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Keeping America's Innovative Edge

A STRATEGIC FRAMEWORK

BY Peter Engelke and Robert A. Manning

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Foreword

BY JON M. HUNTSMAN, JR.

Turning scientific knowledge and engineering prowess into commercial products and services—tech-driven innovation—is a major reason why the United States became the world's foremost economic and geopolitical leader, and why it remains so today. However, there is no guarantee that the future will resemble the past. With worldwide competition increasing in this space, the United States must evaluate how it can retain its edge as the world's leading innovator.

This question is at the heart of a multiyear partnership between the Atlantic Council's Brent Scowcroft Center on International Security and Qualcomm, Inc. The first year of the partnership focused on what makes the US innovation system—what this report calls the "engine"—run so well. This report is the result of that yearlong effort. It presents a whole-of-America, bottom-up look at the country's innovation engine.

Adding to the Scowcroft Center's previous research on tech hubs, the researchers embarked on a cross-country trip to visit four tech hubs: Madison, Wisconsin; Boulder and Denver, Colorado; Austin, Texas; and the San Francisco Bay Area in California. Over the course of this process, they met with local entrepreneurs and founders of startups; university administrators, faculty, and students working on commercializing campus research; venture capitalists helping fledgling startups get off the ground; federal research lab officials leading the nation's critical scientific efforts; coding boot camp owners upskilling workers to place them in software engineering jobs; and elected officials enacting innovation-friendly policies.

Together, this enormous community of people painted a vivid picture of America's innovation engine in full swing—one that continues to be the best in the world, churning out revolutionary technologies with the potential to change the world.

But, they also pointed out shortcomings that the US must address if it is to remain at the top of the rapidly changing global knowledge economy. If the United States fails to close the gaps and adapt to the changes, it risks losing its technological and innovative edge and diminishing a powerful driver of economic growth. In turn, this would mean losing its leadership position in the world.

The aim of this report is to shed new light on the challenges and raise awareness about the need to strengthen and spread technological innovation more broadly across the United States. The report's recommendations offer a blueprint for creating a more inclusive knowledge economy that provides opportunities and prosperity for all Americans, and retains the country's status as the foremost innovator in the world.

Jon M. Huntsman, Jr.
Chairman
Atlantic Council

Executive Summary

BY MATHEW J. BURROWS

Dr. Mathew J. Burrows *is the director of the Atlantic Council's Foresight, Strategy, and Risks Initiative in the Brent Scowcroft Center on International Security. He is the principal author of the National Intelligence Council publication* Global Trends 2030: Alternative Worlds*.*

After World War II, a confluence of factors enabled the United States to become the world's leading technological and economic powerhouse. But now, the United States risks becoming less competitive and losing its edge in tech innovation, which would have profound implications for its global leadership. This paper provides a strategic framework for shoring up US innovation.

Two trends are increasing the risk of a loss in the United States' technological edge. On the one hand, emerging countries now recognize the importance of a knowledge-based economy and are making it a priority. China seeks to dominate the "full stack" of tech innovation, starting at the bottom with the research and development of basic technologies, and continuing up to the production of hardware, software, apps, social media platforms, and other goods across a range of industries from consumer electronics to biotechnology. For example, having already established smart phone companies, the Chinese have begun to invest heavily in producing the underlying technologies within those phones, such as microchips. At the same time, China and other emerging countries, like India, are devoting significant monetary and human capital resources to other emerging technologies, including artificial intelligence, machine learning, and robotics, threatening to leapfrog US advances in these areas.

On the other hand, the United States is now far less willing to make the necessary investments in the sources of innovation at home. Federal funding for basic research and development continues to decline, while support for public universities is being slashed. The United States' attention should be focused on technological transformations and how to prepare for them. As robots and automated manufacturing processes enable factories to produce more goods with fewer people, the US will need to rethink everything from education and skills training to social safety nets to prepare for the jobs of the future.

Together, these trends could have significant geopolitical and socioeconomic implications for the United States. The US military could lose control over mission-critical technology; private firms and companies could fail to commercialize the next revolutionary consumer good; and Americans could find themselves less educated and less employable than other citizens around the world. It is in the United States' best interest to develop more tech hubs in more places, and therefore bring in more diversity to the nation's innovation machine. Expanding the circle of prosperity and spreading technological innovation throughout the country will be important to future economic growth. A more diverse and enlarged set of tech hubs can help seed more sources of prosperity throughout the country.

Harrison H. Schmitt during the third Apollo 17 Extravehicular Activity (EVA-3).

NASA GODDARD SPACE FLIGHT CENTER/FLICKR

Highlights of this Report

Research and Development

Research and development (R&D) is the cornerstone of the innovation process. The federal government is the most important part of the R&D equation, with academia and the private sector playing key roles as well. However, the current downward trajectory of federal R&D spending combined with declining federal and state support for research universities does not portend well for maintaining the United States' technological superiority. If the US innovation engine is not tuned up soon, others will surpass it.

Federal funding for R&D needs to be thought of as the nation's scientific seed corn, enabling basic, pre-competitive R&D that will mature into harvestable technologies in the future. However, federal R&D spending has shrunk significantly over the last few decades; once the world leader, the United States now ranks twelfth in government-funded R&D spending as a percentage of GDP. Additionally, there has been a complete role reversal in sources of funding between the federal government and the private sector. While the private sector is good at taking mature technologies and turning them into commercially viable products, it is not equipped to develop technologies that can give the United States "first mover" advantages. The federal government is the only actor that can set the agenda for and fund basic scientific research with an eye toward long-run social, economic, and national security payoffs.

America's public and private universities are also critical parts of the nation's research backbone. First, universities conduct basic STEM (science, technology, engineering, and mathematics) research, including the bulk of the nation's pure scientific and technical research (alongside federal research labs). Second, they employ many thousands of scientists, mathematicians, and engineers across the country, while educating and training many more students across a huge range of disciplines. Third, university research itself drives commercial invention in the United States. Finally, universities are important hubs for cultural reasons: by concentrating large numbers of talented people of all ages and diverse backgrounds in a single place, they give tech hubs a vibrancy from which invention and innovation can spring. Yet, despite all this, public support for universities and university research has been on the decline. State governments are increasingly treating higher education as a luxury that should be paid for by direct beneficiaries—the students—rather than as a core public good that is vital to the future.

Casey Weir is an apprentice at Central Piedmont Community College studying Mechatronics Engineering Technology.

PHOTO COURTESY OF CENTRAL PIEDMONT COMMUNITY COLLEGE

Human Capital: Rethinking Skills and Skills Training

Human capital is another critical factor in innovation, as it is people who have the skills to turn ideas into commercial products and services. The United States needs to educate more of its own citizens in STEM subjects, while also remaining a magnet for the world's talent. If the United States aspires to have both a strong national economy and broadly shared prosperity, it must provide much better education and training systems that fit the twenty-first century's knowledge economy. Additionally, the very concept of "work"—and the social protection programs built around it—may need to be rethought. However, even as the United States trains more of its citizens, immigration reform is also needed to fill demand for highly skilled workers.

Coding "boot camps"—which have exploded over the past decade—have become an important training intermediary. They provide an intense, immersive experience for people who want to become software developers. Startup accelerators and incubators also are facilitating efforts to give better training in entrepreneurship. They help teach skilled technicians (engineers, scientists, etc.) how to become successful business owners; enable fledgling businesses to co-locate

in common office spaces and receive some initial investment; and offer mentorship, peer collaboration, networking opportunities, and marketing advice. In addition, the nation's community colleges play a key role, as the knowledge economy will require highly skilled workers who can use both their hands and minds. Vocational training and apprenticeship programs have great potential to bring more people into the innovation machine.

Finally, while getting more Americans directly involved in tech innovation, the United States needs to keep the door open—if not widen it more—to non-US talent. Skilled immigrants have played an outsized role in America's innovation machine, more often than native Americans becoming entrepreneurs. Many also fill highly critical positions in the tech fields. The country benefits from the dynamism and creativity that skilled immigrants bring with them. Foreign-born STEM workers who attend US universities but end up having to return to their home countries such as China or India where they will compete against US firms is a self-inflicted wound that Washington must address.

Ideas and Intellectual Property

The United States has a long and robust history of intellectual property protection, dating back to the country's founding. The framers set up a system that protects both the private property right and interest in profit and the public interest in knowledge production and dissemination. In the United States, intellectual property protection extends to patents, copyrights, trade secrets, and trademarks. The US patent protection system has been—and remains—one of the strongest in the world. Since the country's inception, this system has been undergirded by a well-developed body of patent law and a strong system of patent review and approval.

In recent years, critics have argued that the US patent system is inefficient, leads to too many patent infringement lawsuits, creates intellectual monopolies, raises R&D costs, hinders private investment, and hits small firms such as startups particularly hard. However, empirical studies have provided strong counter-evidence that the US patent system continues to do its job very well.

The most contentious part of the debate about the US patent system has revolved around patent litigation. Critics have argued that increased litigation is a significant problem that hinders innovation, raises tech development costs, and harms small tech firms, including startups. But defenders of the patent system note that patent litigation has been a feature of the US system for a very long time, and that litigation rates have only modestly increased if at all. They therefore contend that the litigation problem is greatly exaggerated.

PHOTO BY GEORGE JOCH/COURTESY ARGONNE NATIONAL LABORATORY/WIKIMEDIA COMMONS

Recommendations

The United States must accomplish five main objectives if it wants to maintain its innovative edge:

Enable more citizens to prosper in a twenty-first-century knowledge economy. Federal, state, and local policies must ensure that the innovation engine—and the wealth it creates—is available to all Americans. Making the knowledge economy work for people of all kinds, including women and minority groups, and in all parts of the country rather than only a few, will strengthen the entire nation. To accomplish this, the United States should do the following:

→ Reverse the decades-long trend toward shifting the public-university-funding burden from taxpayers to students. Total student loan debt increased approximately 400 percent from 2004 ($0.26 trillion) to 2016 ($1.31 trillion).[1]

→ Incentivize STEM education, starting at the primary level. The language of the future will be code, and students must learn to read and write it early on.

→ Create a Technology Adjustment Strategy (updating/rethinking Trade Adjustment Assistance) in anticipation of tech-driven disruption and job loss—a comprehensive skills training/social safety net package. It should focus on technology-oriented training and aligning skill with job opportunities that can be provided over the course of a person's working life.

→ Reconsider if postwar social protection programs based on lifetime employment are still the best ones.

Sustain entrepreneurial environments for startups. Talented entrepreneurs are mobile individuals who seek out places to live and work based on several considerations. To build reputations as world-class tech hubs, state and local governments must create and sustain several necessary conditions:

→ Foster the concentration of talent (including like-minded entrepreneurs and skilled technical talent) by linking them to at least one scientific or technical research institution and ensuring easy availability of intermediary institutions, such as accelerators, incubators, and co-working spaces.

→ Ensure better access to capital for tech startups. This includes providing aggressive public funding of R&D at the basic and transitional stages, as well as achieving more balance in federal funding among the sciences. State and local governments can also encourage private capital to focus on startups in smaller tech hubs.

Encourage commercialization of research, no matter where it occurs. Universities play a critical role in tech-based innovation, but often struggle to commercialize their research. Universities need to better facilitate tech entrepreneurship.

→ Fund university-sponsored incubators and accelerators to help get university lab research into the local commercial bloodstream.

→ Broaden the entrepreneurial mindset within universities from simply the development of ideas to the monetization of those ideas. Encourage habits, perspectives, and goals among faculty, research staff, and students to facilitate tech transfers; build the culture and structures to help with such transfers.

→ Identify and employ a best practices template for tech transfer licensing.

Cultivate place and culture. Absent smart and creative state and local policies and practices, America's imbalanced geography of innovation will get worse. State and local governments should do the following:

→ Build and provide effective and efficient transportation systems, affordable housing, high-quality public amenities, good schools, and a clean environment. Tech hubs should not just be where people want to work, but more importantly, where people want to live.

→ Invest in creative public infrastructure.

→ Burnish the unique qualities of their local cultures to attract and build a creative class.

Elevate the positive role that the federal government can play. The United States should recognize there are some things only the federal government can do (convening power, providing for national defense through security-related R&D spending, protecting intellectual property). Besides increasing federal funding for basic R&D, the president should do the following:

→ Assemble a national commission of federal, state, and local government officials, scientists and engineers, university officials, and representatives from civil society and the private sector to identify gaps and vulnerabilities in the US innovation system and recommend ways to reinvigorate US global competitiveness.

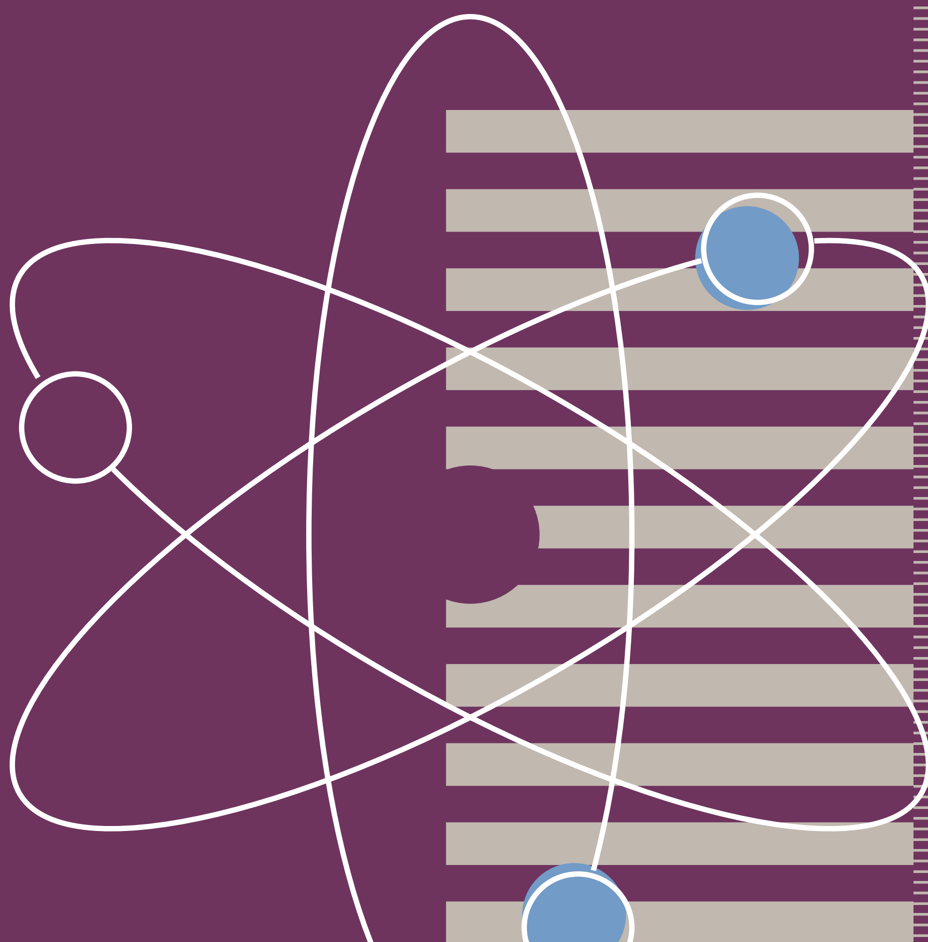
→ Link basic R&D funding to other elements of innovation, by encouraging universities to create robust tech transfer capabilities, directing funds to tech clusters for priority emerging technologies, or incentivizing medical research institutions to collaborate so as to maximize National Institutes of Health grants.

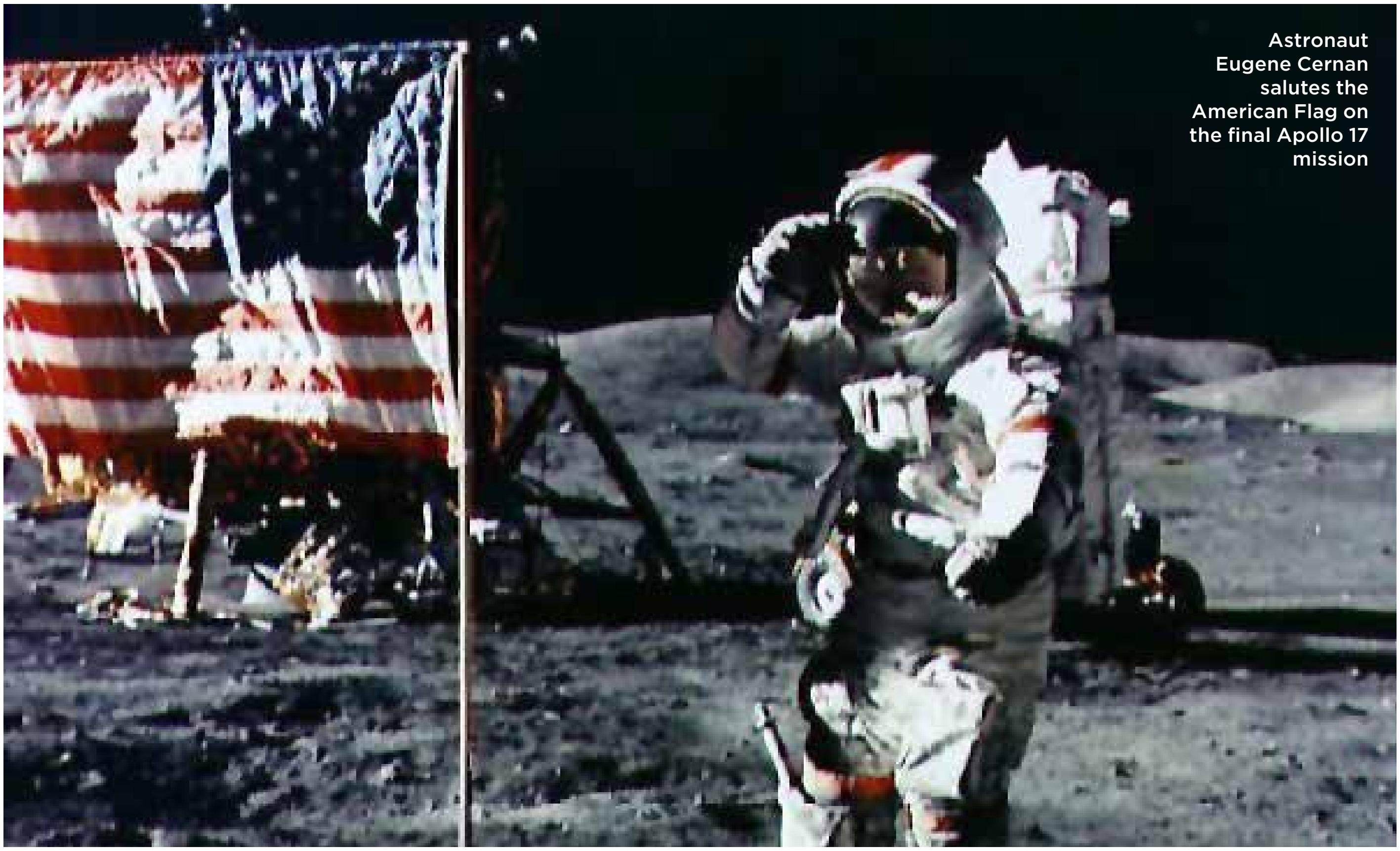
→ Assemble a standing interagency committee to monitor the patent process, including the role of litigation in the system, to advise on whether the patent process is furthering innovation.

Together, these objectives and recommendations define an overarching vision that should drive America's response to increasing global competition in the tech space.

Introduction

Innovation: The process of transforming an idea, concept, or knowledge into a product or service that delivers significant new value.[2]





Astronaut Eugene Cernan salutes the American Flag on the final Apollo 17 mission

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Technical innovation has been fundamental to the economic prosperity and global preeminence of the United States for a very long time. Yet while the United States still enjoys its leading position, there is growing risk that it will lose its edge in technical innovation. There is increasing competition from China and other emerging economies that threatens to displace the United States' top role in a range of key technologies. In an age of ever-faster technical development, the United States will stay atop the global order only if it begins to heed the warnings that have become louder over the past decade, and invests for the future so it continues to turn scientific research into usable technologies swiftly and efficiently. The stakes are enormous, for if the US fails to sustain and strengthen its innovation system, it will be replaced as the world's preeminent economic and geopolitical power.

This report treats innovation as it should be treated: in strategic terms. It examines the process of innovation in the United States and sets out a framework for the US to retain its edge as the global leader in tech-driven innovation. The analysis rests neither on the premise that innovation can be directed only from above by the federal government, nor that it is only the result of heroic individuals tinkering away in their garages. Rather, this document considers both to be essential parts of a national innovation "engine," which together with a series of other moving parts creates the technologies that give the US its competitive edge.

There are at least four types of arguments when it comes to explaining innovation. The first emphasizes the importance of countries, the second of cities, the third of companies, and the fourth of individuals. Each has merit. It makes sense to rank countries by degree of innovativeness, for some countries routinely churn out more innovative material than do others. It makes sense to focus on cities, for the simple reason that innovation occurs far more often in some places than it does in others. Everyone associates Silicon Valley with

The Energy Systems Integration Facility is among the cutting-edge sites NREL uses to collaborate with its partners.

DENNIS SCHROEDER/NREL/FLICKR

innovation for a reason: California's Bay Area, of which the Valley is a part, is the world's premier tech hub. It also makes sense to argue that firms are the sources of innovation. The world's tech giants—Apple, Google, Microsoft, and so on—have developed world-changing technologies. So too have tech startups disrupted the world—Twitter and Uber, to mention just a couple. And finally, of course, innovation is often associated with individuals who, due to genius or inspiration or just plain stubbornness, have invented a world-changing technology or product. Steve Jobs, Bill Gates, Alexander Graham Bell, and many others fall into this category.

All of these arguments are correct, but each is only a partial explanation for how innovation occurs. The reality is that innovation in the United States should be thought of as a system or as a kind of machine—an engine. America's innovation engine has numerous moving, interacting parts, consisting of individual workers, entrepreneurs, researchers, and investors; small and large firms; universities and research laboratories; intermediate institutions of various kinds; and government at the local, state, and federal levels. Each of these parts has a function, and each has a proper role that works in relation to all of the others, much like a physical engine. When one part functions poorly, the engine's performance suffers. When all parts perform well, the engine hums at maximum capacity.

The purpose of this effort is to understand the state of this system of innovation: in part because innovation is so important to the United States' positioning in the world, but also because we (the authors) believe that it is in the best interest of the United States to give more people in more places the chance to participate in the giant wealth creation engine—the machine—that is tech-driven innovation.

As this document describes, America's innovation engine rewards some while leaving many others on the outside looking in. Middle-aged workers, suddenly thrown out of work due to downsizing or outsourcing, often struggle to find their way back into high-paying career paths in a world where their skills no longer apply. Women, the poor, and minorities too often face structural impediments to their full participation. Simply put: not all citizens prosper from America's innovation engine.

There is also an unfortunate spatial dimension to this problem. The fact is that America's innovation engine hums along well in some cities, but is marginal or nonexistent in others. The people who live in the former places benefit economically, those in the latter far less so. This spatial disparity threatens to hollow out the country.

