and Billion-Dollar Companies," Stuart Anderson, *National Foundation for American Policy*, Oct. 24, 2018, https://nfap.com/wp-content/uploads/2018/10/2018-BILLION-DOLLAR-STARTUPS.NFAP-Policy-Brief.2018-1.pdf.

[29] "The Contribution of High-Skilled Immigrants to Innovation in the United States," Shai Bernstein, Rebecca Diamond, Timothy McQuade, and Beatriz Pousada, *Stanford Graduate School of Business*, Nov. 6, 2018, https://www.gsb.stanford.edu/gsb-cmis/gsb-cmis-download-auth/472776.

[30] "How Immigrants Changed the Geography of Innovation," Misra, *CityLab*, 2017.

INNOVATION BARRIERS

High-quality, affordable education is essential in an innovation economy, and the United States must improve access to education to maintain its innovation leadership. A key piece of this will be expanding opportunities for science, technology, engineering, and math (STEM) education and generating greater participation from diverse groups of Americans. The United States is lagging behind other countries in STEM, despite the growing demand from employers for STEM-educated employees. In fact, the United States confers only ten percent of STEM bachelor's degrees worldwide, whereas China and India collectively confer nearly half of the world's science and engineering bachelor's degrees.[31] STEM education directly influences patent production, as a greater percentage of STEM employment in an industry generally yields a higher number of granted patents.

But an education program focused on innovation cannot be limited to STEM. Innovation builds on more than math and science—it requires creativity and non-linear thinking, and should include moral and ethical considerations. In recent years, some educators have focused on the need to add art and design to STEM education—moving from STEM to STEAM.[32]

Diversity is also tied to innovation, as companies with policies that actively seek to retain and promote diverse employees tend to be more innovative and launch more products.[33] But diversity is not limited to inherent qualities like gender, ethnicity, or sexual orientation. Acquired diversity, such as international experience, cross-sector experience, and nonlinear careers, constitute "two-dimensional (2-D) diversity" that improves market performance and innovation. Research suggests firms with 2-D diversity have a 45% greater likelihood of market share growth and are 70% more likely to capture new markets. In short, there are opportunity costs for neglecting diversity.[34]

The United States cannot lead in innovation without combating inherent challenges present today. Immigration restrictions, limited federal funding, and impediments to education are among the many factors that restrict innovation in the United States. At a time when competition is fierce, and technology is rapidly evolving, the opportunity costs are too high for the United States to neglect innovation drivers.

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[31] "Charting a Course for Success: America's Strategy for STEM Education," Committee on STEM Education, *National Science & Technology Council*, Dec. 2018, https://www.whitehouse.gov/wp-content/uploads/2018/12/STEM-Education-Strategic-Plan-2018.pdf.

[32] "STEM TO STEAM," http://stemtosteam.org/.

[33] "Diversity in Business Really Does Boost Innovation, According to a New Study," Melissa Locker, *Forbes*, Jan. 12, 2018, https://www.fastcompany.com/40516536/diversity-in-business-really-does-boost-innovation-according-to-a-new-study.

[34] "How Diversity Can Drive Innovation," Sylvia Ann Hewlett, Melinda Marshall, and Laura Sherbin, *Harvard Business Review*, Dec. 2013, https://hbr.org/2013/12/how-diversity-can-drive-innovation.

Countries like China combine industrial policy, regulation, foreign investment, and technical means to advance a whole-of-society strategy designed to leapfrog the United States and Europe.[35] The Committee on Foreign Investment in the United States (CFIUS) and the recently-passed Foreign Investment Risk Review Modernization Act aim to control foreign investment that might undermine national security, but current law leaves important gaps.[36] The CFIUS process must be robust but smart, comprehensive but not predisposed toward rejecting transactions. Companies can also take steps to protect national security while maintaining foreign partnerships.[37]

Furthermore, the United States must continue to deter economic espionage and cybertheft to protect innovation. The U.S. Intelligence Community has described a range of threat actors who conduct economic espionage to steal intellectual property and trade secrets. It is imperative we secure our data and systems to protect American intellectual property, trade secrets, and proprietary information. The United States cannot lead in innovation if our resources are siphoned off by competitors.