This report examines America's innovation engine from the inside out—or, to apply a different analogy, views it from the bottom up. During the summer and fall of 2016, the authors and other Atlantic Council staff traveled to four recognized tech hubs around the United States: Madison, Wisconsin; Colorado's Front Range (with a focus on the Boulder-Denver corridor); Austin, Texas; and California's Bay Area (the Silicon Valley-San Francisco/Oakland mega region). The Atlantic Council previously visited the Boston-Cambridge area.

The purpose of this "road trip"—admittedly an incomplete tour of the United States' tech hubs—was to learn about why innovation happens in particular places around the United States. With local partners, the Atlantic Council held roundtables in each of the hubs and conducted a series of one-on-one interviews with local leaders, ranging from entrepreneurs to university and federal research lab officials to investors to accelerator owners to scientists and engineers. Each case study is unique, and the road trip was designed to identify and understand how and why each of the hubs works and what the secret sauce is for each. This report's findings are, to a large extent, a distillation of the lessons learned in these places.[3]

This report assumes innovation is a positive-sum game, wherein the success of one place adds to the success of other places around the US. To be certain, there is competition for "knowledge economy" leadership—the United States plays this game, as does the state of Texas, as does Silicon Valley, as do startups everywhere. But the point is that as knowledge is infinite, new knowledge in one place adds to capabilities in others, at least over the long run. It is in the best interest of the United States to create more places that churn out innovative products.

This report is organized as follows. The remainder of this section outlines the stakes for the United States, making the claim that while the US has always been among the world's most innovative societies, its global leadership should not be taken for granted. Keeping the innovation engine running properly should be the top priority of this country's leadership. Some places in the United States do far better at tech-driven innovation than others, with uneven consequences for the country as a whole. Recasting globalization as a technologically-driven phenomenon requiring appropriate responses is an important part of this reprioritization process. The second major section diagnoses the innovation system, taking stock of how it works through an assessment of its various parts. The third major section provides a strategic framework for keeping America's innovation edge in the world. This section provides recommendations for all levels of government as well as for universities and research labs and other pieces of the nation's innovation engine.

A Special Section insert provides a detailed review of each of the four tech hubs that Atlantic Council staff toured during the 2016 trip, plus a shorter review of Washington, DC's status as a tech hub.

Finally, the report features five short essays on various topics penned by guest contributors.

The Stakes

The United States has been a nation of inventors since its founding, from Ben Franklin and Thomas Jefferson to the revolutionary impact of Henry Ford's assembly line, to the creation of the internet, personal computer, Global Positioning System (GPS), and smart phone. America, in short, innovates. Yet this provides no guarantee of future leadership. Historically, the United States did not emerge as the global leader in tech-driven innovation until the twentieth century, and most spectacularly after World War II. A confluence of factors enabled the US to emerge from the war as the world's greatest technological and economic power. This position was greatly assisted by the fact that its rivals were either recovering from the devastation of the war or, in the case of Mao Zedong's China, inwardly focused. It also depended to a great extent on the federal government's decision in the decades after 1945 to invest heavily in science and technology, which led to many of the technologies society now takes for granted, including the internet.[4]

The special conditions that favored the United States after 1945 are gone.

This leadership position is now under considerable stress, for two reasons. First, the special conditions that favored the United States after 1945 are gone. Becoming a global leader in the knowledge-based economy is now a priority for political leaders everywhere, including in the massive emerging economies of China and India. These governments understand the intense international competition for first rank in the global economic and geopolitical sweepstakes.

This observation is not trivial. The Defense Science Board observes that "an increasing fraction of the world's basic research is being conducted outside the United States."[5] More than 51 percent of the world's patents are filed outside the United States.[6] In addition, a significant portion of US private sector research is occurring overseas in corporate subsidiaries and their labs.

Second, the United States now appears far less willing to invest in the sources of innovation, and risks living off of its legacy of past investments. It is important to note that the rise of others does not mean the United States is in decline. The US retains the ingredients for sustaining its leading role—it has sixteen of the world's twenty top-ranked universities, a culture of entrepreneurship, a large and sophisticated venture capital market, a web of tech hubs stretching from Silicon Valley to Boston, and the largest tech companies in the world. Innovation is a ubiquitous buzzword, including at the Pentagon, which has opened an office in Silicon Valley and is appointing a chief innovation officer. Defense officials understand the importance of keeping the US military on the cutting edge of technology.

Yet despite these advantages, the US must continue to make public investments and pull the right policy levers if it is to stay ahead. Political dysfunction and a disillusion with institutions has led to declining federal spending in research and development (R&D), an education system that is not producing enough graduates in STEM (science, technology, engineering, and mathematics), and an array of other challenges that together undermine rather than strengthen the innovation engine.

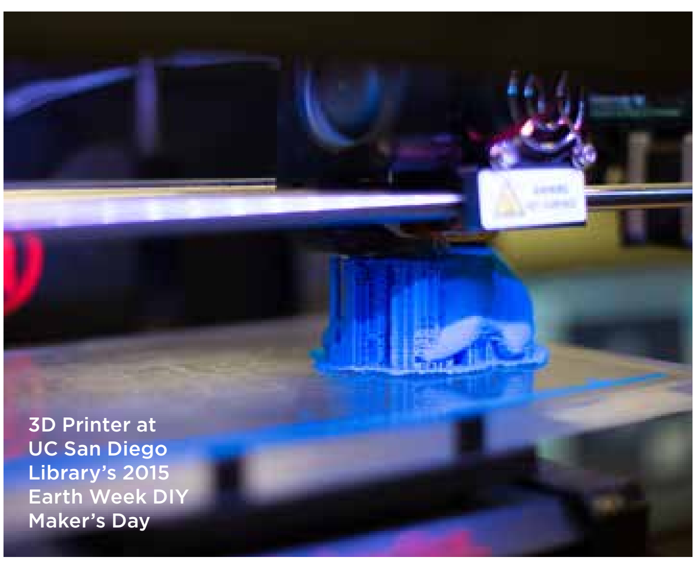
The stakes are not purely geopolitical, for deep socioeconomic questions also are at hand. The world is entering what former AOL Chief Executive Officer Steve Case has dubbed the "third wave" of innovation. Following the rise of the internet in the 1990s and the explosion of the app economy and mobile revolution in the early 2000s, the world entered a period of ubiquitous connectivity.[7] Now, a set of emerging transformational technologies will collectively have as much or more impact on the national and global economies as the digital revolution in the 1990s. These technologies include artificial intelligence, robotics, novel materials, 3-D and 4-D printing, big data analytics, nano-engineering and manufacturing, biotechnologies, and quantum computing. Together, these technologies will profoundly impact the coming decades.[8] They will transform healthcare, education, transportation, finance, food production, and, indeed, the nature of work itself.

Misreading Globalization

The innovation challenge comes at a time when there is increasing backlash against globalization, which in large part is driven by economic inequality within and among nations plus stagnant wages for a great many people. As important as these issues are, the debate about globalization should be recast—we believe we are having the wrong debate about globalization. Trade is important, and it will continue to create winners as well as losers. But the central focus should be on how the United States prepares for the technological transformations that will disrupt national and global markets alike.

Unfortunately, the impact of technology on employment and wages was largely absent as a topic in the 2016 US presidential campaigns. Rather, the major candidates in both political parties focused on trade as an all-purpose villain. Yet the vast majority of manufacturing job loss in the US since 2000—87 percent by one estimate[9]—has been due not to trade, but to the effects of technology and automation. Looking forward, Americans should anticipate a type of globalization that features technology as the central actor. Indeed, this reality might already be here. American manufacturing has held steady at about 15 percent of gross domestic product (GDP), but has represented a declining share of the US workforce for decades.[10] The reason is not hard to divine: robots and automated manufacturing processes have enabled factories to produce just as much with fewer people. These processes will also localize production and shrink global supply chains.

This manufacturing story will be repeated across many sectors, over and again in the coming years. How will the United States rethink and align education and vocational skills with the jobs of the future? How will the United States cushion displaced workers with a social safety net to enable them to sustain and reinvent themselves? How will the United States enlarge opportunity to make the tech-driven economy more inclusive for women, minorities, the poor, and for those mid-career workers whose jobs come to an end through disruption?



3D Printer at UC San Diego Library's 2015 Earth Week DIY Maker's Day

THE UC SAN DIEGO LIBRARY/FLICKR

The Geography of Innovation

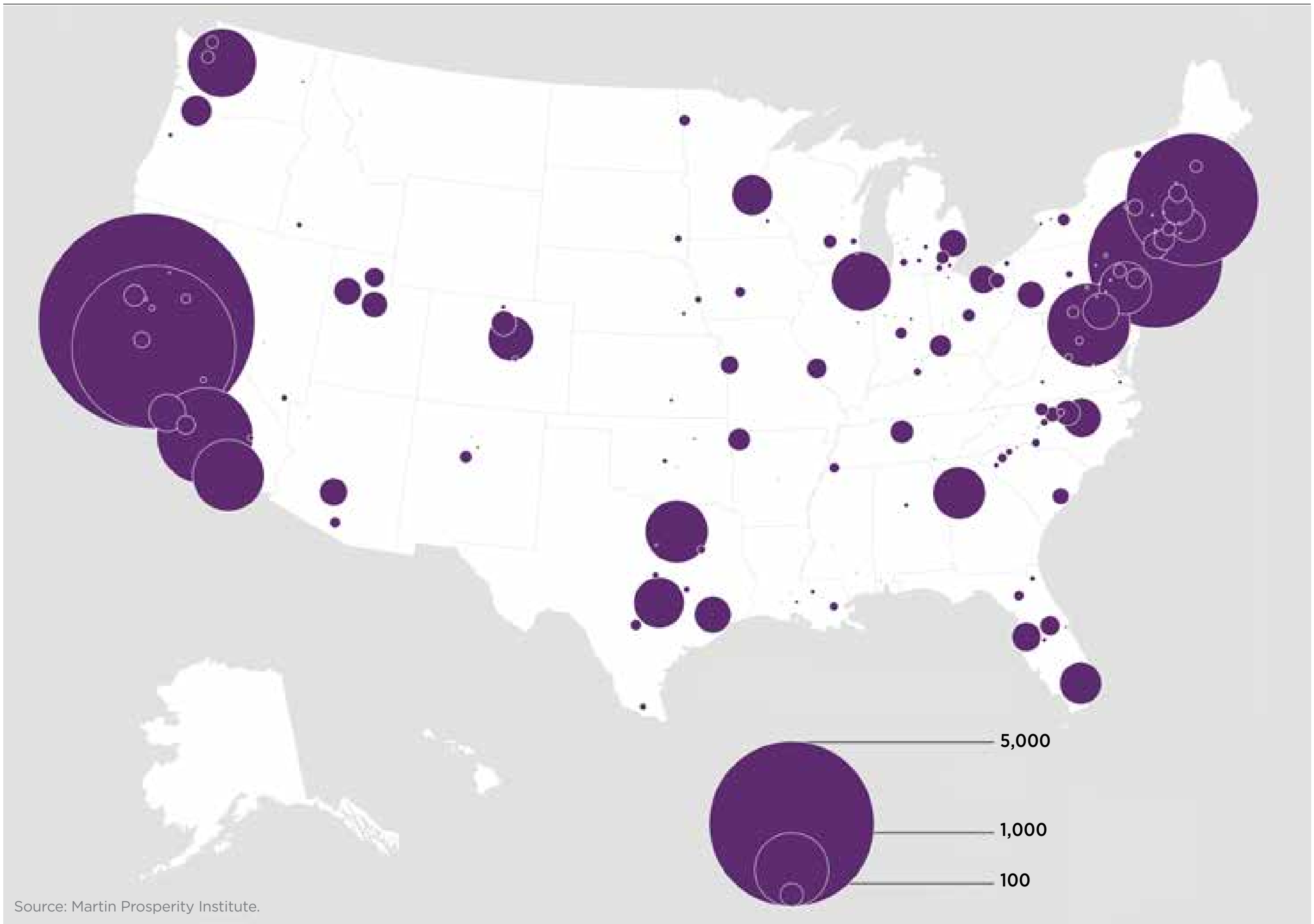
The economic world, to amend a phrase, is not flat.[11] Rather, the world's economic geography is spiky—it is overwhelmingly concentrated in the world's cities. The city's basic feature, physical proximity, is also its great and enduring virtue: the benefits of living and working in close proximity to talented people, and having easy access to a wide range of services and infrastructure, far outweigh the costs for both individuals and firms. Cities are where creative people can find employment, build skills, engage with one another, cross-pollinate ideas, access scientific research institutions such as universities and laboratories, and raise money for their entrepreneurial efforts.[12] They are where firms are born and mature, and where fortunes are won through invention. The history of innovation reads like a history of cities: since the dawn of the Industrial Revolution, Manchester, New York, Detroit, Los Angeles, Palo Alto, and many others all have, at different times, been at the forefront of global innovation.

Historically, there has always been a hierarchy of cities, with the biggest most often being the richest and most productive and the smaller ones resigned to having second-tier status.[13] The economic geography of tech-driven innovation follows this pattern. In the United States, California's Bay Area, including Silicon Valley, is by far the wealthiest and most impactful innovation node. Because it established itself decades ago as the global epicenter of innovation, the Bay Area is now akin to a vortex, with its sheer gravity serving to attract talent, investment, and attention from just about every corner of the globe. Yet while the Bay Area stands alone, a number of US cities also qualify as first-rate tech hubs. These include New York City, Seattle, Boston, Austin, the Boulder-Denver corridor, and North Carolina's Research Triangle. Other important hubs, not as well known, include Los Angeles, San Diego, Salt Lake City, Pittsburgh, and Washington, DC. Finally, the United States boasts a number of far smaller but still vibrant hubs such as Madison, Wisconsin, and Eugene, Oregon.[14]

The United States, therefore, has an impressive dispersal of activity, but the nation's geography of innovation is still heavily weighted toward just a few places, mostly concentrated on the coasts. California's Bay Area, Boston, and New York City alone, for example, account for some 80 percent of venture capital investment nationwide. Of this, 50 percent is concentrated in Silicon Valley.[15]

To reiterate a point made in the Introduction, it is in the United States' best interest to bring more places, and therefore more people, into the nation's innovation machine. Expanding the circle of prosperity—by facilitating the creation of more tech hubs in more states around the country—will be important to future economic growth. While the history of economic geography suggests that the vast majority of tech hubs will never rival the Bay Area, Seattle, or Boston for supremacy, that argument is beside the point. In a world increasingly dominated by technological disruption, wherein entire economic sectors can disappear in the blink of an eye, it is imperative to reinvent local and regional economies everywhere around the country. Pittsburgh in the Rust Belt is one prime example of a successful reinvention; Detroit is trying to follow. Failing to do so risks allowing entire regions to atrophy, and threatens to hollow out the US economy in the years to come.

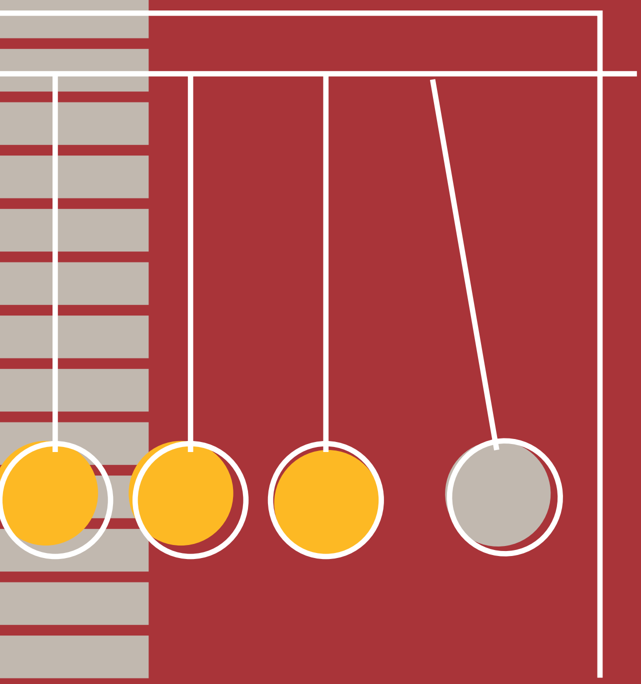
FIGURE 1. **Venture Capital Investment in US $ Millions**



Source: Martin Prosperity Institute.

America's Innovation Engine

A Diagnosis



Cities and regions are the physical places where innovation occurs on the ground, but as this report maintains, innovation is a product of a national system consisting of multiple interacting parts. These parts are varied and include robust R&D, often funded by the federal government and occurring at research universities and federal research labs around the country; tax and regulatory policies that exist at local, state, and federal levels; private investment and entrepreneurial activity within established firms and startups; and the activities of a suite of intermediary institutions that, together, provide the lubricant for the nation's innovation engine. Intermediary institutions include the relatively recent invention of accelerators (since 2005) and incubators that facilitate tech startups and skills training initiatives in the private sector (including so-called software-coding boot camps).

This section diagnoses pieces of this system, with an eye toward those parts that are among the most critical and under some stress.

Research and Development

The United States has had distinct advantages in a variety of areas related to innovation. Arguably, no piece is more important than R&D, rightfully thought of as the starting point and cornerstone of the entire innovative process. R&D is itself a complex equation, consisting of multiple actors, different timelines, and overlapping incentive structures. The actors include the government, most prominently the federal government; hundreds of independent research institutions, especially the nation's public and private research universities; and private firms.

The federal government is the most important piece of the R&D equation. Though too often disparaged, the federal government has played an indispensable role in setting the table for commercial innovation, not least since the middle of last century.[16] The Manhattan Project, which created the atomic bomb, is but one dramatic example of government R&D producing very concrete and, in this case, exceedingly consequential results. The shale revolution (referring to oil and gas drilling) is a prototypical example of how public R&D investment can lead to breakthrough commercial technologies. Shale technologies were incubated by more than a decade's worth of US Department of Energy R&D funding, which when mature spurred bold, risk-taking entrepreneurship in oil and gas exploration.[17] In fact, multiple federal agencies have been instrumental in laying the foundation for innovation across a range of technologies—for example, the National Institutes of Health in pharmaceutical research and other medical areas. In some instances, interagency projects like the National Nanotechnology Initiative have been set up to advance basic R&D in new areas of technology.[18]

At the end of World War II, the seeds of the federal government's postwar role in R&D were planted by Vannevar Bush, one of the nation's top engineers and an organizer of the Manhattan Project. Bush's July 1945 report, *Science: The Endless Frontier*, made a strong case for sustained federal investment in the sciences, specifically through a robust system of federal grants to universities. The Harry Truman administration heeded Bush's advice, setting up a grant-making system that has worked along these lines for decades.[19]

The federal government is the most important piece of the R&D equation.

2005 DARPA Grand Challenge in Primm, Nevada

CHRIS METCALF/FLICKR

Perhaps the most remarkable government agency to catalyze innovation in the postwar United States has been the Pentagon's Defense Advanced Research Projects Agency (DARPA). It is only a slight overstatement to say that without DARPA's visionary R&D funding, there might not be a Silicon Valley. When the Soviet Union launched Sputnik in 1957, two direct consequences were a surge in defense-driven R&D and a short-lived emphasis on STEM education in the United States.[20] Founded in 1958, DARPA helped drive this effort. DARPA-funded basic research at labs around the United States led to the integrated circuits and semiconductors that became the bedrock technologies in the Bay Area (hence the word "silicon" in Silicon Valley). Nor is DARPA ancient history. More recently, it has funded annual competitions called Grand Challenges that have accelerated the private-sector development of robotics, artificial intelligence, and self-driving vehicles.[21]

While DARPA's research funding focuses on military technology, the payoff to much of its investments has been socioeconomic, as the dual-use nature of new technologies often fosters commercialization. DARPA-funded research on semiconductors in the 1960s, and subsequent government procurement, provided the economies of scale that enabled the later development of the personal computer. The ARPANET, created during the 1960s through DARPA funding to connect researchers, evolved into today's internet. Similarly, the research that led to today's GPS, a staple of smartphone technology, was conducted by the US Navy between the 1950s and 1970s. By one estimate, 88 percent of leading inventions between 1977 and 2006 depended in some degree on publicly funded research.[22]

The fact is that the government is the only actor that can lead and fund basic science with an eye toward long-run social, economic, and national security payoffs. The private sector is not equipped to play this role, because scientific research takes years to mature and may not have a commercial payoff in the end. Through DARPA, the National Institutes of Health, the Departments of Defense and Energy, plus other departments and agencies, the federal government funds basic and pre-competitive R&D that the private sector will not fund, and takes initial risks (pre-commercial risks) that the private sector simply is unwilling to accept. This is because the government has the financial staying power to make risky investments over the long term, and—critically—the interest in seeing technologies come to fruition that have broad public application, for example in public health or national security.[23]

The good news is that, overall, US spending on R&D is at 2.8 percent of GDP, a higher level than at any time since the 1960s, and still the most of any nation. Between 1962 and

2013, federal R&D doubled in absolute terms, from $59 billion to $132 billion, with most investment in defense-related R&D (54 percent). Over the past two decades, health-related R&D (22 percent) also took off, though its growth has been intermittent.[24]

But there is very bad news on the R&D front. As a percentage of US GDP, federal R&D spending has shrunk significantly, declining from about 1.2 percent of GDP in 1976 to just shy of 0.8 percent in 2016 (see Figure 2). Over the past decades, there has been a reversal in R&D funding: in the 1960s, around 70 percent of total R&D was federally funded, with 30 percent coming from the private sector. Now, almost 70 percent of funding comes from the private sector, and 29 percent from the federal government. Private-sector research is overwhelmingly applied research, with short (two or three year) timelines for ready technologies to become successful commercial products. Thus the 69 percent R&D funding level is somewhat misleading. The private sector's emphasis is on the "D" in R&D, as it should be. The private sector is very good at taking mature technologies, or nearly mature ones, and turning them into commercially viable products. It is not as good at developing technologies that have a long-run payoff, for a straightforward reason: the bottom-line risk is too great to invest large sums of money in technologies that might (or might not) pay off years or even decades down the road. This logic shows up in dollars. Whereas roughly 80 percent of public research dollars go to basic R&D and 20 percent to applied research, in industry the reverse is true: eighty cents of every dollar spent on research in the private sector is on applied research.[25]

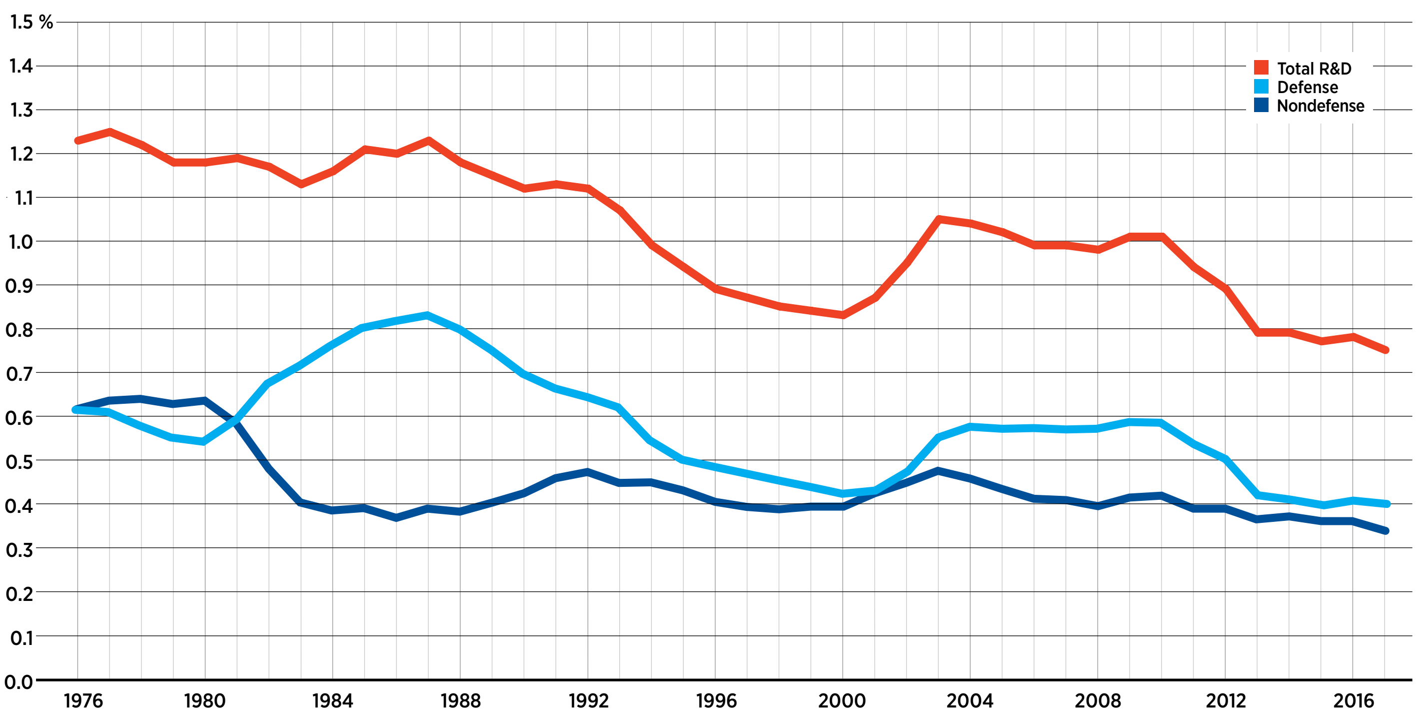
Basic R&D, funded by the federal government, has been the building block of America's innovation engine and was a central plank of America's national security effort during the Cold War. Recent budget sequestration has meant modest declines in R&D since 2013, and federal R&D's 0.89 percent share of GDP is at its lowest level since the pre-Sputnik era. Government funding needs to be thought of as the nation's scientific seed corn, as it is the basic, pre-competitive R&D that will mature into harvestable technologies in the future.[26]

RESEARCH EXAMPLE

Small Business Innovation Research/Small Business Technology Transfer

One important form of federal support for science and technology startups is an obscure program unknown to most Americans yet an important source of seed capital: the

FIGURE 2. Trends in Federal R&D (as a percent of GDP)



Source: AAAS R&D report series, based on OMB and agency R&D budget data. Includes conduct of R&D and R&D facilities. Note: total R&D figures account for DOD adjustments to rectify differences in total obligational authority and new budget authority.

Stages of venture capital equity funding

Friends and family	$5000 – $50,000	develop product, define market
Angel or Seed	$50,000 – $1 million	proof of concept, business model
Series A	$1 million – $10 million	commercialization
Series B	$10 million – $100 million	stock offers, scaling up
Series C	$100 million – $1 billion	full scale commercialization, IPO ready

Small Business Innovation Research (SBIR) and the related Small Business Technology Transfer (STTR).[27] Since created by Congress in 1982, SBIR/STTR grants have become critical to the nation's innovation system, providing thousands of grants annually to small companies (less than five hundred employees), a loan total in aggregate some $2.5 billion. In total, since the programs' inception, these grants have provided $43 billion in research funding. These programs have been enormously helpful to university researchers, providing grants to help them create startups based on their institutional research.[28]

Congress mandates that eleven federal agencies with research budgets over $100 million allocate 2.8 percent of those budgets for SBIR/STTR grants (in 2017, that allocation will be 3.2 percent).[29] Under the Small Business Administration (SBA), the programs provide seed grants ($100,000-$150,000 range) during "Phase 1," which refers to a competitive selection process. Each year the SBA and other federal agencies award hundreds of grants during this phase, with an award rate of around 15-20 percent of applicants. "Phase 2" funding refers to Phase 1 projects that show commercialization promise; these grants are often between half a million to $1 million.[30] "Phase 3" funding is the final phase and it is the stage during which successful firms find commercial funding from venture capital firms and angel investors.

Startups are not the same as small businesses. Whereas a small business seeks immediate profit and a stable enterprise, a startup seeks long-term growth with evolution to high-value payoff (Snapchat, Airbnb, and Uber, all valued in the tens of billions of dollars, are current examples). SBIR/STTR grantees have included iRobot, 23andMe, Qualcomm, and Symantec Corporation, with each receiving critical program grants to assist in the early development of their core technologies.[31]

Another, less well-known, example is Stratatech, a Wisconsin company. Stratatech has received SBIR/STTR program grants from the Departments of Defense and Health and Human Services plus the National Science Foundation to assist in the development of its core technology, which is regenerative skin.[32] (Stratatech is discussed in the Special Section write-up on Madison, Wisconsin.) In all cases, the purpose of the SBIR/STTR grants is to fund technological development that might prove beneficial to society, extending beyond economic return. Stratatech's technology is the perfect example, as it benefits people who suffer grievous burn injuries, such as soldiers wounded in battle.

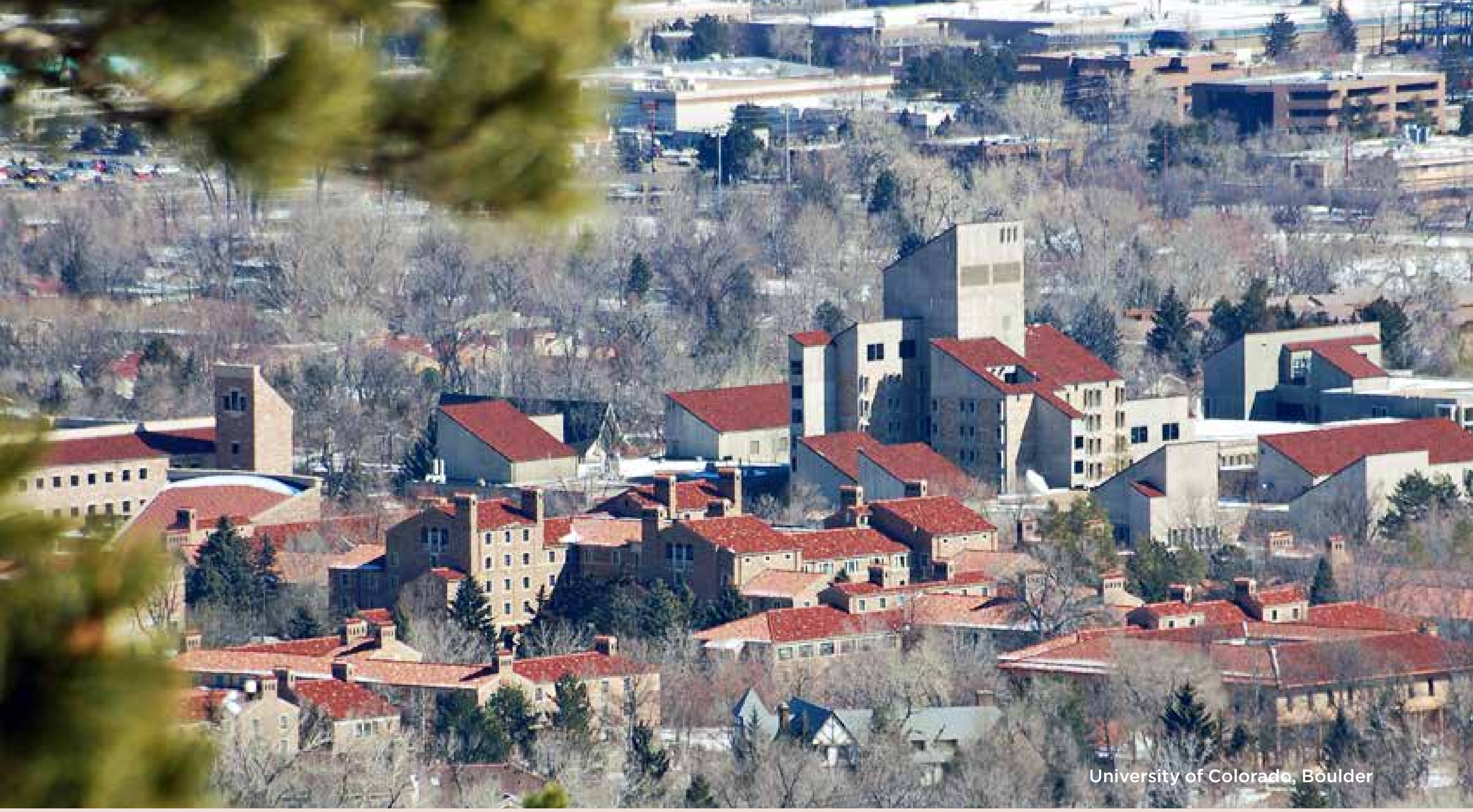
While the SBIR/STTR program is a practical example of smart public-private cooperation, there are ways to improve it and build in other incentives to complement the program. Rhode Island provides an illustration of how state and local governments can improve the process. There, the state and local governments provide incentives to complement SBIR seed grants (and funds from other early investors). For example, the state allows recent university graduates to reduce their college loans if they stay and launch in-state startups. This kind of state-level initiative is important, because public research universities and medical hospital research programs often have a hard time retaining talented people, who often leave the state.

The United States possesses the finest collection of research universities in the world.

RESEARCH EXAMPLE

America's Universities

The United States possesses the finest collection of research universities in the world. In terms of quality and number of world-class research institutions, the US is by far the global leader. America's private universities are critical parts of the nation's research backbone—think of the importance of the Massachusetts Institute of Technology (MIT), Stanford, Carnegie Mellon, and Duke universities to the respective tech hubs of Boston, Silicon Valley, Pittsburgh, and the Research Triangle. But what most sets the US apart from the rest of the world, and what should give every American citizen justifiable pride, are the nation's public research universities. Many public universities rank with the best private schools in terms of scientific and technical research—for example, big state universities in Wisconsin, Michigan, Washington, North Carolina, Ohio, California, and Texas immediately come to mind, as do public engineering schools such as Purdue, Virginia Tech, and Georgia Tech. In



University of Colorado, Boulder

J IANNONE/FLICKR

HOW CAN UNIVERSITIES GET BETTER AT COMMERCIALIZING THEIR LAB RESEARCH?

BY TERRI FIEZ, VICE CHANCELLOR FOR RESEARCH & INNOVATION, UNIVERSITY OF COLORADO BOULDER

One of my passions is making sure the incredible discoveries made by our faculty and researchers have the greatest impact possible. Through my work here at CU Boulder, and previous experience at Oregon State and a number of startup ventures, I have learned that commercialization is one of the most effective ways to connect breakthrough results from universities with the individuals and communities who need them the most.

Aligning our research outputs with the needs of the broader world requires embracing an entrepreneurial approach by providing the training, incentives, and resources to codify the approach into "the way things get done." The inertia to maintain age-old approaches is strong on most campuses, so the effort to change the mindset must be strategic and comprehensive.

We need to show faculty and staff the rewards of entrepreneurial approaches, provide the training and resources to successfully deploy such approaches, and, perhaps most importantly, offer the cultural green light to take risks that so often discourage innovators.

In addition to ensuring that contracting practices and other administrative requirements make collaboration easy, important needs include the following:

- foundational education and training on entrepreneurial mindsets, including building core competencies like collaboration skills, embracing network approaches, and tolerating failure as part of an iterative process;
- formal and informal recognition of innovation and entrepreneurial efforts to both reward top performers and model approaches for the rest of campus;
- leadership and incentive structures that recognize failures as sometimes necessary steps towards breakthroughs so setbacks are tolerated and even celebrated;
- cultivation and support of entrepreneurial activities by faculty, students, and research staff provided by campus-affiliated mentors and successful community entrepreneurs;
- institutional embracing of outside perspectives to enhance outputs and create communities to further encourage ideas, innovators, and commercial success; and
- engagement with non-university partners to help commercialize and realize the full potential and impact of university innovations.

Progress in these areas would encourage greater innovation on campus and collaborative networks to more effectively transfer the impact to broader communities through commercialization.

terms of quantity of institutions, the United States truly has no peer in the world, possessing hundreds of major research universities nationwide.

The United States' innovation system benefits enormously from research universities for four reasons. First, universities conduct basic STEM research, arguably the bulk of the nation's pure scientific and technical research alongside the federal research labs. Whereas the private sector conducts much of the applied research in the United States, universities engage in the basic research that is a necessary precursor for that applied work. Federal government spending on R&D goes to private and public universities in every part of the United States. In 2014, one reputable survey found that 167 universities received at least $40 million per year in federal research dollars (Baltimore's Johns Hopkins University, a private institution, received the most funding, while the University of Michigan, a public one, received the second most).[33]

Second, universities employ many thousands of scientists, mathematicians, and engineers across the country (faculty, lab workers, etc.) while educating and training many more students across a huge range of STEM disciplines. This constitutes one of America's great reservoirs of human capital and, through the students and faculty who end up transitioning to the private sector, a wellspring for the country's innovation engine.

Third, university research itself drives commercial invention in the United States. "Tech transfer" is a term of art in the nation's universities, referring to the processes by which pure research done in university labs is transferred into the nation's commercial bloodstream. Through university tech transfer programs, university R&D is a tremendous force for innovation. During the 1980s and 1990s, startups at universities created some $33.5 billion in market value.[34]

While the tech transfer process would initially appear to be a straightforward proposition, unfortunately it is anything but. When compared with other countries, in general, American universities encourage lab research to "escape" into the nation's commercial bloodstream at far faster clips.[35] But in absolute terms, some US universities are much better at it than others. As discussed in the Special Section, some of the nation's universities have long-established and well-deserved reputations for facilitating tech transfer, including the University of Wisconsin-Madison, the University

RICHARD HURD/FLICKR

Science Hall, University of Wisconsin-Madison campus of Washington, and MIT. This history includes the stuff of legend: in 1951, Stanford's Fred Terman created the Stanford Industrial Park on the campus in Palo Alto, attracting firms such as Varian Associates and Hewlett-Packard, which became critical pieces of the Silicon Valley story.[36]

Fourth, the importance of universities to local tech hubs extends well beyond their deep pools of technical talent and high-quality lab research. As stated throughout this report, universities are often important to local tech hubs for purely cultural reasons. Put bluntly, by concentrating large numbers of talented people of all ages and diverse backgrounds in a single place, universities give hubs a vibrancy from which invention and innovation can spring. This observation is true of all four of the case studies visited during the Atlantic Council road trip. While the University of Colorado, University of Texas-Austin, University of Wisconsin-Madison, and Stanford/University of California-Berkeley (UC-Berkeley) have slightly different effects on each tech hub, respectively, all provide a dynamism that is at the core of the hubs' successes. The same goes for the nation's rich array of federal research laboratories, spread across the country—in Colorado, New Mexico, California, Tennessee, and many other states.

Yet, despite the overwhelming evidence supporting robust funding of universities and university research, the United States risks not doing so. For years, public support at the federal and state levels has been in decline. A 2012 report by the National Academy of Sciences (NAS) observed, among other things, that federal funding for university research was in decline and that state funding for higher education had been "eroding for more than two decades," even before the onset of The Great Recession in 2008. Moreover, the report observed that the private sector had "largely dismantled the large corporate research laboratories that drove American industrial leadership in the twentieth century," such as Bell Labs.[37]

Since NAS released its report, the research funding situation has gotten worse. After decades of increases, driven largely by national security and public health priorities, federal investment in university research declined by 13 percent between 2011 and 2015. State funding for university research has held steady at around $3.8 billion per year, a tiny figure when compared with the 2015 federal government total of $37 billion.[38] A recent *Wall Street Journal* story shows that major public universities are now facing even deeper budget cuts, as many states face budget shortfalls.[39] The problem with state funding, however, lies with state governments' overall fiscal support for public research universities, which remains dangerously low.[40] Since the 1980s, state governments have been cutting back on their support for state universities, increasingly treating higher education as a luxury that should be paid for by direct beneficiaries—the students—rather than a core public good that is vital to the future. In 2014, The Chronicle of Higher Education reported that per-student state spending was at its lowest level since 1980, reflecting a downward trend that shows few signs of stopping.[41]

The current trajectory of federal R&D policies and spending, combined with flagging state support for higher education and an ongoing deficit in STEM graduates, does not portend well for the future. The United States, once the world leader, now ranks twelfth in government-funded R&D intensity (R&D spending as a percentage of GDP), according to the Organisation for Economic Co-operation and Development (OECD).[42] In contrast, the competition is getting stiffer: China's massive R&D and targeted industrial policies in areas like robotics and artificial intelligence are beginning to pay off in both the military and commercial realms, as a recent *New York Times* analysis showed.[43] If the US innovation engine is not tuned up soon, it may be displaced by China's.

Human Capital

A country's greatest resource is its people. Human capital is the critical factor in innovation, as it is smart people who have the skills to turn ideas into commercial products and services that give rise to the entire process. To a degree that far overshadows its major competitors, the United States' comparative advantage is that it is a magnet for foreign talent. Though foreign-born residents of the United States represent only an eighth of the country's population, in STEM fields their numbers far outweigh this figure (for instance, roughly half of STEM PhDs are foreign-born residents).[44] Skilled immigrants have an outsized role in America's innovation machine, often becoming the entrepreneurs behind new companies (one recent study says that more than half the US tech startups valued at $1 billion or more were created by foreign-born entrepreneurs) or filling the highly skilled technical positions in companies across the country.[45]

To put this situation another way, the United States benefits from the dynamism and creativity that skilled immigrants bring with them while compensating for its own shortcomings. In particular, the United States is unable to produce enough of its own citizens with the requisite technical skills

A country's greatest resource is its people. Human capital is the critical factor in innovation.

Startup School 2011

ROBERT SCOBLE/FLICKR

to fuel the needs of the innovation engine.

Obviously, the long-term answer to the US STEM deficit is a rethinking of US education and training. There needs to be a renewed emphasis on training to align the US workforce with the needs of the labor market for a century that will be dominated by the knowledge economy. But that is a protracted process that will require a serious intellectual effort involving deep philosophical and pedagogical questions. It also will require collaboration among government, educators, citizens, and the private sector.

The American skills deficit involves more than addressing shortfalls in the existing system of formal education, defined as kindergarten through university. That system, while beneficial to society in countless ways, also is designed for a world of work that is increasingly dated. For one thing, the pace of tech-driven economic change means that people need lifetime training if they are to remain valuable members of the workforce beyond their formal schooling years and into middle and advanced ages. Intermediate skills training institutions, discussed below, should be prioritized. For another, the emerging "sharing" or "gig" economy, characterized by part-time employment and independent contracting (as embodied by Uber and Lyft), requires a rethinking of the very concept of what work is and the social policies that flow from it.

The United States must maintain its attractiveness to foreign-born skilled workers if it expects to stay ahead of its global competition. According to a Deloitte survey and other estimates, over the coming decade the US will face a shortage of some two million highly skilled workers.[46] Filling the job requirements for both tech startups and the Googles and Apples of the national economy will mean granting visas to highly skilled foreign-born STEM graduates for the foreseeable future—there simply is no other way to fill the demand. Much of the nation's foreign talent comes to the United States to attend university (yet another reason to retain America's advantage in higher education). There are about one million foreign-born students in the United States.[47]

The US government issues a fixed number of H-1B visas to private firms, who use them to hire highly skilled STEM workers (there are also L-1 visas for intracompany transfers). While the program has a formal cap of 85,000 people per year (including 20,000 foreign graduates from US universities), the demand for such visas vastly outstrips supply, leading to the granting of many exceptions.[48] In 2013, for example, the government issued 153,000 H-1B visas and 67,000 L-1 visas.[49]

Given the ongoing gap between the skilled tech worker supply in the United States and the demand for such workers, the H-1B visa program's impact on the American economy ought to be assessed. Analyses tend to endorse a net positive, with some distributional consequences for specific categories of work but an overall boost to the national economy. A Congressional Budget Office (CBO) analysis, for example, found it had negligible impact on native-born American workers, in no small part because the CBO concluded that skilled immigrants' inventiveness and entrepreneurialism would lead to productivity advances across the economy.[50]

A dilemma remains for the United States. Tens of thousands of foreign-born STEM workers who attended US universities end up returning to their home countries such as China or India every year—where they will compete against US firms. In so doing, the US suffers from a self-inflicted wound to one of its core comparative advantages, namely its global draw as a society of entrepreneurial immigrants. Some obvious fixes, such as permitting foreign STEM graduates to remain in the US, are under consideration. Yet, the H-1B visa policy, whose very purpose is to fill the gap in highly skilled US workers, is mistakenly caught in the larger debate over immigration policy, with some in Congress seeking to pare the program back.[51] However, Senator Orrin Hatch, chair of the Republican High-Tech Task Force, has introduced legislation to expand H-1B visas and address flaws that allow gaming of the system.[52]

The problem is that narrow policy debates involving high-skilled immigration invariably are pulled into the country's larger, and politically explosive, debate about immigration in general. This is an unfortunate reality, despite the gap between supply and demand for high-tech workers (that American citizens cannot fill at present) and the fact that skilled workers represent only a fraction of all immigrants coming into the US.[53]

American policy makers have to understand that pushing skilled people away from the United States will benefit other countries, friends and foes alike. For example, Canada has taken notice. In 2013, Canada adopted a Startup Visa program that offers permanent visas to entrepreneurs. "We're seeking to benefit from the dysfunctional American immigration system," Canada's Employment Minister Jason Kenney boasted, stating flatly that his country saw opportunity in a US system that turns away talented people.[54] Other countries can be expected to adopt similar policies.

ACCELERATED SKILLS TRAINING FOR THE JOBS OF THE FUTURE

BY APARAJITHA VADLAMANNATI, POLICY ASSOCIATE, HACK REACTOR

Trends show that to remain valuable members of the workforce, people will need to stay in the workforce longer, switch jobs more often, adopt new technology faster, and maintain a wide, intersecting array of knowledge. Traditional college degrees are insufficient for a long, nonlinear career path, which is where short vocational training programs can help fill the gaps and create the flexible workforce of tomorrow.