While the United States should take a stronger stance to protect assets and deter economic espionage, these approaches should not be conflated with protectionist and risk-averse policies. Protectionism can hamper economic growth by reducing the pressure of international competition, thus devaluing the production of new technology. Japan's rising challenge to U.S. technological dominance in the 1980s proves that protectionism is not the only solution to combating rising economic powers. Despite growing pressure for protectionist policies, the Reagan administration instead implemented an investment tax credit to drive domestic innovation. Aggregate R&D by U.S. companies rose dramatically, rewarding U.S. companies for decades after.[38] The underlying principle remains valid today: larger markets yield more profits. Participating in international markets means potentially higher returns on R&D investment, incentivizing companies to innovate and compete internationally. Trade with other countries also facilitates the exchange of new ideas. In other words, innovation relies on collaboration and competition. A strong international market drives technological advances, while protectionist policies and lackluster funding will impair innovation and economic growth.

Perhaps the biggest barrier to innovation is fear of failure and the unwillingness to take risk. Foundational, curiosity-driven research often lacks an "*a ha!* moment" when it can be declared a success. The tangible benefits of foundational or purpose-driven research may not materialize for years or decades, if at all. But if innovators—companies *and countries*—are unwilling to take those risks, innovation will wither. The United States needs to fund research at all stages, knowing some efforts will not bear fruit and that there cannot be a post hoc search for blame when this happens. We must embrace a risk-taking cultural ecosystem that fosters curiosity.

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[35] "Update Concerning China's Acts, Policies, and Practices Related to Technology Transfer, Intellectual Property, and Innovation," Office of the United States Trade Representative, Nov. 20, 2018, https://ustr.gov/sites/default/files/enforcement/301Investigations/301%20Report%20Update.pdf.

[36] "Recognizing Vendor Risks to National Security in the CFIUS Process," Annie I. Antón and Justin Hemmings, *Lawfare*, Jan. 4, 2019, https://www.lawfareblog.com/recognizing-vendor-risks-national-security-cfius-process.

[37] "How Big Tech Can Work With China But Protect U.S. Security," Michele A. Flourney and Josh Hochman, *Bloomberg*, Jan. 31, 2019, https://www.bloomberg.com/opinion/articles/2019-01-31/u-s-tech-companies-should-embrace-export-controls-to-china.

[38] "How Protectionism Poisons Innovation," Howard R. Gold, *Chicago Booth Review*, Sept. 24, 2018, http://review.chicagobooth.edu/economics/2018/article/how-protectionism-poisons-innovation.

We cannot have a repeat of 1993, when Congress walked away from the Superconducting Super Collider in Texas. As a result of that shortsightedness, Switzerland is now home to fundamental breakthroughs in physics at the Large Hadron Collider—the replacement for our cancelled Super Collider. [39] These discoveries could have been taking place in the United States, along with the significant attendant investment and research that has grown up around the Collider.[40]

Moreover, history is rich with technologies that "experts" believed should have been abandoned or ignored during the early stages of development. The U.S. Postmaster General declined to purchase the rights to Samuel Morse's telegraph in 1845, after expressing doubts that "its revenues could be made equal to its expenditures." Thirty years later Western Union Telegraph rejected the opportunity to purchase Alexander Graham Bell's telephone patents, viewing the telephone merely an "electrical toy." Thomas Edison persisted in developing the electric light, despite analysis by an investigating committee of the British Parliament that his invention was "unworthy of the attention of practical or scientific men." And American inventor Lee de Forest scoffed at the television, calling it "an impossibility, a development of which we need waste little time dreaming." [41] We need a government and private sector environment that encourages, not punishes, these risk-takers.

In the end, we must choose what failure we as a society deem acceptable. Are we comfortable living with the consequences of our failure to innovate and encourage an innovation society? Or can we accept the occasional research failure and embrace the risk that breeds innovation? During the 20th century, the United States was a risk-taking nation—we came down decisively on the side of fostering innovation and accepting that not all research would be successful. We are now facing that choice again, and the decisions we make will impact us for the rest of this century.

[39] "The Supercollider That Never Was," David Appell, *Scientific American*, Oct. 15, 2013, https://www.scientificamerican.com/article/the-supercollider-that-never-was/.

[40] "The Impacts of Large Research Infrastructures on Economic Innovation and on Society: Case Studies at CERN," Organization for Economic Cooperation and Development, 2014, http://www.oecd.org/sti/inno/CERN-case-studies.pdf, p. 15.