Educational institutions such as Hack Reactor, an accelerated software engineering program, are reimagining skills training for a rapidly changing economy. Hack Reactor students come from many backgrounds. Some have previous technical experience or computer science degrees, a few have been unemployed or are seeking to return to a career after a hiatus, and others have previous experience in marketing, finance, product management, and other areas. Over three months, working six days a week from morning to evening, students learn and apply in-demand JavaScript concepts. Of our campuses with complete data, we have consistently maintained over 90 percent job placement rates. In our original San Francisco campus, we maintain a 98 percent placement rate and our graduates receive average annual salaries of over $100,000.

While this model of education is most popularly focused on technical fields, it can be applied to other vocations as it matures to develop a foundational pedagogy. The core principle of most programs is to teach a fluid, highly applicable curriculum responsive to market needs and student demands while providing job placement support.

Even though response to graduates has been mixed—some companies still prefer college graduates with theoretical knowledge for their most senior engineering roles—there is no doubt in the transformative power of these programs to upskill workers. Accelerated programs that remain loyal to student success with responsible and forward-thinking oversight have enormous potential to provide a viable alternative or supplement to university education. As careers become more flexible, so must the acquisition of educational qualifications.

HUMAN CAPITAL EXAMPLE

Rethinking Skills and Worker Training

Even the most enlightened immigration scheme for high-tech workers is at best a temporary palliative. Ultimately, if the United States aspires to have both a strong national economy and broadly shared prosperity, it will have to create skills training systems that fit the twenty-first century's work-place conditions.

While the US innovation system is second to none in its institutional features—world class research universities and labs, an entrepreneurial culture, strong intellectual property (IP) protection, and a well-developed venture capital industry—the US education system continues to lag in fostering STEM graduates. The US therefore faces an ongoing deficit of highly skilled workers. As emphasized in the National Academy of Sciences *Gathering Storm* reports cited previously, OECD statistics rank the US thirty-third out of thirty-six advanced economies in its proportion of STEM graduates.[55]

To compete in the global knowledge economy, the United States will have to revisit what it means to have a trained workforce. There is bad news and good news here. The bad has already been discussed—unfortunately, the US does not produce enough skilled workers. But the good news is that there are many pathways for filling the gap between demand and supply.

These pathways include a host of intermediary institutions that together work to upskill and reskill America's workforce, including people who want to become entrepreneurs as well as tens of millions more who will continue to earn their living the old-fashioned way, through paid labor. Some of these institutions are decades old but are in need of some tweaking, while others are much younger and are already at the forefront of this battle.

ACCELERATORS AND INCUBATORS: One important new factor that has exploded over the past decade is the rise of startup accelerators and incubators. These models are businesses that help entrepreneurs launch tech startups. In a sense they are training institutions: they train people who might otherwise be talented technicians (engineers, scientists, and so forth) to become business owners. They enable fledgling businesses (often just the entrepreneur him/herself) to co-locate in common office spaces; usually provide some initial investment capital; offer mentorship, peer collaboration, and networking opportunities with potential investors; and help with marketing. Incubators tend to provide support over longer periods and often are funded by one venture capital group.[56]

The United States will need to find ways to ensure that the knowledge economy is accessible to tens of millions of everyday workers.

The accelerator model provides an apt example of how these institutions train entrepreneurs. According to Ian Hathaway, a researcher who conducted a nationwide study of these programs, an accelerator provides "a process of intense, rapid, and immersive education aimed at accelerating the life cycle of young innovative companies, compressing years' worth of learning-by-doing into just a few months."[57] In a highly selective process, applicants submit business plans to the accelerator's investors and, if accepted, obtain space in a common work area with other entrepreneurs for a set period of time, usually around three months. Accelerators usually accept 10 percent or fewer of applicants. Investors provide seed money (averaging about $100,000), often in exchange for equity in the startup in the 6-8 percent range. Program entrepreneurs are expected to "graduate" at the end of their stay. Hathaway's research showed that from 2005 to 2015, 172 accelerators nationwide funded about five thousand startup companies.[58]

Two of the best known accelerators are Y Combinator, based in Silicon Valley and Boston, and Techstars, which was founded by Brad Feld in Boulder and now has more than a dozen branches in the US and abroad.[59] Incubators include 1776, based in Washington, DC (one of 1776's staff penned a guest contribution for this report, about Washington's tech scene), and Idealab, based in Pasadena, one of America's oldest tech incubators.[60]

Over time, these models have evolved to the point where the boundaries between accelerator, incubator, co-working space, and other permutations of the same idea have blurred. A whole series of organizations now cross the lines between these categories. These include Galvanize, a Denver-based company with nine locations nationwide that both incubates startups and trains workers for the digital economy, and 1871, a Chicago-based company that combines high-quality co-working spaces, workshops, training, and a range of other services.[61]

CODING BOOT CAMPS: So-called coding boot camps also have become important intermediary institutions focused on training and education for today's digital economy. As their name suggests, the boot camps, a new phenomenon since 2012, provide an intense, immersive training experience for people who want to become software developers. They have become one of the fastest growing post-secondary school vocational training institutions in the country.[62] As the world


Dev Bootcamp, San Francisco

DEV BOOTCAMP/FLICKR

now runs on code, the rationale behind the coding boot camp is to fill the gap between demand for skilled coders and their undersupply. The boot camps take advantage of universities producing too few computer science graduates every year. Given the high salaries on offer around the country for skilled coders (ranging from the high five figures to low six figures), boot camps offer a low investment in terms of time and money, relative to getting a four-year degree, to people of all ages. The term *relative* applies: boot camps normally offer an intense, full-time, immersive program consisting of very long workweeks.[63]

There are now hundreds of such camps nationwide, all trying to take advantage of the market demand. Some of these are well established, with deserving reputations for placing their graduates in the private sector at high salary levels. For example, San Francisco's App Academy offers a twelve-week immersive program that boasts high placement rates and median salaries for their graduates. It also is innovative in that it offers free tuition to its students until they land jobs as coders (after which the company takes 18 percent of the students' first year salaries).[64] Similar stories abound in this space (see the essay written by a staff member of the Hack Reactor coding boot camp).

Boot camps have their limits, however, and there are a couple caveats. While those interviewed for this report generally were very enthusiastic about the boot camp training model, they suggested that there are limits. For one thing, if the boot camps do their work well, at some point the supply of coders will match the demand for them, and salary levels will begin to reflect saturation levels. For another, while the boot camp model can be replicated in other technical fields, in some fields there will never be a substitute for lengthy, in-depth education that only universities can provide. One boot camp executive said there simply is no way to teach people advanced physics or chemistry over compressed timeframes.

COMMUNITY COLLEGES: One important point to make—and one to reinforce over and again—is that the United States will need to find ways to ensure that the knowledge economy is accessible to tens of millions of everyday workers. While the knowledge economy is about startups and coding, it also includes manufacturing and building and many other things. Hence, it will require highly skilled workers (and highly paid ones) who can work with both their hands and minds in real-world workspaces. Tomorrow's factories, for example, might require fewer people overall but those they do employ will

Computer Numerical Control (CNC) machine operator Blake Veeneman at Port City Castings Corporation in Muskegon, Michigan

LANCE CHEUNG/USDA/FLICKR

need to possess advanced skills.

This arena is where the nation's community colleges can—and have begun to—step in to play a critical role. Community colleges are like universities in that they are old institutions, and also like universities their roles remain critical in the digital age.

Vocational training at community colleges, specifically apprenticeship programs, has great potential to bring more people into the innovation machine. In the United States, roughly 5 percent of students are in apprenticeship programs, most of whom are in the construction industry. In Germany, which is universally regarded as one of the best countries in the world in apprenticeship training, that number is roughly 60 percent.[65] The German apprenticeship model, also one of the oldest in the world, covers a wide array of fields, from manufacturing and information technology (IT) to banking. Its backbone is the notion of "dual training," which melds classroom education in vocational schools (equivalent to community colleges in the United States) and on-the-job training apprenticeships. This stems from a decidedly different approach to education and training, and reflects a much more collaborative relationship between the education establishment, the private sector, industry, and business/civic organizations.

This observation is not an argument for the United States to copy the German system, which even if desirable would be difficult to pull off owing to the scale of the challenge. There are important cultural differences between Germany and the US that are not easily bridged, from a lack of focus on STEM education to attitudes toward vocational training and general education (the US pays a price for the vocation's lack of stature and, conversely, for its ethos that all people should go to college).

Perhaps most importantly, building a German model in the US would require a level of public-private sector collaboration aimed at identifying trends in future skilled-employment needs and then linking its educational system to that trajectory. While such collaboration does not yet exist on the German scale in the US, there has been an evolution in this direction, evident in a renewed emphasis on apprenticeship training at community colleges.

One well-known and very relevant example is the apprenticeship training offered at Central Piedmont Community College (CPCC), located in Charlotte, North Carolina. Dozens of German firms have settled in the Charlotte area, including many industrial companies, creating a strong demand for skilled industrial workers in this part of the state. Recognizing this fact, CPCC has embarked upon

German-style apprenticeship programs, with the goal of marrying classroom work at CPCC with hands-on training in advanced manufacturing at local German companies. Among other programs, CPCC and IHK Karlsruhe, a German chamber of commerce and industry, have been offering joint certifications in advanced manufacturing occupations such as CNC (Computer Numerical Control, which is the digital technology that orders lathes to cut metal at high levels of precision).[66]

A recent analysis in the New York Times cited other examples, including John Deere, which designed a training curriculum and provided equipment to several community colleges in order to help train technicians that the company could use in its dealer network (starting salaries for technicians are $40,000). The Barack Obama administration created programs to rework apprenticeship in the US, allocating $65 million to make apprentice training count as academic credit in the nation's community colleges. In 2017, the state of Colorado expects to begin a public-private partnership that offers apprentice training, beginning in high schools, in a variety of fields, including healthcare, IT, financial services, and manufacturing.[67]

Ideas and Intellectual Property

Another fundamental component of any innovation engine is the protection of inventions, creative works, and other IP. The United States has a long and robust history

CLOSING THE SKILLS GAP THROUGH COMMUNITY COLLEGES

BY JILL LUTZ, EXECUTIVE DIRECTOR, SKILLS INITIATIVE, CENTRAL PIEDMONT COMMUNITY COLLEGE

Community colleges provide innovative, short-term training that can meet employer needs in technology-intensive fields such as advanced manufacturing and information technology. Closing the skills gap in the years to come will rely on different training and recruiting methods, given a rapidly changing economy and a declining workforce through aging. Training workers on a short-term basis and then cultivating that talent through career pathways or ladders via apprenticeship programs can provide companies with strong retention rates and a skilled workforce, with proprietary knowledge left intact.

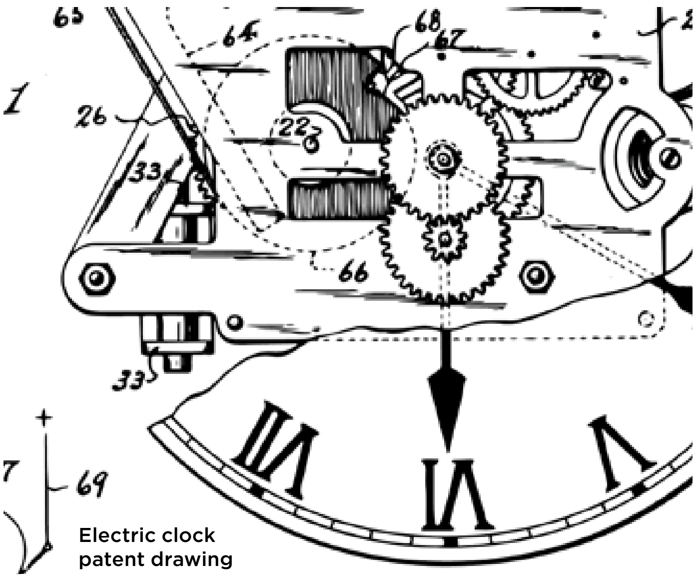
For over twenty years, Charlotte's Central Piedmont Community College (CPCC) has partnered with several advanced manufacturing companies through Apprenticeship 2000, which trains local high school students for in-demand occupations in their facilities. This employer consortium advocates for registered apprenticeship across North Carolina, and has counseled parents, students, educators, and advanced manufacturing companies about the value of apprenticeship programs and work in the skilled trades. In 2012, CPCC expanded upon this partnership by launching Apprenticeship Charlotte, which also advocates for and promotes apprenticeship as an option for local employers in any industry struggling to identify skilled talent through traditional pathways.

CPCC has found that most companies want a customized approach that appeals to their unique needs and encompasses various populations including veterans, people changing careers, and under- and unemployed individuals. With a diverse student body, CPCC has experienced great success with apprenticeship in advanced manufacturing and transportation industries. Both Apprenticeship 2000 and Apprenticeship Charlotte programs have retention rates of over 80 percent. From a national perspective, the US Department of Labor states that upon completing an apprenticeship program, 91 percent of trainees are employed nine months later.

Employers in these industries know that a two-year degree or shorter-term diplomas and certificates from a community college can meet their staffing needs. Community colleges can also train individuals for positions in other industries, such as information technology and health care. For example, a 2016 *U.S. News & World Report* article ranked web developers as a top IT job, citing 27 percent job growth through 2024 and a median salary of over $63,000. In terms of training, experts stated that experience and certificates—rather than a bachelor's degree—are weighted heavily in most hiring decisions.[68]

The industries of the future will require a skilled workforce. Through robust apprenticeship programs, community colleges can fill a critical need. Through training and retraining people, the apprenticeship model upskills workers at all stages of life. In so doing, more people can participate in the knowledge economy, benefiting themselves, their communities, and ultimately the United States.

KEN LUND/FLICKR



Electric clock patent drawing

TOM WOODWARD/FLICKR

of IP protection, dating back to the country's founding. The framers properly recognized that the production of knowledge needs to be incentivized through a system that allows inventors to reap commercial benefits from their creations, at least for a time. Article 1, Section 8, of the US Constitution specifies that Congress has the power "to promote the progress of science and useful arts, *by securing for limited times* to authors and inventors the exclusive right to their respective writings and discoveries."[69]

The framers, therefore, set up a system that protects both the private property right and interest in profit and the public interest in knowledge production and dissemination. Private actors would benefit financially from their inventions and writings but only for a limited time, after which their inventions were allowed to become public goods. The idea that intellectual property was an extension of property rights was further strengthened in subsequent legislation, including the Patent Acts of 1790 and 1836.[70]

In the United States, IP protection extends to patents, copyrights, trade secrets, and trademarks. Patents are exclusive property rights the government grants inventors in exchange for public disclosure; the invention must be novel, useful, and "nonobvious."[71] Patents are the IP arena where the most intense policy battles are fought, as patents cover scientific and technical invention. However, there have been battles over copyrights and trademarks as well, though these involve artistic and creative content, such as logos.

The basic idea behind patent protection, as laid out in the Constitution, has a straightforward and appealing logic to it. But it turns out that it is difficult to balance the private interest in patent protection with the public one. Finding the optimal balance has proven challenging, both in the US and around the world, and that tension has led to periodic bursts of debate about how to tune patent law.

Broadly speaking, there are two ends of the patent protection spectrum. "Strong" systems have robust patent enforcement at their centers, based on the thesis that doing so gives firms and individuals the confidence that their ideas—and profits—will be protected. "Weak" systems, with looser patent enforcement mechanisms, are based on the idea that firms and individuals will have greater incentive to take more risks with IP, at least in part, because they have less to fear from patent litigation.[72] The reality of course is more complex, and there are variants along the spectrum. Nonetheless, both ends of this spectrum have their advocates and critics.

The US patent protection system has been—and remains—one of the strongest in the world. Since the country's inception, this system has been undergirded by a well-developed body of patent law and a strong system of patent review and approval. Although there has been a serious debate about the US founders' beliefs concerning patents, there is a robust academic literature that supports the claim that patents have been treated as a type of property right in American jurisprudence from the first days of the nation to the present.[73] These scholars argue that the strength of the US patent system was fundamental to the emergence of the country as a technological and industrial powerhouse. Some academic studies indicate a healthy correlation between strong patent laws and national economic growth. After examining cross-sectional data on the matter, Hoover Institution Senior Fellow Stephen Haber concluded that "there are no wealthy countries with weak patent rights, and there are no poor countries with strong patent rights."[74]

Patent holders in the United States have a twenty-year right to exclude others from profiting from their inventions (unless license is granted by the holder), in exchange for public disclosure of their inventions.[75] The very strength of this system has led to criticism in recent years.[76] One argument is that the US patent system is inefficient (it takes too long to get a patent application approved) and that it leads to too many patent infringement lawsuits. This reasoning asserts that the US system stifles innovation because it creates intellectual "monopolies" instead of encouraging competition, raises R&D costs, hinders private investment, and hits small firms such as startups particularly hard because they cannot afford the patent litigation costs.[77] Other arguments assert decreasing patent quality, implying the US patent system encourages firms to over-apply for patents—for example, through a relaxation of standards.[78] However, a number of empirical studies have rebutted this list of arguments, including by countering the argument that the framers of the Constitution thought that patents were a form of monopoly.[79]

There also is compelling empirical evidence that the strong system in the United States continues to do its job very well.[80] In 2015, after analyzing data from nearly forty-six thousand patent applications filed by US startups, the US Patent and Trademark Office (USPTO) found that the US patent system not only does not harm startups' ability to compete, it actually assists them. The USPTO concluded that the approval of first patent grants for startups leads to the firms' subsequent growth (including more hiring), increases their ability to attract investment (venture capital), and improves the odds the firms will file more patents.[81] A 2013 Brookings study concluded that the increasing number of patents in the US has not led to reduced patent quality, asserting in part that the increasing rate of patent filings has actually lagged behind the increasing rate of R&D spending.[82]

The most contentious part of the debate about the US patent system has revolved around patent litigation, specifically the role of so-called Non-Producing Entities (NPEs) or Patent Assertion Entities (PAEs). The phrase "patent troll" is often used to describe NPEs/PAEs and refers to how some NPEs have no purpose other than to identify and buy underperforming patents (basically, patents that were filed and subsequently ignored or forgotten), then turn around and sue any firm that appears to have infringed on that patent. The pejorative use of the word "troll" has the unfortunate effect of slandering far too many actors. The NPE/PAE category often includes universities and research institutions, independent inventors and start-ups, and even some manufacturers. These actors are critical pieces in the larger tech development ecosystem and have a legitimate interest in protecting their IP.[83]

Over the past decade at least, critics have argued that NPE/PAE litigation is a significant problem that hinders innovation, raises tech development costs, and harms small tech firms, including startups, that cannot hire the legal teams necessary to deal with NPE/PAE-initiated suits. This argument asserts that trolls occupy valuable court time with unnecessary lawsuits, extracting value from firms that have committed no real offense. One oft-cited survey of NPE-initiated lawsuits, for example, found that over half (55

ALAN KOTOK/FLICKR

U.S. Patent and Trademark Office in Alexandria, Virginia

Mayo Clinic, Rochester, Minnesota

ALAN LEVINE/FLICKR

percent) of all defendants in these suits were small companies with less than $10 million per year in revenues.[84]

But defenders of the patent system note that patent litigation has been a feature of the US system for a very long time, and that litigation rates have only modestly increased if at all. They therefore contend that the troll problem is greatly exaggerated. For example, the 2011 America Invents Act prohibited litigants to file lawsuits against multiple defendants (instead of targeting three defendants in a lawsuit, for example, three separate lawsuits would need to be filed).[85]

Current patent reform efforts are focused on reigning in litigation. A case before the US Supreme Court, TC Heartland LLC v. Kraft Foods Group Brands LLC, involves the geographic limits of patent lawsuits. Senate Republican leaders say that if the court's decision is contrary to setting geographic limits, they will pursue legislation to limit venues of patent legal actions.[86]

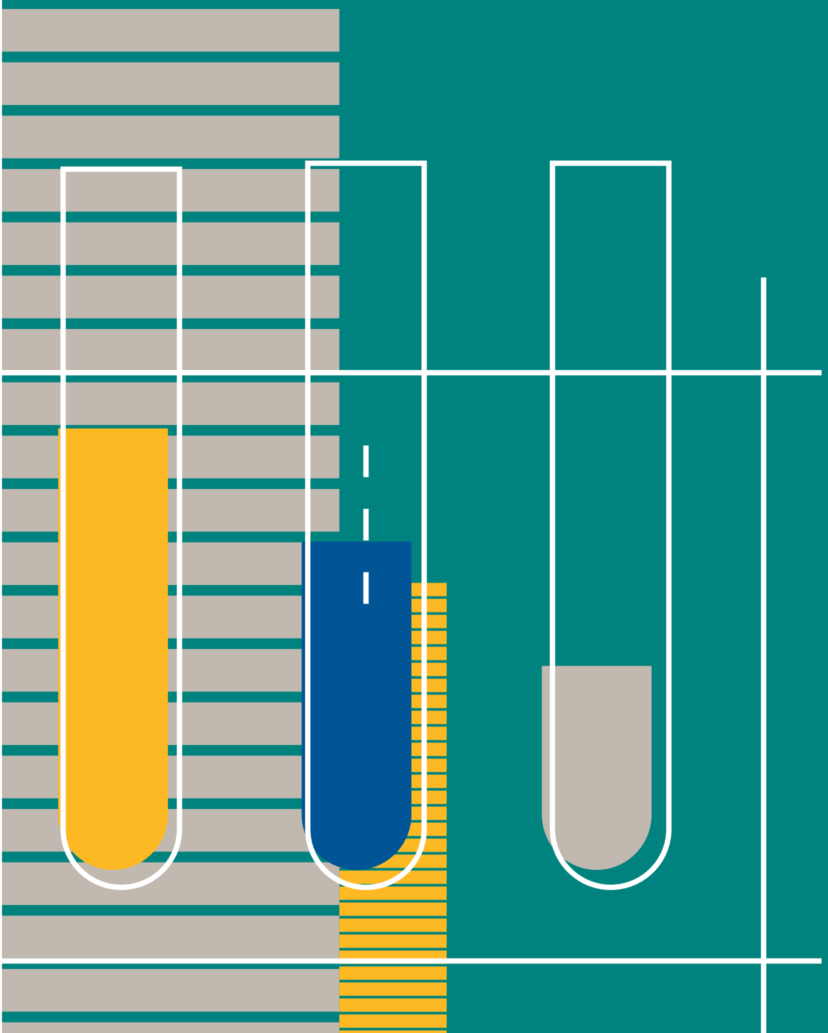
Finally, it is important to again emphasize the role of economic geography in knowledge production in the United States. It should not come as a surprise that the nation's tech hubs generate the bulk of its IP. This relationship can be traced through the geography of patent production.

In 2013, Richard Florida, of "creative class" fame, led a study of patent production in the United States.[87] The data that he and his partners examined led to two broad conclusions.[88] The first and least surprising was that the biggest tech hubs produce the most patents. Between 2001 and 2011, the top twenty patent-producing hubs were responsible for 63.7 percent of the nation's patent applications. California's Bay Area, also unsurprisingly, was first at 13.6 percent.

Their second finding, a bit more surprising, was that smaller tech hubs produce a disproportionate number of patents. After normalizing the data for local share of the national economy, Florida and his team found that several smaller hubs such as Boulder, Ann Arbor, and Rochester, Minnesota (home to the Mayo Clinic) had among the highest patent production scores in the United States. In other words, once one controls for city size, the smaller tech hubs often are as productive as much larger hubs in IP production. Boulder, for example, while small in relative size, has the University of Colorado, numerous federal research labs in the area, and a thriving startup scene, all based on a vibrant local culture. Their finding thus reinforces the importance of strong local research institutions—universities, research labs, and medical research hospitals in particular—within local innovation ecosystems. Florida's research tracks with the authors' outreach in that smaller firms, particularly in research-intensive areas like biotech and often those spun out of university laboratories, can and do make important contributions via breakthrough technologies. (The Special Section provides an in-depth examination of Colorado's Front Range tech ecosystem.)

How To Keep America's Innovation Edge

A Strategic Framework



What, then, can be said about the state of America's innovation system? The most basic observation is that this system remains the world's most productive of its kind and that, while other countries are building their own versions, for now the US engine is unrivaled. No one else possesses the culture, history, policy climate, and institutional strength and variety of the United States. But as stated at the outset of this report, there is one gigantic caveat, namely that the US pays too little attention to maintaining and strengthening its innovation system, the engine that is metaphorically powering the US economy.

As the great baseball pitcher Satchel Paige once advised, "Don't look back, somebody may be gaining on you." This is a truism in the innovation sphere. If the US rests on its laurels, it risks losing its edge to a host of competitors around the world, not least of which is China. The nation's leaders therefore should treat innovation in strategic terms, befitting its importance for the US economy and its geopolitical position in the world. This section provides a framework for keeping America's innovation edge. Its focus is on how its various parts can function better individually and in unison.

Workers

This report first focuses on workers because a national economy will not function over the long run if the bulk of its people, which is to say its wage earners and their dependents, do not prosper from it. Policy makers at all levels need to focus on the conditions that enable workers, including both salaried and hourly workers, to prosper within a twenty-first-century knowledge economy. Bringing more people into the nation's knowledge economy will do more than just make the innovation engine bigger. Including people who too often find themselves struggling to find a way in, including women, minorities, and ordinary workers of all kinds, will be a force multiplier for the entire US economy.

The proper question concerns how to bring more workers into the nation's innovation system. The answer has two basic components, one focused on skills and the other on the social safety net. The first centers on the skills that enable workers to compete in technology fields. When it comes to America's citizenry, too few people possess the right skills and education to qualify for high-paying jobs in tech fields.

The skills debate therefore rightly begins with furnishing good primary-to-university education. While an assessment of K-12 education is outside the scope of this report, higher education is not. The federal and state governments need to ***reverse the decades-long trend toward shifting the public-university-funding burden from taxpayers in general to students in particular***. Given increasing global competition in the knowledge economy, any strategy that asks ordinary families to incur massive debt to educate their children is absurd and counterproductive. Beyond this observation, universities, philanthropists, and policy makers at all levels need to find ways to ***incentivize STEM coursework*** (even for students who are not enrolled in STEM fields) and ultimately to produce more STEM graduates. This should also include incentivizing STEM teachers (e.g., through loan write downs, scholarships, and higher salaries).

At the same time, the debate should not be limited to university education because formal education that ends at age twenty-two or twenty-three is insufficient for today's—and tomorrow's—economy. The rapid speed, high volatility, and changing structure of the tech-driven knowledge economy means constant retraining over a person's working life. One piece of the answer is discussed in the previous section, which is to change the culture of "college or nothing." The debate about college education is misplaced, for even university graduates invariably will have to upskill and retrain later in life. While upskilling can and often does mean more formal degree-granting education (graduate school), for many workers a two- or three-year graduate program is a non-starter personally and financially.

For decades, the US government has run a program called Trade Adjustment Assistance (TAA), which assists workers who can show that foreign trade has left them unemployed. Although the intent is sound (to retrain workers for new careers and put them back into the workforce), in practical terms TAA has not proven to be up to the challenge of reskilling millions of people who have found themselves on the wrong side of trade. For one thing, workers must prove, causally, that trade harmed them—a difficult task. For another, the TAA budget has always been far too small—and has been declining in recent years—and can assist only a fraction of all workers in need.[89]

But the basic idea behind TAA is worth revisiting and updating for this century. One authoritative 2015 study found that 88 percent of jobs lost since 2000 were caused by technology, automation, and productivity gains.[90] If, as the authors of this report and many others argue, technological disruption is the long-term challenge for America's workforce, then it makes sense to rethink the entire concept of the TAA to adapt to tech-driven instead of trade-driven job adjustment. Perhaps called the ***Technology Adjustment Strategy (TAS), the idea would be to build a public-private collaboration focused on lifetime skills training in anticipation of tech-driven disruption***. The TAS would marry public funding or incentives with on-the-ground participation from both public and private skills training institutions. It would place intermediary institutions that are designed to upskill the workforce with technologically oriented training at its center. These would include the aforementioned community colleges and coding boot camps, but also institutions that are geared toward training minorities, women, the economically disadvantaged, and displaced mid-career workers. Code 2040, for instance, is a San Francisco–based nonprofit that builds training and other programming around African American and Latino tech talent.[91]

Although a national effort, the TAS could be augmented by state, county, and city policies (for example, state tax credits or vacant office space) to further deepen the talent

DIVERSE WORKFORCES FOR HIGH-TECH SUCCESS

BY SANJAY MATHUR (CEO) AND JULIE STEELE (COMMUNICATIONS DIRECTOR), SILICON VALLEY DATA SCIENCE

The most evident benefit of a diverse workforce is that your team includes a multitude of views and experiences, making their collaborative creativity and problem-solving skills more robust. Just as you would not want a football team entirely made up of halfbacks, you do not want employees with only one set of skills or viewpoints.

When designing new products, the ability to see through the eyes of potential customers is crucial. Contrast a product line like Oxo Good Grips kitchen tools, which was originally designed for those with arthritis but has become universally popular, with a product like BIC for Her pens, which attempted to appeal to women but became an infamous internet laughingstock. The critical difference between the two is the ability to connect rather than to pander. A diverse team can make those connections much more effectively.

Even outside of product development, creativity and market understanding are the keys to success. In our line of work, we access and analyze large datasets to help our clients create new value from their information. In an increasingly digitized and interconnected world, where imperfect data are regularly used to make and support decision-making, diverse teams with the ability to look at a problem through multiple lenses have a huge advantage.

Multiple studies[92] have shown that diverse teams generally improve productivity. When you consider the importance in all kinds of industries of avoiding groupthink, engaging in creative problem-solving, and avoiding miscommunication with customers, it is not hard to see why. In short: hiring a diverse workforce is not only the right thing to do for an inclusive society, but it is also the right thing to do for your business.

Laura Wiedman Powers of Code2040

pool in local tech hubs. The federal government might heed the advice of Microsoft founder Bill Gates, who recently endorsed the idea of a ***robot tax*** to pay for the retraining of workers whose jobs are being eliminated by robots and artificial intelligence.[93]

The second worker-based component relates to the social safety net—health care, unemployment, and retirement systems, among others. As with reforming America's K-12 system, an in-depth discussion of reforming its safety net is outside the scope of this report. But the question, at least, is worth asking: With the gig economy upon us, ***are postwar systems that are based on lifetime employment still the best ones?***

Those interviewed for this report did not believe so. At a Silicon Valley roundtable, much discussion centered on how European and Canadian systems such as ***universal and portable health care*** make it easier for startups to succeed. The premise was that in those countries there is no need for an entrepreneur to worry about how to provide health care when trying to get a young startup off the ground. Many interviewees also expressed concern that in the future people will be left on the outside looking in, no matter what skills training countermeasures are employed. They therefore put the notion of a ***guaranteed annual income***, an idea decades old (and one endorsed by Richard Nixon during his presidency), squarely on the table.[94] The idea of wage insurance to compensate displaced workers is also a related idea that many think has merit as one component of a social safety net (or call it TAS global competitiveness) package.

Pulling on a narrow range of policy levers ... is not a magic solution.

Entrepreneurs and Startups

Entrepreneurs seek out supportive environments in which to create startups, which is why they cluster in specific places. In the technology arena, startup activity happens in these places for a reason. Tech entrepreneurs benefit from finding the conditions that enable them to put their talents and creative thinking into motion.

In general terms, talented entrepreneurs are globally mobile individuals who seek out places to live and work based on a mix of considerations. These considerations include (in no particular order):

- the vibrancy of local culture;
- a high quality of life, including good social and physical infrastructure;
- a high concentration of talent (including like-minded entrepreneurs and skilled technical talent);
- the presence of at least one scientific or technical research institution;
- the availability of intermediary institutions such as accelerators, incubators, and co-working spaces; and
- access to seed capital (including public-sector grants plus private-sector angel investors and venture capital).

From this list, one can easily see how larger and more well established hubs have a built-in advantage, and why places that are just beginning to build reputations as tech hubs struggle to do so. ***Pulling on a narrow range of policy levers—for example, a singular focus on state or local tax levels—is not a magic solution.*** Those interviewed for this report consistently placed state and local tax levels at the bottom of their priority lists when it came to locational decisions. Austin might benefit from having no state tax in Texas, and entrepreneurs interviewed in the city usually labeled this situation as "nice," but at the same time they made it clear that they were in Austin for other reasons. (Austin is reviewed at length in the Special Section.)

For policy makers at all levels of government (and in public institutions such as public research universities), supporting entrepreneurs therefore means paying attention to the conditions that will build an entrepreneurial community.

Access to capital is one of the consistent challenges facing tech entrepreneurs. The "valley of death" refers to the period during a startup's life between when it receives its initial funding and when it begins receiving revenues from sales sufficient to cover costs and turn a profit. For many tech startups, especially those that create novel technologies transferred from a university or other research laboratory, the distinctions are between the basic research, initial commercialization, and scaling up to major production phases.

In the four tech hubs visited during the Atlantic Council road trip (Austin, Madison, Boulder-Denver, and the Bay Area), interviewed entrepreneurs were unanimous in their

STUART ISETT/FORTUNE BRAINSTORM TECH/FLICKR support for ***aggressive public funding of R&D at basic and transitional stages***. Federal grant programs such as SBIR/STTR are regarded as effective instruments for funding startups that are trying to develop promising technologies but have not yet reached full commercialization stage. ***Achieving more balance in federal funding among the sciences*** could also improve results—currently the life sciences receive a disproportionate share of all federal research funding. The President's Council of Advisors on Science and Technology (PCAST) recently made a similar recommendation, observing that as semiconductors are building blocks of advanced manufacturing sectors, basic and pre-competitive applied R&D on them should be a priority.[95] Developing more public-private partnerships that might leverage both federal R&D funding as well as privately funded applied research, perhaps incentivized by tax credits, could create additional opportunities.

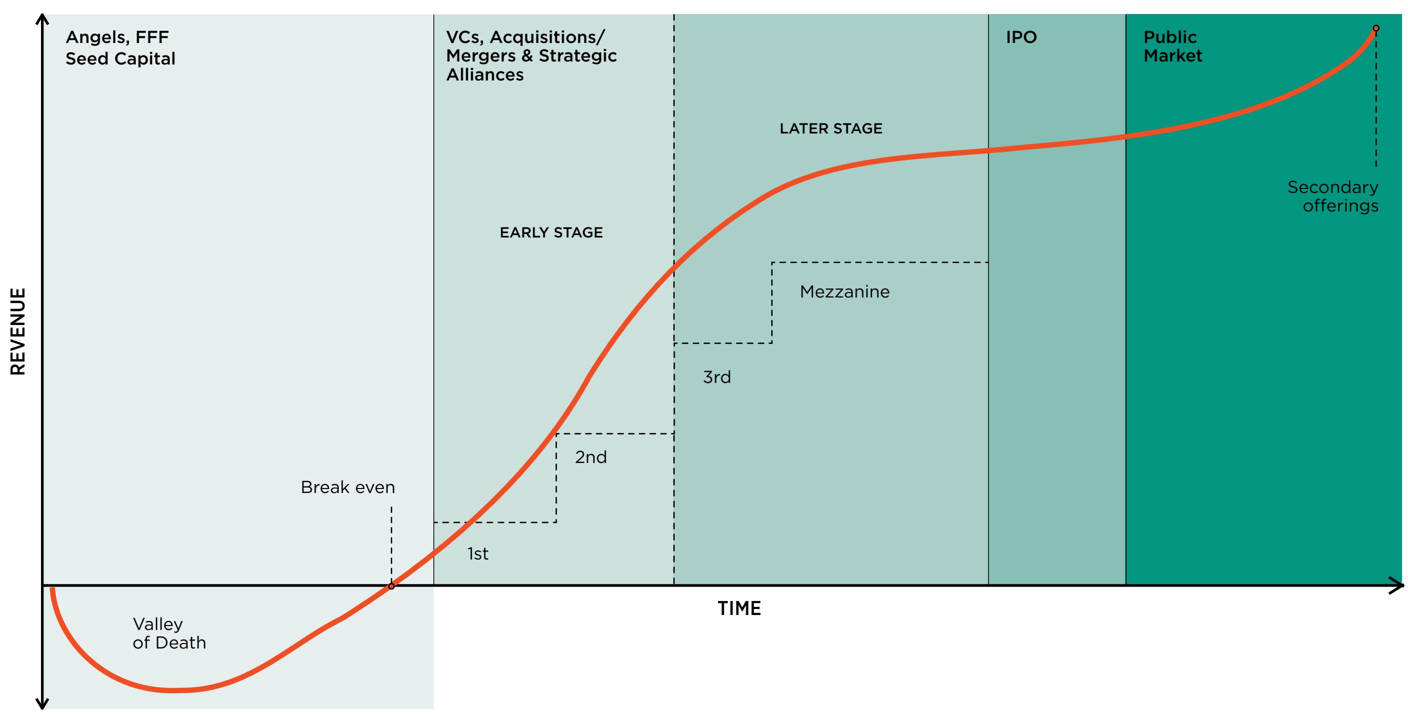
Public-sector support is most critical for those startups that are attempting to commercialize novel, lab-based technologies that often have long gestation periods. It is least critical for those startups that are attempting to build a variant of mature technologies. A biotech-based startup that is attempting to commercialize groundbreaking lab research is a good example of the former; a digital-economy startup that is attempting to build a new app is a good example of the latter.

In smaller tech hubs in particular, access to capital is a very real structural problem that inhibits startup formation and success. This is where ***state and local governments can step in to encourage private capital to focus attention on startups in smaller tech hubs***. A 2005 law passed by the state of Wisconsin, for example, concentrated on incentivizing angel investors to fund in-state startups. As discussed in the Special Section, entrepreneurs in Madison regard that law as increasing local startups' ability to find seed capital. Policy makers should be wary of treading too heavily here, for at some point capital markets have an important role to play in identifying promising companies to support while allowing other less promising ones to die.

Research Universities

As discussed previously, America's research universities are one of the country's greatest assets when it comes to scientific and technological development. The previous section spelled out several reasons why this is the case, including conducting basic R&D, training large numbers of STEM graduates, and providing much of the dynamism that attracts entrepreneurs and others to local tech hubs. For all of these reasons and many others having nothing to do with technology development, ***public funding for America's public universities needs to increase***. Through declining funding, federal and state governments have been eroding

FIGURE 3. Startup Financing Cycle



Source: Kmuehmel/Wikimedia Commons.

Walnut Bridge, Chattanooga, Tennessee

CAMERON FLANDERS/FLICKR

this fundamentally important institution for decades.

When it comes to the university's role in tech-based innovation, no issue is greater than tech transfer. There are good reasons why universities struggle to commercialize their research. Part of the explanation rests on the basic distinction between pure and applied R&D—it simply is difficult to translate pure research into commercially viable terms, even under ideal circumstances.

But much of the rest of the explanation centers on two culprits. One is academic culture, which values the development of ideas through research—which, it must be pointed out, is the basic purpose of research universities—and far less the monetization of those ideas. As Terri Fiez, vice chancellor for research and innovation at the University of Colorado Boulder (CU-Boulder), argues "the inertia to maintain age-old approaches is strong on most campuses, so the effort to change the mindset must be strategic and comprehensive." She writes about how universities can change habits, perspectives, and goals among faculty, research staff, and students. As a policy question, ***tech transfer is largely in the hands of university administrators, because they are the ones who build the culture and structures to facilitate such transfer***. Faculty tenure systems, to name just one such structure, can be tweaked to encourage entrepreneurialism.

The second culprit involves similar challenges faced by entrepreneurs in the private sector. Getting university research into the commercial space involves thorny problems that university faculty, staff, and students simply are not equipped to deal with. These include the expected problems of finding access to startup capital and a lack of training in business practices, but also challenging legal issues such as IP rights and patent protection. State and local governments, local tech entrepreneurs and firms, and local investors (venture capitalists, etc.) should work closely with university administrators to ***identify and employ a best practices template for tech transfer licensing*** to learn from leading universities in this space, including the University of Wisconsin-Madison, the University of Washington, Stanford, and MIT. The

University of Wisconsin-Madison, for one, has a ninety-year history of tech transfer through its Wisconsin Alumni Research Foundation, discussed in the Special Section, that has successfully and consistently shepherded faculty, staff, and students through the IP/patent and startup spaces.

Cities and States

If this report stresses any single takeaway, it is that place matters. State and local governments, institutions, and leaders have great responsibility, for they create the conditions on the ground that give rise to tech hubs. Absent smart and creative state and local policies and practices, America's imbalanced geography of innovation will get worse. The good news, however, is that this geography is not written in stone, and it can change for the better. As Pittsburgh's experience demonstrates, it is entirely possible to bring local industrial-era economies that have been written off as dead into the knowledge economy. State and local leaders can pull multiple types of levers to accomplish this feat.

For all the gee-whiz aspects of the tech-driven knowledge economy, basic conditions still apply. People at every hub visited during the Atlantic Council road trip spoke about the critical importance of old-school factors to the success of those hubs: ***effective and efficient transportation systems; affordable housing; high-quality public amenities; good schools; a clean environment***. Many if not most of these factors are in the hands of city planners, and are core features of any well-functioning city anyplace on Earth. These factors are as important in Silicon Valley as they are anywhere else (perhaps more so, considering the stakes for the Valley) and they should not be assumed as a given. City and state officials need to pay close attention to how these variables shape perceptions of a place, and life within it.

A close relative of this observation concerns public infrastructure. The road trip also revealed that cities and states, in partnership with the federal government, ***should invest in creative public infrastructure*** to maximize tech hubs' global competitiveness. Roads and bridges are one thing, and will always be important, but infrastructure needs to be thought of as much more. Discussions in Boulder/Denver and Austin gave rise to an obvious force-multiplier infrastructure suggestion: bullet trains linking Denver to Boulder and other Front Range cities or Austin to San Antonio would almost certainly create integrated metropolitan areas, spurring long-term growth.

Another perfect example is provided by the city of Chattanooga, Tennessee. Its public fiber-optic internet system, known as "The Gig" for its gigabit-per-second speed, was a form of creative infrastructure investment. As discussed in the Special Section, the city government's decision to build The Gig (with the help of a timely federal grant) has paid off handsomely, vastly accelerating Chattanooga's reputation as an emerging tech hub and—not coincidentally—as a cool place to live.[96]

The Chattanooga example also points to how old-school factors, including public infrastructure, interact with the cultural dimension of tech hubs. Although the creative class idea as originally advocated by Richard Florida is now a couple decades old, the basic idea deserves ongoing recognition. State and city leaders alike ought to be under no illusion that successful tech hubs can be built solely around technicians and scientists, no matter how gifted they are. As discussions during the Atlantic Council road trip revealed, tech hubs are successful in large part because they are where creative types—the creative class—also live and work. Mixing scientific and technical talent with artists, foodies, musicians, students, dreamers, tinkerers, inventors, and just plain offbeat personalities was a not-so-secret ingredient in each hub's success (Austin's unofficial motto, embraced by that city's tech community, is "Keep Austin Weird"). Although a recipe, not every dish is the same: ***state and city leaders should burnish the unique qualities of their local cultures to attract and build a creative class***.

[Economic] geography is not written in stone, and it can change for the better.

Finally, it is worth repeating that state governments do influence a few critical policy areas. One significant recommendation is to ***neither cut higher education funding nor hamper state universities' ability to conduct research and commercialize it***. Doing so is destructive to the institutional cores of tech hubs. Rather, states should be looking for ways to boost their universities, for example, through ***funding university-sponsored incubators and accelerators that help get university lab research into the local commercial bloodstream***.

A cooperative, public-private logic should apply to other state policies as well. In 2014, for example, Massachusetts announced a Global Entrepreneur in Residence program, which enabled foreign students already studying at state universities to apply for university-sponsored visas after graduation. This program applied to only those students who wanted to become entrepreneurs in Massachusetts, thus representing a mechanism to encourage skilled and technically minded entrepreneurs to stay in-state rather than return home.[97]

SMALL BUSINESS INNOVATION AND THE US DEPARTMENT OF DEFENSE

BY ANONYMOUS

The US Department of Defense (DOD) Small Business Innovation Research (SBIR) program increasingly constrains the application and commercialization of innovative technologies. The intent of the SBIR program is to infuse small business innovation into government programs. However, the DOD implementation methodology limits SBIR to very specific areas, often based on speculation of the technologies' benefits by the program's topic selection committees. A preferred method would be to allow small businesses to propose innovations whose benefits are unforeseen by the selection committees.

For example, small businesses have pioneered new technologies that recover heat energy that would otherwise be wasted, thus reducing fuel consumption and extending the range of DOD ships and vehicles. However, no SBIR topics include this need, so the SBIR program does not encourage the development of these technologies. Additionally, unlike the broad SBIR topic areas that other government agencies use, topic descriptions for this program are increasingly restricted to facilitating the execution of existing acquisition programs.

Finally, DOD provides funding for Phase 1 (for proof of concept) and Phase 2 (to demonstrate commercial viability), but not Phase 3 (commercialization). As a result, DOD often misses opportunities to promote the commercialization of technologies developed in the first two SBIR phases.

In summary, DOD should undertake a comprehensive review of SBIR implementation processes. SBIR funding should be competitively awarded based on the ultimate benefit of new technologies identified by small businesses across a large number of broad DOD topic areas. The current SBIR topic selection process does not benefit from an awareness of all emerging innovations. Likewise, a transparent process that advocates for commercializing SBIR Phase 3 programs would encourage greater small business participation and facilitate the application of innovative technologies. Thus, DOD would enhance greater innovation if it allowed wider latitude in proposing SBIR Phase 1 topics beyond primarily facilitating the execution of current acquisition programs.

Federal Government

This report opened with the assertion that America's innovation system results from neither garage tinkerers working on their own nor the federal government directing invention from above. Rather, innovation results from the many pieces assessed in these pages. But at the same time, ***the federal government also has a necessary, even vital, role to play in innovation***. Indeed, a positive role for the federal government can be found in nearly every one of the other pieces discussed above, ranging from worker training to university research to smart infrastructural investment and a wide swathe of other areas.