[41] "Hindsight, Foresight, And No Sight," Peter Baida, *American Heritage*, June/July 1985, Vol. 36, Issue 4, https://www.americanheritage.com/hindsight-foresight-and-no-sight.

A PATH FORWARD

For the United States to remain the global innovation leader, the federal government must lead the way. This will require focus, funding, and a willingness to take risks that is often lacking in government and political leadership. But maintaining America's leadership position will take more than directing dollars to specific research projects; it must include reexamining government policies in areas as disparate as defense, immigration, education, tax, and trade. In short, it requires a whole-of-government, if not a whole-of-society, effort. Whatever course we chart today must be flexible as new global and technological realities emerge. Below are recommendations, both general and specific, to set the United States on the path toward solidifying and increasing its innovation leadership.

- **BUILD CONSENSUS:** ***The United States government and the private sector should collaborate to build a national consensus and momentum behind specific research priorities.***
    - Without the unifying pressures of the Cold War, the United States needs surrogates to focus and sustain a national R&D effort. The "war on cancer," which began in 1971, offers one model for driving funding and research. It also offers lessons regarding how to scope the mission and define success, *e.g.*, while cancer has not been eradicated, treatments and mortality rates have greatly improved.
    - Another model is to identify objectively unsustainable situations (e.g., energy development, environmental conditions, or health care costs) and focus research funding on relevant critical technologies for next generation innovation. The government must make the case for why it is essential to the United States' national and economic security for us to lead in these areas. We do not want another "Sputnik moment" when a foreign competitor leaps ahead of the United States in AI, quantum computing, or sustainable energy.
    - Scientific grand challenges are another place to marshal research and provide an opportunity to partner with the private sector to support specific work.

- **INCREASE RESEARCH FUNDING:** ***The federal government should greatly increase funding for foundational scientific research and develop a strategy to guide grantmaking.***
    - The federal government should establish research priorities in funding and direction. This should be done in coordination with the private sector but recognizing the different role and goals of the private sector.

- Congress should ensure that federal agencies have the budget authority and appropriations to bring the federal government back to at least a 50% share of basic research nationwide. Authorizing language should be accompanied by statutory language that expressly embraces risk and encourages federal agencies to adopt a risk tolerant approach to awarding federal research grants.
- More funding for the National Science Foundation specifically will encourage a strategic approach to basic research by funding projects that are complementary and aligned with broad national research objectives.

- **PROMOTE FREE TRADE POLICIES:** ***The United States must protect valuable intellectual property while avoiding protectionist policies that stifle trade or weaken the economy.***
  - The United States must avoid protectionist policies that stifle trade or weaken the economy.
  - The government should ensure that export controls over technology do not constrain or disadvantage R&D in the United States or try to control technologies that are already global.
  - The CFIUS process must be robust but smart; comprehensive but not predisposed to rejecting transactions.
  - A key component to intellectual property protection is cybersecurity. All organizations should consider previously published recommendations from the Aspen Cybersecurity Group related to operational collaboration, IoT security, and workforce development.

- **ENCOURAGE IMMIGRATION:** ***Congress and the Administration should work together to create an immigration system that makes the United States a magnet for immigrants across the world.***
  - The United States needs to remain a magnet for immigrants from around the world. Policies should encourage immigration broadly, incentivize immigration by high-skill individuals, and encourage student immigrants to live in the United States after obtaining an education.
  - At a time when many foreign students are deciding to return home after earning post-graduate degrees in the United States, all levels of government must create competitive incentives to encourage these highly valued individuals to remain.

- **INVEST IN EDUCATION:** ***We must continue to align educational instruction and access with innovation priorities.***
  - We must continue to develop our educational system at all levels.
  - STEM education is important, but not sufficient. We must recognize that innovation is a combination of creativity and move from STEM to STEAM.

- We must also factor in ethical and moral considerations related to technology and develop education programs that teach innovators to consider how a technology can and should be used, not just how to create it.
- We must make sure that higher education is accessible to all Americans.

THE ASPEN CYBERSECURITY GROUP is the nation's leading cross-sector, public-private cybersecurity forum comprising former government officials, Capitol Hill leaders, industry executives, and respected voices from academia, journalism, and civil society that work to translate pressing cybersecurity conversations into action. See below for a list of its formal membership as of August 2019:

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