Indeed, there are a few things that only the federal government can do, such as setting immigration policy, providing for national defense through security-related R&D spending (e.g., DARPA), and negotiating and enforcing international IP agreements. Conversely, there are some things the federal government should not do. That list includes providing open-ended subsidies and creating technology funds in the attempt to pick winning and losing companies. Similarly, there are things the government should do but needs to avoid making overly bureaucratic, such as grant-making approval processes that are too slow to handle the speed at which startups operate.

The following recommendations should be seen as additions to the multifaceted dimensions of the federal government's role, as described above.

CONVENING POWER: ***The president should assemble a national commission of federal, state, and local government officials, scientists, and engineers; university officials; and representatives from civil society and the private sector to identify gaps and vulnerabilities in the US innovation system and recommend ways to reinvigorate US global competitiveness.***

RESEARCH AND DEVELOPMENT: An obvious recommendation is to ***maintain and increase federal spending for basic R&D***. In an era of tight resources, this is an open-ended recommendation, so a rule of thumb, recently suggested by PCAST, would be to increase federal funding for basic R&D in rough proportion to private sector reductions. This formula would need to connect federal R&D more synthetically to pre-competitive applied research.[98]

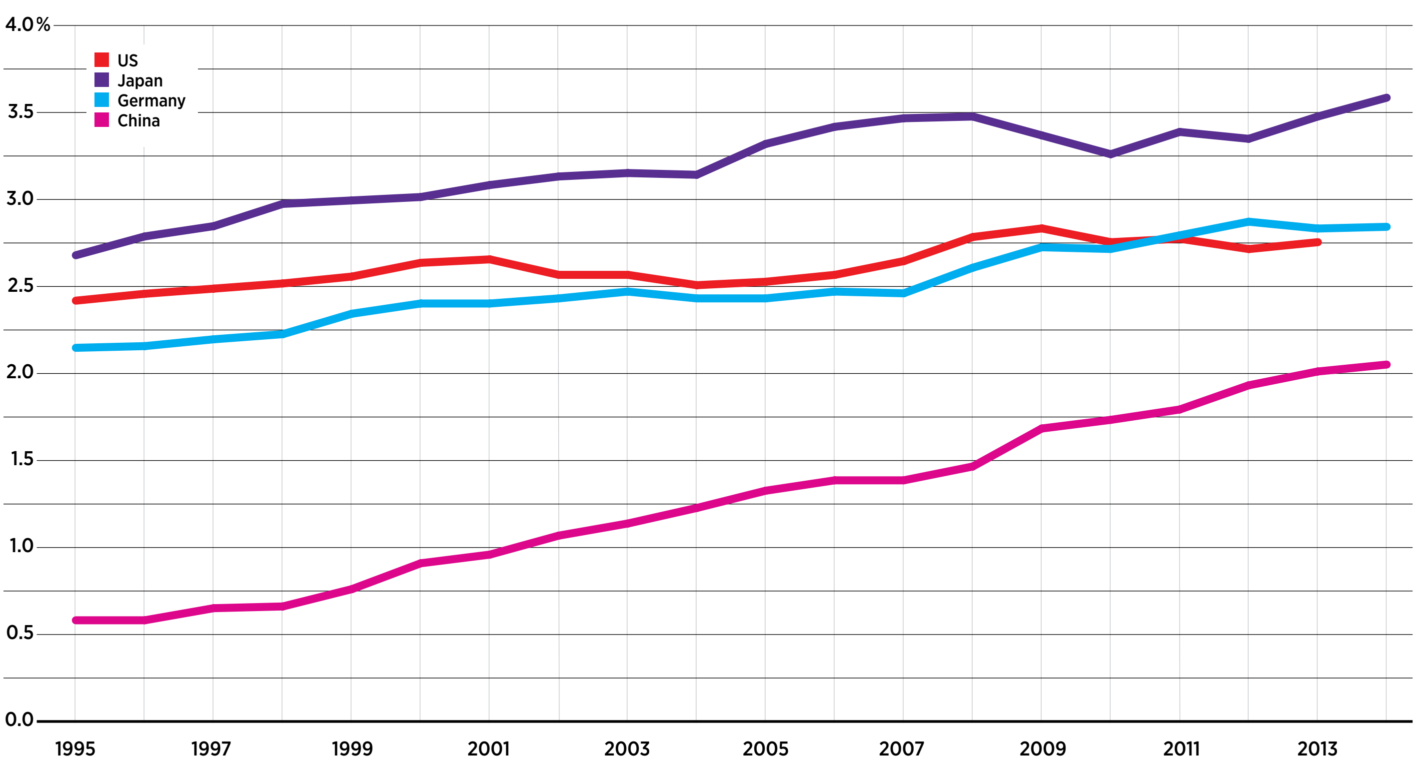
But as with state funding and policy, the federal government needs to keep finding ways to join forces with other parts of the machine to fully leverage its investments. One way would be to ***help universities create more robust tech transfer capabilities***. Another would be to incentivize research institutions to collaborate under federal grants, for example through National Institutes of Health grants. Still another would be to direct funds to clusters of technologies in priority areas of research.

The Obama administration built a strategy designed around this insight, creating the National Network for Manufacturing Innovation (NNMI), a public-private partnership that merges federal investment with those of the private sector and academia. Seven institutes are included under NNMI's rubric, focusing on advanced manufacturing technology in areas ranging from 3-D printing, advanced photonics, and advanced composites to hybrid electronics.[99] Beyond NNMI, the Obama administration's national effort also emphasized the scaling of tech startups, and its Startup America initiative included $1 billion in SBA loans to small tech businesses, among other incentive-based policies.[100] Whether the new administration will build on, reform, and/or and expand such efforts remains to be seen.

INTELLECTUAL PROPERTY: As discussed at length in the previous section, debate over how to best strengthen IP is contentious. Given that the world is at a moment of unprecedented technological transformation, maintaining the benefits of the US patent system is an essential priority for keeping the entire innovation engine competitive. A key imperative is to keep the patent system user-friendly to innovators, particularly researchers at universities and private labs, startups and fledgling firms trying to get beyond the "valley of death," and established firms that are interested in defending their hard-earned IP.

Under the auspices of either the National Economic Council or White House Office of Science and Technology Policy, ***the president should assemble a standing interagency committee to monitor the patent process, including the role of litigation in the system, to advise on whether the patent process is furthering innovation***. The commission should include representatives from federal agencies and offices (e.g., the USPTO, the Federal Trade Commission, the US Trade Representative, and the Commerce department) as well as from law, academia, and the technology community (with representation from large and small tech firms). Ideally, all committee representatives would have a broad understanding of how the nation's patent system interfaces with other aspects of the country's innovation engine. The committee would gather and weigh evidence about how the US patent system is affecting that engine and how the system compares to other patent systems around the world. The committee would provide periodic reports to the president, Congress, and the public.

FIGURE 4. Total R&D as Percent of Gross Domestic Product (GDP), Selected Countries



Source: OECD, Main Science and Technology Indicators, January 2016, available at http://www.oecd.org/sti/msti.htm.

SPECIAL SECTION

AMERICA'S TECH HUBS

This Special Section takes an in-depth look at the four tech hubs that Atlantic Council staff toured in 2016: California's Bay Area (the Silicon Valley, San Francisco, and Oakland mega-region); Colorado's Front Range (the Boulder-Denver corridor, specifically); Madison, Wisconsin; and Austin, Texas. In addition, this section includes a short piece on how Washington, DC, should be thought of as a tech hub in addition to being the nation's capital. Finally, the section provides a short overview of other established US hubs, including Seattle and Boston, as well as cities to keep one's eye on in the coming years.

California's Bay Area: Astride the World

Golden Gate Bridge and San Francisco skyline

BRYAN ROMANS/FLICKR

California's Bay Area, a region that stretches northward from Silicon Valley (San Jose, Palo Alto, and environs) to San Francisco and Oakland, is the world's premier technology hub. By almost every imaginable metric, the Bay Area is ahead of every other hub in the world, often by a large margin. The region, Bay Area interlocutors told us, "is its own center of gravity" with "an ecosystem to dream about." There are few reasons to be concerned about the region's staying power in the foreseeable future, and indeed there is no reason to believe that it will fall from first place in the near term. Yet, over the longer run, the Bay Area will face stiffer headwinds, some of its own making.

It is difficult to overstate the massive scale and dynamism of the Bay Area's tech-driven economy. The region's 6.6 million people generate some $577 billion in GDP, a figure that puts the Bay Area on a par with Sweden or Switzerland in terms of economic output.[101] Yet even that impressive figure understates the Bay Area's true importance. It hardly needs to be said that Apple, Google, Facebook, Twitter, and other Bay Area tech giants create products that disrupt the entire global economy, in the process making these firms among the most profitable in the world. The region's economy is highly diverse as well, home to Fortune 500 companies across multiple economic sectors, including consumer goods, energy, finance, and health care.[102] Yet technology remains the region's economic engine, one that at the same time is busily transforming the other sectors. Think of how Tesla, Google, and Apple are attempting to rethink the automobile—and upend the auto industry in the process—by using Bay Area technologies that they helped develop.

These are a few of the reasons why the Bay Area (sometimes defined as just Silicon Valley) always ranks first on national and global tech hub indices. For example, the Compass consultancy firm ranked Silicon Valley first on its Global Startup Ecosystem Ranking index, giving the region first place on four of five metrics for 2015. The region, it said, is "the poster child for the global startup ecosystem" that "has about as much capital and exit volume as the rest of the top 20 ecosystems combined."[103] Indeed, the Bay Area is as well known for its startup culture as it is for its now-established tech giants. Compass claimed that Silicon Valley has three times more startups per capita than Seattle or Bangalore, giving it the highest "startup density" in the world; the highest growth in venture capital (VC) investment, capturing 45 percent of the top twenty global hubs' VC investment; and a labor market perfectly suited for startup culture, including short hiring times for talented people and a workforce accustomed to moving from one startup to another.[104]

The region's cultural strengths are fundamental to its sustained success.

Other data support these claims. Silicon Valley startups have much greater access to capital compared with startups elsewhere. The consultancy firm PwC, for example, estimated that during the third quarter of 2016, Silicon Valley startups received $4.6 billion over 264 investment deals, compared with $1.8 billion over 93 deals for New England (Boston) and $1.4 billion over 112 deals for the New York metro area. This investment disparity is consistent over time.[105]

What explains the Bay Area's success? The question itself has become a cliché, as countless people around the world have sought to divine the region's secret. Although well known, the region's history is an important part of the explanation. Stanford University was a scientific and engineering research center for decades before World War II, and it along with federal research labs in the area provided the seeds for a dramatic postwar explosion. During the 1950s and 1960s, the region began to grow—an array of new tech firms (including Fairchild Semiconductor and its many spinoffs) joined with the university and Cold War–era federal defense and aerospace research institutions to create what is now called "Silicon Valley" and place it, for the first time, on the global technology map.[106] Structural causes were critical pieces of this story. The Bay Area, then as now, boasted outstanding universities, including Stanford and UC-Berkeley, and an array of big federal research facilities including Lawrence Livermore National Labs (founded by UC-Berkeley in 1952) and NASA's Ames Research Center. It was no accident that what became the world's premier tech hub was surrounded by well-funded and world-class scientific research institutions.

But most analysts point first to cultural explanations when trying to understand the Bay Area's success, at least from the 1960s onward. Silicon Valley's proximity to San Francisco and its counterculture meant that alternative thinking began to creep into the Valley's predominantly technical mindset. The result was that collaboration, sharing, risk-taking, and openness to new ideas embedded themselves deeply into the Valley's culture, occasionally driven by people immersed in both California's counterculture and in its tech scene. Over decades, the Bay Area's unique cultural milieu emerged, one that is now legendary for its creativity, daring, inventiveness, and an almost theological belief in technology's emancipatory power.[107]

This culture is translated into business terms through multiple pathways: individuals at competing companies share information regularly, guaranteeing the rapid transmission of ideas throughout the ecosystem; firms encourage their employees to take risks and spin off companies; workers move easily from one company to another, without retribution from previous employers; entrepreneurial failure is not regarded as a sin but as a source of learning that will lead to success; and so on.[108] Those interviewed in the Bay Area repeated the point many times over, that the region's cultural strengths are fundamental to its sustained success.

Given these advantages, does the Bay Area face any real risks? The answer is that while it is highly unlikely that the Bay Area's tech-driven economy will implode, the region does face the long-term risk that its dominant position will decay as other hubs in the United States and around the world rise. (Again, however, recall that a basic premise of this report is that the knowledge economy is a positive-sum game, wherein the benefits to a country from having multiple thriving tech hubs far outweigh the downsides.)

Most Bay Area observers, including those interviewed for this report, point to two broad sets of challenges for the region. The first involves strengthening, altering, or maintaining key federal policies and practices, including research funding, taxes, regulation, and immigration. Suffice it to say that federal research funding and immigration policy were of very high interest to this report's interviewees. They agreed

Silicon Valley

PATRICK NOUHAILLER/FLICKR

that while private investment—VC and angel funding, specifically—brings in billions annually to the Bay Area, it cannot and should not substitute for public sector investment in basic research. Only the public sector, they maintained, has the means and desire to invest in science for long-run social and economic return (this argument cropped up elsewhere, most often and strongly in Madison). There was a similarly unanimous opinion regarding federal immigration policy. The Bay Area benefits perhaps more than any other tech hub in the world from an ability to attract exceptional foreign talent, especially technical talent. Considering immigration fundamental to maintaining the region's global edge, Bay Area leaders such as Facebook's Mark Zuckerberg have been outspoken advocates of expanding the nation's H-1B visa cap.[109]

The second category consists of the "traditional" challenges of housing, transportation, education, and quality of life. The Bay Area is suffering on these fronts, most grievously in transportation and housing. The region's sprawling dimensions and, for the most part, its automobile-dependent transportation system cause long commutes and near-constant congestion. Housing is an even more dire problem. The region's sustained tech boom has skyrocketed housing prices, to the point where the three most expensive rental areas in the country are in the Bay Area (San Francisco, San Jose, and Cupertino; by comparison, Manhattan is fifth). Housing is the major reason why the cost of living is 40-70 percent higher in the Bay Area compared with the rest of the country, helping to drive low- and middle-income people to the periphery or out of the region altogether.[110]

In Austin, Boulder/Denver, and Madison, we also heard about each of these traditional challenges, but they were often viewed in positive rather than negative terms. For the most part, residents of the other hubs were optimistic that their challenges were fewer and the quality of life that their regions offered was higher than in the Bay Area (but transportation was a near-universal concern elsewhere). Indeed, as interviewees consistently noted in each of the hubs, including in California, the Bay Area's success might undercut its competitiveness, to the benefit of other regions. The Bay Area fear is that talented people will seek refuge in lower-stress regions offering a higher quality of life, and that large firms that are headquartered in the Bay Area will shift some operations to other hubs to take advantage of cheaper talent and real estate (see the Austin case study for an example).

Finally, a mention should be made of the hubris that one encounters in the Bay Area. Many in the region's tech sector believe, not without some justification, that they stand astride the world. Their view, which they freely state, is that technological disruption creates a more perfect world; less often stated is their underlying belief in technology's inherent benevolence. And why would they not believe this? Their work places them at the pinnacle of the global economic order, in possession of almost unfathomable riches.

One consequence, however, is a general lack of appreciation for the profound socioeconomic transformations, especially the negative aspects of those transformations, that Bay Area technologies have unleashed over the past few decades. To be fair, there is a heightened awareness within the Bay Area's tech sector that it is a force behind that region's inequality. This awareness is more pronounced among people who live and work in the historic cities of San Francisco and Oakland, which have been having searing debates about gentrification and wages.

Regarding the national level, however, it is fair to say there is less concern about the relationship between technological disruption and America's highly uneven economic geography. In Silicon Valley in particular, one infrequently hears about the downsides of disruption, that it has a negative dimension as well as a positive one. When disrupted firms and even entire sectors collapse and die, specific workers concentrated in specific places on the map of the United States are often left far behind. The Bay Area's technologies disrupt the US economy, very often leading to higher productivity and greater aggregate wealth in the process. But few in the region seem willing to wrestle with the dimmer distributional consequences that can and do occur as a result, often in places far away from California.

Colorado's Front Range: Rocky Mountain High


Denver

SHEILA SUND/FLICKR

There is a remarkable story in how a 1960s hippie haven evolved into perhaps the densest (per capita) startup community in the United States—and with no small amount of serendipity. A modest-size town of one hundred thousand, Boulder—laced with cozy coffee shops and seemingly endless craft beers—feels like a cross between the laid-back atmosphere in Berkeley and the high energy of Palo Alto in the 1980s. An attractive outdoor lifestyle, a concentration of highly educated STEM graduates in tech-related industries, a "pay-it-forward" culture of inclusiveness, and an accumulation of entrepreneurs and seed venture capitalists are all elements that have catalyzed Boulder's status as a startup hub.

Boulder is now part of a dynamic, larger Boulder-Denver-Ft. Collins Front Range corridor where Google, IBM, Facebook, Amazon, Twitter, and other major firms feel compelled to have a presence along with several hundred startups. The region's dynamism helps explain why the US patent office opened a regional bureau in Denver.

A series of fortuitous decisions dating back to the 1870s and a dollop of luck help explain Boulder's success—and its challenges. Shortly after Boulder was founded as a city, the city fathers bought surrounding land to keep the area beautiful, persuaded the state legislature to place Colorado's first public university there, and donated land and funds to build the campus.

The second phase of Boulder's development was aided by the Cold War, when President Harry Truman decided in 1949 to disperse major government institutions outside Washington. The city fathers bought 211 acres of land, and outbid eleven other cities for what is now the National Institute of Standards and Technology.

This was followed by the federal government locating the Rocky Flats nuclear weapons manufacturing complex in the Boulder area. Boulder later became the site of the National Center for Atmospheric Research, and more than a dozen other federal agencies, including the National Oceanic and Atmospheric Administration. The National Renewable Energy Laboratory (NREL), with 2,300 federal employees and an over $700 million impact on Colorado, is also located there.[111] This has helped make the region a center for alternative energy research and a hub for clean tech. There are twenty-nine federal labs in Colorado including those around Boulder that—combined with CU-Boulder, a major research university (its biotech program spawned the company Amgen)—provide one ingredient for tech success: an economic talent cluster filled with a creative class of highly educated scientists, engineers, technicians, and entrepreneurs.

Along the way, the city took steps to preserve its green, open spaces in the shadow of the Rockies' lifestyle attractiveness. First, it limited the height of buildings on the surrounding mountains. This was followed in 1967 by a sales tax on purchases of open spaces around the city to prevent development. Boulder now owns ninety-seven thousand acres of green space surrounding the city. It also limited new housing starts to 2 percent a year.

"After eight days in Boulder, I felt like I had as many friends as I did in eight years in Palo Alto."

In the 1960s, in another incidental development, IBM located its tape storage division in Boulder. Dissident engineers left and created StorageTek, whose bankruptcy spawned a host of other data storage startups. The unconventional, creative types drawn to Boulder's rustic, outdoor lifestyle generated natural foods firms, such as Celestial Seasonings, one of the best known.[112]

By the 1990s, the Boulder area had become a leading region for data services, software, biotech, clean tech, and natural foods, facilitated by a small group of venture capitalists and an inclusive culture. Then, in the mid-1990s, as the internet economy began to take off, all of Boulder's attributes and bucolic charm led it to become a magnet for startups. This was catalyzed by accelerators like Galvanize, and in no small measure by Brad Feld, a venture capitalist who moved from Boston and launched a spate of internet companies.[113]

After the 2000-2001 dot-com collapse, Feld launched Techstars in 2007, an early accelerator that has since funded nearly six hundred businesses and spun off a dozen affiliates in the US and abroad. Techstars, typical of accelerators, offers those entrepreneurs whose applications it accepts $100,000 in funding for 6 percent of equity, three months of free office space, and, perhaps most valuably, a network of dozens of mentors, Techstars alumni, and potential angel investors.[114] Along with Galvanize and other such enterprises, Techstars helped generate the dynamism in the Boulder tech ecosystem.

While Boulder has some of the common features of other startup hubs—a research university, a concentration of highly educated people, and a strong sense of community—how all the moving parts interact is distinct. One of its intangibles is a flat (anti-hierarchic) "pay-it-forward" inclusive ethos that is welcoming to outsiders. One recent tech émigré said, "People are happy to meet you and instantly help you. After eight days in Boulder, I felt like I had as many friends as I did in eight years in Palo Alto."

CU-Boulder, however, though a major research university with more than $300 million in R&D grants, has been tangential to Boulder's startup ecosystem, beyond feeding in talent. CU-Boulder's numerous institutes might be linked to federal labs and statewide efforts to promote commercialization like the Innovation Center of the Rockies, but the university's institutes have not enjoyed a reputation for driving tech transfer into the local innovation ecosystem. This is beginning to change. CU-Boulder now hosts weekly tech meet and greets and its STEM and business graduates not only feed the Boulder talent pool, but increasingly are attracted to CU-Boulder because of it. There is an awareness of the deficit and the Atlantic Council's discussions in Boulder point to efforts afoot both to bolster ties with the tech startup community and to better move its R&D onto a path of commercialization.

NREL is another distinct element of the Boulder-Front Range innovation ecosystem. It is the only national lab that does applied (as well as basic) R&D and focuses on commercializing it. NREL is reflective of a somewhat separate subculture of a particular type of tech startup, and of the region, as a clean-tech hub. NREL's commercialization efforts, both direct and indirect, are embodied in a number of programs. NREL's Commercialization Assistance Program (NCAP), for example, offers firms with fewer than five hundred employees forty free hours of NREL researcher time to overcome technical problems for renewable energy or energy efficiency technologies. One wind entrepreneur cited NREL test facilities' help with certification, and said the advantage of NREL's facilities are one reason clean-tech startups locate in the area.

NREL also has numerous innovation programs. Its Lab-Corps program helps entrepreneurs commercialize technology created in national labs. NREL's Wells Fargo Innovation Incubator program supports early stage commercial tech startup companies through technology development, validation, and pilot opportunities. It also has R&D partnerships with several Colorado universities aiming to facilitate tech clusters.[115]

NREL does not do sole commercialization, but engages in its own entrepreneurial activities through technology transfer partnerships—currently 696 of them. These partnerships with small and large businesses, federal entities, and nongovernmental organizations contract for technical services and/or commercializing NREL-created technology in exchange for royalties or in some cases equity shares, depending on whose role is dominant in the patent or the licensed technology (with royalties going to NCAP or other NREL innovation activities).

For a variety of reasons, however, some self-imposed and some structural, Boulder is unlikely to be more than a microcosm of Silicon Valley. Boulder's commitment to lifestyle, open spaces, and building restrictions are already beginning to show signs of strain. Real estate prices, though nowhere close to the average home in Palo Alto ($2.48 million) or San Francisco are edging upwards, with the average home costing over $729,000.[116] This is expanding the number of techies that commute from Denver or surrounding suburbs and fostering debates in Boulder about housing limits and building heights.

Limits of physical space and of access to venture capital are creating something of a symbiotic relationship between Boulder and Denver. When startups get much beyond two hundred employees, they tend to move to or open offices in Denver. Access to venture capital beyond Series A level ($1-$10 million), for which there are barely a dozen sources, similarly makes it difficult to scale-up startups. Many suggested that the presence of a $1 billion "brand" firm, like Facebook or Twitter, might change the equation vis-à-vis venture capital.

The likely keys to sustaining and enhancing the Boulder-Front Range tech startup dynamism (and lifestyle attractiveness) are the following: 1) better transport infrastructure (e.g., fast rail that shortens commutes from Boulder to Denver and surrounding areas) that would create more of an integrated region and 2) more interaction if not synergy between the universities, federal labs, and offices and the various sub-ecosystems of distinct types of tech startups. Such developments would make the whole greater than the sum of its parts and position the region as a growth magnet.

University of Colorado, Boulder

YUYA SEKIGUCHI/FLICKR

Madison, Wisconsin: Applied Science

BOBBYLIGHT/FLICKR

Madison, Wisconsin, is best known for two things: it is the state capital and it is home to the flagship University of Wisconsin (UW) campus.[117] Unfortunately, it is not as well known for its tech hub dynamism. The city has a small but vibrant and growing community of tech startups, a well-educated population (including a high concentration of people with backgrounds in science and engineering), and a deserved reputation as a beautiful place to live.

Madison is neither a major city nor a sleepy college town. At 640,000 people in the metro area, Madison sits in between these two extremes.[118] The presence of the state capital and the state's biggest university, both founded in the nineteenth century, have long given Madison institutional and economic stability. Although the region has an industrial history, traditionally that sector has been much less important. Predictability rather than dynamism therefore characterized the city's economy for much of its past.

The significance of UW to Madison's tech ecosystem dwarfs that of other universities studied in this report. No other hub is as bound to the fortunes of a single institution as Madison is to UW. The University of Wisconsin-Madison counts as one of the world's premier research institutions. With a three-billion-dollar budget, forty thousand-plus students, and more than two hundred research centers, UW consistently ranks among the nation's very best universities for the quality of its research. UW does many areas of science and engineering well, not just a few, all on a campus that sits on a narrow isthmus between two lakes in the middle of Madison. That concentration enables much cross-pollinating of ideas.

For decades, UW has been in some way responsible for Madison-area tech startups. In the late 1970s, for example, two local firms, Epic Systems and Ultratec, were created as proverbial basement startups by their founders, both of whom were affiliated with the university at the time. Both companies took decades to grow to scale. Now, both are large employers in Madison. Epic Systems, a medical software company, employs thousands on its unique campus outside of Madison, providing a major attraction for engineering and biomedical talent from around the country.[119]

What separates UW from nearly all other universities in the United States and around the world, however, is the Wisconsin Alumni Research Foundation (WARF). WARF is an independent 501(c)(3) organization, founded in 1925, to protect intellectual property arising from UW research. All faculty, students, and staff are required to disclose their inventions to WARF, which takes the lead in guiding inventions through patenting and licensing processes, paying the costs of doing so, and fighting patent disputes when they arise. Through this mechanism, WARF fulfills its mission to ensure that UW research enters into the commercial bloodstream and that IP owners are protected.

WARF manages an investment portfolio of $2.6 billion, based on royalties it receives from patents and licenses. It returns large annual grants to the university (nearly $100 million in 2016) to support everything from faculty recruitment and retention to student aid to building and laboratory construction. Recognized as the model technology-transfer institution in the United States, WARF has played an important role in federal IP policy. Among other things, WARF leadership was instrumental in passing the 1980 Patent and Trademark Law Amendments Act (the Bayh-Dole Act), which gives universities the right to own and commercialize IP stemming from federally funded research.[120]

WARF has spurred scientific and technical research at UW for over ninety years. But while UW has attracted outstanding scientists and researchers, historically UW faculty have been much more interested in pure research than in entrepreneurialism. Even for a university as advanced in patenting and licensing of research (WARF provides faculty, staff, and student inventors 20 percent of all royalties from their inventions), historically there was a general reluctance to embrace business culture and commercial innovation.

Recently, Madison's story has evolved in an entrepreneurial direction. Madison's Chamber of Commerce estimates that perhaps twenty-three thousand innovation-related jobs have been created in Madison over the past decade, across the biotech, information technology, business and financial, and knowledge sectors.[121] The growth of firms like Epic Systems has meant an influx of both talent and money. The university, for its part, also has become more proactive in driving change. UW operates University Research Park, which hosts 126 tech firms and supports tech transfer from university research labs into the private sector. UW also now promotes an extensive set of activities focused on innovation, including startup clinics, training and certificate programs, and networking forums. WARF and UW, for example, now collaborate through WARF's Discovery to Product initiative that is designed to "move UW-Madison technology and innovation to market."[122] These activities and platforms are intended to both de-risk the startup process itself—the research park, to provide just one example, provides high-quality infrastructure to startups—and to further expose UW faculty, staff, and students to entrepreneurialism.

More broadly, Madison is building a national reputation for its attractive business climate. The high quality of life that Madison offers, combined with its low cost and ease of living (for instance, its short commutes), compares exceedingly well with larger hubs. Madison's small scale but high density—the tech community is mostly concentrated in the city—gives the ecosystem social cohesion, builds trust, and enables people to earn reputations quickly.

These observations point to a bright future for Madison's tech ecosystem. The seeds for long-range success have been planted, and the trend lines are moving in the right direction. UW's evolving culture of entrepreneurialism is driven as much by students and the business community within the university as by STEM faculty. Just as critically, Madison now has private sector success stories that can be shared nationally with potential investors and new talent. Everyone in Madison hopes and expects that the virtuous circle will continue.

But Madison's continued success is not guaranteed, and there are reasons for caution. One of the more worrisome concerns is state politics. Over the past several years, the relationship between the state legislature and governor on the one hand and Madison on the other has deteriorated, in turn affecting UW's budget for the worse. While there are multiple explanations for this situation, one of them is straightforward. The state's economy is characterized more by stability, with traditional manufacturing and farming predominant, than by tech-driven entrepreneurialism. Most of Wisconsin is characterized by numerous small communities, in contrast to Madison and Milwaukee, which are very different in terms of demography and socioeconomics. Within the state, Madison therefore fights the stereotype that it is an elite bastion of intellectualism. UW has historically struggled to explain how it, and its tech-driven spinoff economy in Madison, are beneficial for all of Wisconsin.

Another concern includes access to capital. Madison, like many smaller tech hubs, has a limited pool of investment capital upon which startup firms can draw. A 2005 state law created the Wisconsin Angel Network, designed to encourage angel and venture capital investment. Its tax credits have helped. So too have the activities of local venture capital firms, such as HealthX Ventures, which identify, nurture, and fund tech startups to take advantage of Madison's concentration of biotech talent.[123]

Madison, like other hubs around the United States, boasts useful ventures that are at risk of not being funded. Some of these have social utility that extend well beyond any commercial value. Stratatech, a Madison biotech company, shows how important it is to fund such ventures. Founded in 2000 by a UW professor and currently housed at the University Research Park, Stratatech's skin replacement technology is a major burn treatment breakthrough. Federal government support, via contracts with the Departments of Defense and Health and Human Services, has been indispensable for the company's scientific research and its commercial growth. So too has WARF, which holds several company patents.[124] Although the cost of biotechnology research is going down, breakthroughs like Stratatech's require both time and money to reach the commercialization stage.

The biotech startup example points to a distinction that one often hears in Madison, between quality and quantity. The "fail fast" idea, deeply embedded in Silicon Valley's culture, has not caught on in Madison. There is a greater reluctance to give up on startups, and more of a willingness within Madison to help entrepreneurs succeed. Part of the explanation is cultural, a reflection of Midwestern values about work, reward, and persistence. But part of it revolves around a conviction that entrepreneurialism should add up to something beyond commercial gain. Startups like Stratatech, so this argument goes, may be fewer in number but are worth having for their benefits to society.

Madison's small scale but high density ... gives the ecosystem social cohesion, builds trust, and enables people to earn reputations quickly.

Austin, Texas: Keeping It Weird

Night view of Austin's skyline

Like Madison, Austin is a state capital and home to a major public university, the University of Texas at Austin (UT Austin). Unlike Madison, Austin is a large city (two million people in the metro area) with a diverse population and economy to match.[125] But beyond UT Austin and the state capital, Austin is famous for several other reasons. Its culture has become the stuff of legend, and is at the core of Austin's reputation as a place that mixes the offbeat with the artistic to produce a unique urban vibe.[126] Finally, Austin is one of America's fastest-growing tech hubs.

Austin can legitimately claim to be a major player in technology and innovation. The city has a well-established tech ecosystem that is one of the most vibrant in the nation, particularly in software development and the app economy. The facts on the ground reflect this status. While big technology firms including Apple, Oracle, Google, and Dropbox, among others, have opened or are planning to open campuses in Austin, the city is better known for its startup culture. In August 2016, the Kauffman Foundation, which produces a national startup index, ranked Austin first in the nation for startup activity (normalized by population).[127] In aggregate, there are close to five thousand technology companies of all sizes in the Austin area, and nearly fifty tech incubators, accelerators, and co-working spaces.[128] One survey of Austin-based startups found that in 2015, for the second year in a row, the Austin startup community attracted roughly $1 billion in investment capital. A few mature startups made dramatic "exits," led by HomeAway, the vacation rental platform, which was sold to Seattle-based Expedia for $3.9 billion.[129]

All of this activity has produced a hot labor market in Austin: although estimates vary, the tech sector is responsible for some 12 percent of the city's total employment, with an average wage of nearly $104,000 per year.[130] *Forbes* magazine estimated that over the decade beginning in 2004, tech sector jobs increased by 74 percent in the city.[131] A shorthand statistic, commonly mentioned in conversation

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Austin City Hall

DAVE WILSON/FLICKR

with Austin residents, is that about 150 people per day, every day, move into the city. While not all of these newcomers are drawn in by the rapidly growing tech sector, it is a fair bet that a large percentage move in for this reason.

Any assessment of why Austin is a successful tech hub has to begin with the city's culture. Austin's food, arts, and music scenes, plus the energy that the university's fifty thousand-plus students bring to the city, are big reasons why Austin is a tech hub in the first place. This milieu, encapsulated in the tongue-in-cheek slogan "Keep Austin Weird," gives the city its reputation as a cool hipster place to live. That reputation attracts talented people from all over the country and, increasingly, the world. Austin's global visibility is burnished by its annual South by Southwest conference (known by its acronym, SXSW), which began as a music festival in 1987 and expanded from there to include film and, eventually, technology. Part business, part show, SXSW has become one of the most important events on the global tech sector's calendar, a fact validated in 2007, when a then brand-new Twitter leveraged SXSW's platform to explode into the mainstream.[132]

Austin's tech ecosystem is therefore a huge beneficiary of the city's culture, though the tech community itself has become part of the city's vibe. To these cultural considerations, Austin offers the benefits of a large city with the affordability of a smaller one. Unlike the Bay Area or Boulder, there are few geographic limitations constraining Austin's explosive growth, which means that housing costs should remain low relative to Silicon Valley for the foreseeable future. (One real consequence is that traffic congestion, due to sprawl, has become a serious headache.) There is also no state income tax.

Dell Computer Corporation and UT Austin are the largest institutions in Austin's tech scene. Dell, founded in 1984 by a UT Austin freshman (Michael Dell), has been the biggest tech firm in the city for decades. Dell's presence gave the city an early and sustained footing in the enterprise software sector, and like UT Austin, Dell has provided the city with a steady supply of skilled technical labor.[133]

UT Austin is one of the world's largest universities, and has a stellar academic reputation. In the technology arena, the university can boast a healthy amount of research activity. Beyond its student body, which provides the city with much of its energy and a portion of the local tech sector's talent, the university has several important programs and centers focusing on innovation. The IC^2 Institute is a UT Austin "think and do" tank, founded in 1977, that focuses on collaboration among researchers, public officials, and entrepreneurs to enable Austin's tech ecosystem. IC^2 programs include the Austin Technology Incubator, which advises local startups.[134] UT Austin's Cockrell School of Engineering has an Innovation Center, led by Dr. Robert Metcalfe, founder of the Ethernet. It focuses on commercializing UT Austin research through startups as "vehicles of innovation."[135] It offers advice and training to faculty and staff, provides small startup grants, and hosts competitions, among other activities.

But Austin's happy story is beset by a few challenges. One, mentioned frequently by those active in the city's tech scene, concerns both Dell and UT Austin. While Dell was critical for putting Austin on the national and global tech maps, it has not built a spinoff culture from which the rest of Austin's tech ecosystem benefits. Rather, Dell has built a reputation for protecting its own assets and technologies rather than for encouraging its employees to start new ventures in Austin.

In a similar vein, UT Austin does not spin out startups as frequently as the University of Wisconsin and a select few other universities. A major problem, heard over and again in Austin, is that the university and the city's startup community really do not overlap. Although the university is trying to change things, for a number of reasons, including culture and institutional inertia, UT Austin has struggled to turn faculty and lab research into commercial success. So, unlike in Madison, much of the startup activity in Austin surrounds proven technologies, especially in information technology and the app economy. The university's lab breakthroughs figure little in Austin's startup economy.[136] UT Austin is therefore viewed as being most valuable for providing a skilled workforce and for attracting talent to the city. Many hope that the new Dell Medical School, which emphasizes the positive and disruptive role of technology in medicine, will help change this equation.

A second challenge involves whether Austin has the means to enter the top rank of tech hubs. It is true that Austin's growth has been spectacular, and as the startup rankings demonstrate, in some important respects Austin already is at the forefront of the nation's tech hubs. Yet the omnipresent fear, articulated by members of the tech community (and one heard in Madison and Boulder as well) is that a ceiling exists for Austin. As with other inland tech hubs, securing access to capital is a constant headache. Although Austin startups enjoy greater access than their counterparts in the other hubs visited in this study, firms in Silicon Valley—the recognized global leader—have far greater access than those in Austin.[137] Indeed, local tech leaders fret that Silicon Valley will define Austin's ceiling. Austin, they fear, might not reach the top rank of tech hubs because its most successful startups will be forced to relocate headquarters to Silicon Valley. Investors, they argue, will insist that successful startups be positioned in high tech's epicenter, which is the Bay Area. Conversely, while Silicon Valley's heavyweights such as Google and Apple will place some functions in Austin to take advantage of the city's talent and lower costs, those companies also will retain their most critical functions, including their headquarters, in California rather than shift their entire operations to Austin.

Can the city keep its offbeat charm, rooted in its food, music, and arts scenes, while getting rich off of technology?

Yet, regardless of whether Austin ever reaches the status of Boston or Silicon Valley, tech-driven growth is set to continue for some time. The consequences of this growth create a final challenge for Austin. As Austin's tech sector has succeeded, the city in turn has become a more expensive place to live. With that transformation has come a have-versus-have-not divide, one that has begun to show up in the city's politics. In May 2016, Austin's voters decided to regulate the sharing economy, a decision that was interpreted as a swipe against the Silicon Valley car-sharing firms Uber and Lyft, both of which lobbied hard to prevent this outcome.[138] More broadly, this "Prop 1" debate showed that not all Austin residents are happy with the rapid transformation that the tech sector has brought with it.

A subset of this debate surrounds the "Keep Austin Weird" dilemma: Can the city keep its offbeat charm, rooted in its food, music, and arts scenes, while getting rich off of technology? This fear has been part of Austin's landscape for a long time. Both sides have their arguments. The pessimists believe such an outcome is an inevitable by-product of wealth, while the optimists say that the tech sector's growth will stimulate its offbeat culture. As tech comes in, the optimists believe, the creative communities will prosper rather than be driven out. Artists and musicians will find new creative outlets (e.g., gaming, film, visual arts, and design) for which they will be well paid.

Washington, DC: Not Your Grandfather's Capital

BY **BRITTANY HEYD, MANAGING DIRECTOR & GENERAL COUNSEL, 1776**

Washington, DC's startup scene has exploded over the past several years and is 1776's global headquarters for good reason. As a global incubator and venture fund fueling innovation in startups, corporations, and governments, 1776 and its community have benefitted from Washington's nexus of connections, its residents' change-the-world attitude, and the city's global reputation. The high volume of educated millennials, the city's growing population and developing neighborhoods, and access to customers and investors all have contributed to this emerging technology center on America's East Coast, especially in the industries of cybersecurity, health, energy, and education.

Since 1776 was founded four years ago, Washington's startup ecosystem has grown rapidly. 1776's latest *Innovation That Matters* report found that Washington, DC, has over 700 startups in the region with 224 recent exits, placing the city sixth nationally. In a recent *Financial Times* report, Washington performed among the top regions globally for investment, posting a 26 percent increase in fundraising totals in 2016. In recent years, the Washington region has seen a number of high-profile initial public offerings, including for Opower, Cvent, Evolent Health, ComScore, Sourcefire, Microstrategy, 2U, Blackboard, and more. These exits are important because they create company-building knowledge locally and provide wealth to founders who often reinvest it in the next generation of startups.

The Washington region also benefits from large firms that attract young, energetic tech talent to the area, including Uber, Palantir, WeddingWire, LivingSocial, and more. Many of these people, armed with strong networks and experience, then go on to later start their own companies. This cycle is a huge win for the region's innovation ecosystem. Additionally, with many corporations, associations, and governments visiting on a regular basis or headquartered in Washington, DC, startups have access to key decision makers who can serve as customers or pilots for their products. Above all, Washington, DC, is home to entrepreneurs who want to change the world for the better, who feel the best time to do so is now, and who believe that startups can be an alternative career path to government and nonprofits for effecting that change.

U.S. Capitol Building

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A few other established tech hubs ...

BY SAMUEL KLEIN, PROGRAM ASSISTANT, FORESIGHT, STRATEGY, AND RISKS INITIATIVE, BRENT SCOWCROFT CENTER ON INTERNATIONAL SECURITY, ATLANTIC COUNCIL

Seattle

TIFFANY VON ARMIN/FLICKR

In 2016, the Atlantic Council visited several tech hubs around the United States, each of which is profiled in this report. This section highlights a few other current and emerging tech hubs around the country. The list is by no means exhaustive and does not include successful hubs such as Chicago, Los Angeles, and Phoenix, but is illustrative of the breadth and scope of burgeoning tech hubs across the nation that are the seeds of US innovation.

Boston is widely regarded as one of the most important tech hubs in the United States and the world, second only to California's Bay Area. Boston features world-class research universities, including Harvard, MIT, Boston University, and Tufts. The city is best known for the life sciences, due to its world-renowned medical schools and hospitals in addition to its universities. Boston also features a highly desirable urban lifestyle. General Electric recently moved its global headquarters from Bridgeport, Connecticut, to Boston to take advantage of a talent pool less interested in living in the suburbs.[139] The greater Boston area is one of a small number of regions that attracts significant investment capital, and its leading universities are adept at tech transfer. MIT recently launched a new fund and accelerator called The Engine, which seeks to help startups pass through the "valley of death"—the gap between a lab idea and a successful commercial product.[140]

Seattle is also one of the nation's premier tech hubs. A major reason is the presence of the established tech giants Microsoft, Boeing, and Amazon. But more recently, Seattle has established itself as a place for startups. Seattle is known for its tight-knit community that fosters a culture of collaboration—rather than competition—among its population. A hot area is the commercial space industry. With Boeing already an established name, other companies looking to disrupt the satellite industry include Blue Origin (founded by Amazon's Jeff Bezos) and Vulcan Aerospace (started by Microsoft co-founder Paul Allen).[141] But against this backdrop of success there is concern that Seattle could face problems plaguing other tech hubs like Silicon Valley. While quality of life remains high, cost of living has started to become a problem.[142] (In a move to combat this, Seattle

Pittsburgh

MARIANO MANTEL/FLICKR.

recently became the first large city to adopt a $15 minimum wage). However, the city is still known for its lively food, art, and culture scenes, and favorable infrastructure like public schools and transportation—all draws for a high-tech workforce.

Raleigh, Durham, and Chapel Hill collectively make up a major tech hub known as the Research Triangle Park (RTP) in North Carolina. The region's three major universities (University of North Carolina, Duke University, and North Carolina State University) are the main players behind RTP's establishment, growth, and prosperity. Their collaboration successfully created a reputation for advanced research and innovation that attracts investment and interest from businesses and governments.[143] Besides the co-location and collaboration, the RTP cities also provide a lively environment for high-tech talent. The area boasts redeveloped warehouses for affordable living, a vibrant arts and culture scene, and outdoor amenities. Nor is the RTP sitting on its success. A recent example is Raleigh's Centennial Campus, which offers amenities from research and lab facilities to incubators and accelerators. Overall, these developments make RTP not only "a place to live and work, but a place to go."[144]

The **Salt Lake City and Provo** metropolitan areas boast big research universities, skilled workforces, and an outdoors lifestyle. Universities include the University of Utah, Utah State, and Brigham Young University. Situated along the Rocky Mountains, Salt Lake City and Provo residents can hike, camp, ski, and mountain bike. Culturally, an emphasis on self-reliance and a tight-knit community enable startups to gain a foothold.[145] Utah's university graduates often stay in the state, contributing to growth and sustainability.[146] Several major tech firms have placed offices in the region, including Adobe, eBay, and Netflix. Between 2013 and 2014, venture capital spending increased 153 percent (from $316.2 million to $801 million), and in 2015, the state ranked eleventh in venture capital deployed.[147]

Pittsburgh is a Rust Belt city that has successfully reinvented itself. Other industrial cities across the United States, such as Detroit, are hoping to emulate Pittsburgh's lead. The roots of tech innovation in the Steel City can be traced to strong research universities, including the University of Pittsburgh and Carnegie Mellon University (CMU). In particular, CMU has become a global leader in robotics, artificial intelligence, and computer science. The city, too, has shed its image of a "has-been" and is now seen as a "cool" place to live.[148] Talent is flowing in and new startups are emerging. University faculty and graduates—and their ideas for startups—are staying local to take advantage of a high quality of life combined with a low cost of living. The future looks bright: in 2015, Pittsburgh's population grew for the first time in decades.[149]

...and some cities to keep an eye on.

The established tech hubs are not the only important stories. Equally important are those places around the United States that have the potential to become high-growth tech hubs. This section discusses a few such cities, and does not include promising places like Winston-Salem or Indianapolis.

View of Chattanooga from Lookout Point

Chattanooga, Tennessee's high-tech story stems from federal investments, which helped build a public fiber-optic network that provides gigabit-speed internet services to this Appalachian city.[150] Now, more recently known as Gig City, Chattanooga has the fastest, least-expensive internet services in the United States. The city's fiber optic network has attracted startups in need of such speed to Chattanooga, and with it new talent and investment capital. New housing, office space, and restaurants are springing up in a reinvigorated city center too.[151] Adding to the University of Tennessee-Chattanooga's research base and student body (some ten thousand full- and part-time students), the US Department of Energy's Oak Ridge National Laboratory is opening an office in Chattanooga's innovation district.[152] "We don't need to be the next Silicon Valley," Mayor Andy Berke has said. "That's not who we're going to be, and we shouldn't try to be that. But we are making our own place in the innovation economy."[153]

Huntsville, Alabama, has a combination of research centers and STEM talent. Located near the Alabama-Tennessee border, Huntsville is home to several federal research centers focused on the military and aerospace industries.[154] One example is the Marshall Space Flight Center, NASA's largest, which conducts rocketry and propulsion research. It is no surprise that the United States' largest rocket science research center attracts a lot of rocket scientists: in 2014, 16.7 percent of workers in the metropolitan area held a job in STEM, giving Huntsville the third most technical workforce in the country.[155] In turn, competition for this talent has spurred increases in quality of living, as local businesses look to improve and provide new amenities that cater to the needs of young tech entrepreneurs.[156]

Lincoln, Nebraska, is a promising hub that has gotten off the ground with the help of organizations—such as Silicon Prairie News, which covers startups in the area and organizes tech conventions—that help connect entrepreneurs with investors.[157] Add to the Midwestern mindset of neighbor helping neighbor and hard work ethic, plus the University of Nebraska's talent pool, and you have the seeds of a tech hub.[158] A low cost of living and high quality of life have also contributed to its increasing success. The city has started to see some redevelopment in its Haymarket area and warehouse districts. The University of Nebraska and Lincoln are turning old fairgrounds into an innovation campus.[159] One unique startup is Hudl, which provides football players and coaches with the ability to share, store, and review game footage. It is the fastest growing company in Nebraska, helped by the large football culture around the university.[160]

Boise, Idaho, is another promising small-city candidate. With an eye toward urban living and high quality of life, the city of Boise has been working to create a vibrant downtown.[161] Affordability remains low, while outdoor amenities are plentiful. Downtown Boise is now home to a cluster of academic and private-sector firms in the technology space, in turn allowing students to gain access to internships and job training, while giving industry access to research and talent. This symbiotic relationship has the potential to launch Boise as a tech hub. In 2014, Boise State University relocated its computer science department to downtown Boise, a move that placed the department within walking distance of Boise's top technology firms.[162] Boise is home to Clearwater Analytics, a financial technology company, and Micron Technology, which is one of the world's top five semiconductor manufacturing firms.[163] With the university, both companies help attract a steady stream of talent and capital and help other startups emerge in the city.[164]

Boise Capital Building

CHATTANOOGA: CHARLENE M. SIMMONS/FLICKR; BOISE: BRAD PERKINS/FLICKR

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Endnotes

1 "Center for Microeconomic Data," Federal Reserve Bank of New York, https://www.newyorkfed.org/microeconomics/hhdc.html.

2 This definition distills of multiple definitions of innovation. The authors feel this best captures the concept.

3 The Acknowledgements section provides a partial list of individuals who assisted in this process, and without whom this report would not be possible.

4 The authors thank Paul Saffo for his thoughts on this history.

5 Defense Science Board, *Technology and Innovation Enablers for Superiority in 2030*, Department of Defense, October 2013, http://www.defenseinnovationmarketplace.mil/resources/DSB_TechnologyInnovationEnablersSuperiority2030.pdf.

6 National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, *Rising Above the Gathering Storm, Revisited: Rapidly Approaching Category 5*, The National Academies Press, 2010, doi:https://doi.org/10.17226/12999.

7 Steve Case, *The Third Wave: An Entrepreneurs Vision of the Future* (New York: Simon & Shuster, 2016).

8 Mathew J. Burrows, *Envisioning 2030: US Strategy for the Coming Technology Revolution*, Atlantic Council December 9, 2013, http://www.atlanticcouncil.org/publications/reports/envisioning-2030-us-strategy-for-the-coming-technology-revolution. For discussion of how the tech revolution may spur a new wave of manufacturing, see Mark Mills, *The Coming Revolution in Manufacturing*, Manhattan Institute, December 14, 2016, https://www.manhattan-institute.org/html/coming-revolution-american-manufacturing-9676.html.

9 Michael J. Hicks, and Srikant Devaraj, *The Myth and Reality of Manufacturing in America*, Ball State University Center for Business and Economic Research, June, 2015, http://conexus.cberdata.org/files/MfgReality.pdf.

10 Baily, Martin Neil and Barry P. Bosworth, *US Manufacturing: Understanding Its Past and Its Potential Future*, Journal of Economic Perspectives, 28(1): 3-26, 2014, DOI: 10.1257/jep.28.1.3. See also U.S. Bureau of Economic Analysis, *Value Added by Private Industries: Manufacturing as a Percentage of GDP* [VAPGDPMA], Federal Reserve Bank of St. Louis, March 2, 2017, https://fred.stlouisfed.org/series/VAPGDPMA

11 Thomas L. Friedman, *The World is Flat: A Brief History of the Twenty-first Century* (New York: Farrar, Straus and Giroux, 2005).

12 Among the best books on the subject is Edward L. Glaeser, *Triumph of the City: How our Greatest Invention Makes us Richer, Smarter, Greener, Healthier, and Happier* (New York: Penguin, 2012).

13 For one classic expression of the hierarchy of cities idea, see Saskia Sassen, *The Global City: Introducing a Concept*, Brown Journal of World Affairs 9, 2 (Winter/Spring 2005): 27-43, accessed March 3, 2017, http://www.saskiasassen.com/pdfs/publications/the-global-city-brown.pdf

14 Christopher Mims, "Startups try to Spread Outside of Silicon Valley," *Wall Street Journal*, July 11, 2016, http://www.wsj.com/articles/startups-try-to-spread-outside-of-silicon-valley-1468209662.

15 See Ian Hathaway, *Accelerating Growth: Startup accelerator programs in the United States*, Brookings, February 17, 2016, https://www.brookings.edu/research/accelerating-growth-startup-accelerator-programs-in-the-united-states/

16 For a brilliant work on the critical role of government in innovation, see Mariana Mazzucato, *The Entrepreneurial State: Debunking Public vs. Private Sector Myths* (New York: Anthem, 2013).

17 See Alex Trembath, "The History of the Shale Revolution," Breakthrough Institute, 2011, http://thebreakthrough.org/archive/history_of_the_shale_gas_revolution).

18 "FACT SHEET: President Obama Announces New Actions to Further Strengthen U.S. Manufacturing," White House Press Office, accessed March 3, 2017, https://www.whitehouse.gov/the-press-office/2014/10/27/fact-sheet-president-obama-announces-new-actions-further-strengthen-us-m.

19 Beryl Lieff Benderly, "Two Reports and the Worlds They Made," *Science*, May 4, 2012, DOI: 10.1126/science.caredit.a1200049, http://www.sciencemag.org/careers/2012/05/two-reports-and-worlds-they-made.

20 On this history, see Mariana Mazzucato, *The Entrepreneurial State: Debunking Public vs. Private Sector Myths*. Revised Edition (New York: Public Affairs, 2015) Kindle Location 2324-2331.

21 On DARPA and driverless cars, see Edward Alden, Bernard L. Schwartz, and Rebecca Strauss, *How America Stacks Up: Economic Competitiveness and U.S. Policy*, Council on Foreign Relations, January 2016, 25. On DARPA's history, see "Where the Future Becomes Now," Defense Advanced Research Projects Agency, http://www.darpa.mil/about-us/darpa-history-and-timeline.

22 See Fred Block and Matthew R. Keller (eds.), *The State of Innovation: The U.S. Government's Role in Technology Development* (Boulder, Paradigm, 2011). On ARPANET, see Kim Ann Zimmerman, "Internet History Timeline: ARPANET to the World Wide Web," Live Science, June 4, 2012, http://www.livescience.com/20727-internet-history.html. On GPS, see "Global Positioning System History," NASA, October 27, 2012 (last updated July 31, 2015), https://www.nasa.gov/directorates/heo/scan/communications/policy/GPS_History.html.

23 This, indeed, is the core argument in Mazzucato, *The Entrepreneurial State*.

24 See *Federal Policies and Innovation*, Congressional Budget Office, November 2014, https://www.cbo.gov/publication/49487.

25 Art Jahnke, "Who Picks Up the Tab for Science?," Boston University Research, Summer 2015, http://www.bu.edu/research/articles/funding-for-scientific-research/.

26 Matt Hourihan, *Federal R&D Budget Trends: A Short Summary*, American Association for the Advancement of Science, December 19, 2016, http://www.aaas.org/sites/default/files/R%26D%20Budget%20Overview.pdf.

27 For an interesting, UK assessment of SBIR see David Connell, *"Secrets" of the World's Largest Seed Capital Fund*, Centre for Business Research, University of Cambridge, February 2006, http://www.cbr.cam.ac.uk/fileadmin/user_upload/centre-for-business-research/downloads/special-reports/specialreport-secretsseedcapitalfund.pdf. Mazzucato 2015 also has a write-up of the SBIR program at Kindle Locations 2403-2474.

28 "About SBIR," SBIR·STTR, US Small Business Administration, https://www.sbir.gov/about/about-sbir.

29 The agencies are NASA, the National Science Foundation, the Environmental Protection Agency, and the Departments of Defense, Homeland Security, Education, Transportation, Agriculture, Health and Human Services, Energy, and Commerce. Of these, Defense and Health and Human Services receive the most funding by far. See "SBIR STTR Program Overview Presentation" accessed through "About SBIR," SBIR·STTR, US Small Business Administration.

30 For a state-by-state, agency-by-agency breakdown of awards, see "About SBIR," SBIR·STTR, US Small Business Administration. A short summary of this process is also provided in Connell 2006, pp. 2-3.

31 "SBA 100," SBIR·STTR, Small Business Administration, https://www.sba.gov/sba-100/list; "23ANDME, INC.," SBIR·STTR, US Small Business Administration, https://www.sbir.gov/sbc/23andme-inc. Qualcomm, of course, is partnering with the Atlantic Council in the production of this report.

32 "Stratatech Corporation," SBIR·STTR, US Small Business Administration, https://www.sbir.gov/sbirsearch/detail/319100?page=1.

33 John V. Lombardi et al., *The Top American Research Universities: 2014 Annual Report*, The Center for Measuring University Performance at Arizona State University and the University of Massachusetts-Amherst, 2014, 42-46, https://mup.asu.edu/sites/default/files/mup-2014-top-american-research-universities-annual-report.pdf.

34 Gary N. Keller, "Guide on intellectual property (IP) commercialization," World Intellectual Property Organization, September 30, 2015, p. 21, "http://www.wipo.int/edocs/mdocs/mdocs/en/cdip_16/cdip_16_inf_4.doc" www.wipo.int/edocs/mdocs/mdocs/en/cdip_16/cdip_16_inf_4.doc; see also "FY2015 Licensing Survey," Association of University Technology Managers, http://www.autm.net/fy2015-survey/.

35 See, e.g., the comparative Europe-US discussion of university tech transfer in Peter Engelke and Robert A. Manning, *Labor, Technology, and Innovation in Europe: Facing Global Risk through Increased Resiliency*, Atlantic Council, June 2013, http://www.atlanticcouncil.org/publications/issue-briefs/labor-technology-and-innovation-in-europe-facing-global-risk-through-increased-resiliency.

36 Richard Gawel, "Fred Terman: The Father of Silicon Valley Raises an Industry," *Electronic Design*, December 3, 2011, http://electronicdesign.com/communications/fred-terman-father-silicon-valley-raises-industry; Paul Gullickson, "Silicon Valley Pioneers / How Varian and Its Klystron Tube Illuminated the Future," SF Gate, June 5, 1998, http://www.sfgate.com/bayarea/article/Silicon-Valley-Pioneers-How-Varian-and-its-3004560.php.

37 National Research Council of the National Academies, *Research Universities and the Future of America. Ten Breakthrough Actions Vital to Our Nation's Prosperity and Security* (Washington, DC: The National Academies Press, 2012), 4, doi:https://doi.org/10.17226/13396.

38 Ronda Britt, *Universities Report Fourth Straight Year of Declining Federal R&D Funding in FY 2015*, NCSES Info Brief (Washington, DC: National Science Foundation, November 2016), Figure 1 and Table 2, https://www.nsf.gov/statistics/2017/nsf17303/.

39 Melissa Korn and Cameron McWhirter, "Public Universities Become Prime Targets for State Budget Cuts," *Wall Street Journal*, February 10, 2017, https://www.wsj.com/articles/public-universities-become-prime-targets-for-state-budget-cuts-1486722602.

40 For a detailed discussion of the role of universities in innovation, see Krisztina Holly, "Universities and Innovation Networks," Center for American Progress, 2012, https://www.americanprogress.org/wp-content/uploads/issues/2012/01/pdf/dwwsp_university_innovation.pdf. See also *Public Research Universities: Changes in State Funding*, American Academy of Arts & Sciences, 2015, https://www.amacad.org/multimedia/pdfs/publications/researchpapersmonographs/PublicResearchUniv_ChangesInStateFunding.pdf.

41 Sara Hebel, "From Public Good to Private Good: How Higher Education Got to a Tipping Point," The Chronicle of Higher Education, March 2, 2014, 33, http://www.chronicle.com/article/From-Public-Good-to-Private/145061.

42 http://www.oecd.org/science/inno/msti.htm.

43 John Markoff and Matthew Rosenberg, "China's Intelligent Weaponry Gets Smarter," New York Times, February 3, 2017, https://www.nytimes.com/2017/02/03/technology/artificial-

intelligence-china-united-states.html.

44 Michael G. Finn, *Stay Rates of Foreign Doctorate Recipients from US Universities*, Oak Ridge Institute for Science and Education, 2014, http://orise.orau.gov/files/sep/stay-rates-foreign-doctorate-recipients-2011.pdf.

45 Stuart Anderson, *Immigrants and Billion Dollar Startups*, National Foundation for American Policy, 2016, http://nfap.com/wp-content/uploads/2016/03/Immigrants-and-Billion-Dollar-Startups.NFAP-Policy-Brief.March-2016.pdf.

46 Craig A. Giffi et al., "Help Wanted: American Manufacturing Competitiveness and the Looming Skills Gap," Deloitte University Press, Deloitte Review Issue 16, January 26, 2015, https://dupress.deloitte.com/dup-us-en/deloitte-review/issue-16/manufacturing-skills-gap-america.html.

47 *Student and Exchange Visitor Information System*, US Immigration and Customs Enforcement, US Department of Homeland Security, 2014, https://www.ice.gov/doclib/sevis/pdf/by-the-numbers1.pdf.

48 "The H-1B Visa Program: A Primer on the Program and Its Impact on Jobs, Wages, and the Economy," American Immigration Council, https://www.americanimmigrationcouncil.org/research/h1b-visa-program-fact-sheet

49 Nathan Musick and Philip Webre, *Federal Policies and Innovation*, Congressional Budget Office, 2014, 30, https://www.cbo.gov/sites/default/files/113th-congress-2013-2014/reports/49487-Innovation.pdf

50 Benjamin Page and Felix Reichling, *The Economic Impact of S. 744, the Border Security, Economic Opportunity, and Immigration Modernization Act*, Congressional Budget Office, June 2013, 12-13, https://www.cbo.gov/sites/default/files/113th-congress-2013-2014/reports/44346-Immigration.pdf. A more recent study of data from 1994 to 2001 estimated slightly reduced wages for some American tech workers but an "overall welfare" boost for the national economy: John Bound, Gaurav Khanna, and Nicolas Morales, "Understanding the Economic Impact of the H-1B Program on the U.S.," National Bureau of Economic Research Working Paper No. 23153, February 2017, http://www.nber.org/papers/w23153.

51 Patricia Zengerle, "Two Republican Senators Seek to Slash Legal US Immigration," Reuters, February 7, 2017, http://www.reuters.com/article/us-usa-trump-immigration-senate-idUSKBN15M1VB.

52 Patrick Thibodeau, "H-1B advocate Sen. Orrin Hatch sets stage for new visa battle," Computerworld, February 17, 2017, http://www.computerworld.com/article/3171151/it-careers/h-1b-advocate-sen-orrin-hatch-sets-stage-for-new-visa-battle.html

53 *Federal Policies and Innovation*, Congressional Budget Office, November 2014, 29, https://www.cbo.gov/sites/default/files/113th-congress-2013-2014/reports/49487-Innovation.pdf.

54 Quoted in Steve Case, *The Third Wave*, 182.

55 "Skills," Organisation for Economic Co-operation and Development, http://www.oecd.org/skills/. Also cited in Joseph Parilla, Jesus Leal Trujillo, and Alan Berube, *Skills and Innovation Strategies to Strengthen US Manufacturing: Lessons from Germany*, Brookings Institution, 2016, https://www.brookings.edu/wp-content/uploads/2016/06/LessonsFromGermany.pdf.

56 A comparison of both is in George Deeb, "Is A Startup Incubator Or Accelerator Right For You?," *Forbes*, August 28, 2014, http://www.forbes.com/sites/georgedeeb/2014/08/28/is-a-startup-incubator-or-accelerator-right-for-you/#16ab69b83386. See also Susan Cohen, *What Do Accelerators Do? Insights from Incubators and Angels*, 8, 3/4, http://www.mitpressjournals.org/doi/pdf/10.1162/INOV_a_00184.

57 For a discussion of how accelerators work, see Ian Hathaway, "What Start up Accelerators Really Do," *Harvard Business Review*, March 1, 2016: https://hbr.org/2016/03/what-startup-accelerators-really-do.

58 Ibid.

59 For an assessment of leading accelerators around the US, see Dan Fehder, Susan Cohen, Yael Hochberg, "These Are the Top 20 US Accelerators," *TechCrunch*, March 17, 2015, https://techcrunch.com/2015/03/17/these-are-the-top-20-us-accelerators/.

60 Conner Forrest, "Accelerators vs. Incubators: What Startups Need to Know," TechRepublic, November 17, 2014, http://www.techrepublic.com/article/accelerators-vs-incubators-what-startups-need-to-know/. On Idealab, see http://www.idealab.com/. On 1776, see http://www.1776.vc/about/.

61 Rip Empson, "Part Incubator, Workspace & Code School, Galvanize Wants to Turn Denver into a Startup Hub; Uber, Forkly & More Already On Board," *TechCrunch*, November 9, 2012, https://techcrunch.com/2012/11/09/part-incubator-workspace-code-school-galvanize-wants-to-turn-denver-into-a-startup-hub-uber-forkly-more-already-on-board/. See also http://www.galvanize.com/about/. On 1871, see https://1871.com/about/.

62 See Christopher Mims, "A New Kind of Jobs Program for Middle America," *Wall Street Journal*, February 26, 2017, https://www.wsj.com/articles/a-new-kind-of-jobs-program-for-middleamerica-1488114000.

63 Erik Sherman, "Complete guide to the top 24 coding bootcamps," TechBeacon, https://techbeacon.com/complete-guide-top-24-coding-bootcamps.

64 Ibid.

65 Parilla, Leal Trujillo, and Berube, *Skills and Innovation Strategies*.

66 "IHK Certificates," Central Piedmont Community College, https://www.cpcc.edu/et/certification-center/ihk-faq.

67 See Jeffrey J. Selingo, "Wanted, Factory Workers, Degree Required," *New York Times*, January 30, 2017, https://www.nytimes.com/2017/01/30/education/edlife/factory-workers-college-degree-apprenticeships.html.

68 "Best Technology Jobs," U.S. News & World Report, http://money.usnews.com/careers/best-jobs/rankings/best-technology-jobs; "Frequently Asked Questions," United States Department of Labor, www.dol.gov/apprenticeship/toolkit/toolkitfaq.htm#1a.

69 US Constitution, Article II, Section 8 via Cornell University, https://www.law.cornell.edu/constitution/articlei#section8. Emphasis added.

70 Stephen Haber, "Patents and the Wealth of Nations," *George Mason Law Review* 23, 4 (2016), p. 821.

71 "How Intellectual Property Can Help or Hinder Innovation,"

Entrepreneurship Policy Digest, The Kauffman Foundation, April 7, 2015, http://www.kauffman.org/~/media/kauffman_org/resources/2015/entrepreneurship%20policy%20digest/april%202015/ip_policydigest_040715.pdf.

72 Ibid.

73 See, e.g., Haber, "Patents and the Wealth of Nations"; Adam Mossoff, "Who Cares What Thomas Jefferson Thought about Patents? Reevaluating the Patent 'Privilege' in Historical Context," Cornell Law Review 92 (2007), 953-1012; Adam Mossoff, "Introduction," in Adam Mossoff, ed., *Intellectual Property and Property Rights* (Northampton, MA: Elgar Research Collection), ix-xxii; B. Zorina Khan, *Trolls and Other Patent Inventions: Economic History and the Patent Controversy in the Twenty-First Century*, Stanford University, Hoover Institution Working Group on Intellectual Property, Innovation, and Prosperity, Working Paper Series No. 13001, September 2013.

74 See Haber, "Patents and the Wealth of Nations," 815.

75 "Original IP and Corporate R&D," The Kauffman Foundation, http://www.kauffman.org/microsites/state-of-the-field/topics/technology-and-innovation/original-ip-and-corporate-r-and-d.

76 For an outstanding set of critiques of the patent system from an economist's perspective, see Joseph E. Stiglitz, "Economic Foundations of Intellectual Property Rights," *Duke Law Journal* 40 (2008), http://scholarship.law.duke.edu/dlj/vol57/iss6/3.

77 Joan Farre-Mensa, Deepak Hegda, and Alexander Ljungqvist, *The Bright Side of Patents: USPTO Economic Working Paper No. 2015-5* (Washington, DC: US Patent and Trademark Office, 2015), 1.

78 "High quality" patents refer to those that are cited in scientific and technical literature or lead to other inventions. See Jonathan Rothwell et al., *Patenting Prosperity: Invention and Economic Performance in the United States and Its Metropolitan Areas*, Brookings Institution, 2013, 2, https://www.brookings.edu/wp-content/uploads/2016/06/patenting-prosperity-rothwell.pdf.

79 See, e.g., Jay P. Kesan et al., "Paving the Path to Accurately Predicting Legal Outcomes," University of Illinois College of Law Research Paper No. LBSS12-09, January 2012, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1987258; and Jonathan H. Ashtor, Michael J. Mazzeo, and Samantha Zyontz, "Patents at Issue: The Data Behind the Patent Troll Debate," Northwestern Law Review, 2014, https://www.google.com/#q=Ashtor+Patents+at+Issue&*. On the framers and monopoly argument, see, e.g., Mossoff, "Who Cares What Thomas Jefferson Thought about Patents?"

80 See Joan Farre-Mensa, Deepak Hegde, and Alexander Ljungqvist, "The Bright Side of Patents," National Bureau of Economic Research, Working Paper No. 21959, January 2016, http://www.nber.org/papers/w21959.

81 Ibid., 1-6.

82 Rothwell et al., *Patenting Prosperity*, 7–8, 12.

83 Christopher A. Cotropia, Jay P. Kesan, and David L. Schwartz, "Unpacking Patent Assertion Entities (PAEs)," *Minnesota Law Review* (2014), 649-703.

84 Colleen V. Chien, "Startups and Patent Trolls," Santa Clara University School of Law, Legal Studies Research Papers Series (2012), 1–3.

85 See Kesan, "Paving the Path to Accurately Predicting Legal Outcomes," and Ashtor, Mazzeo, and Zyontz, "Patents at Issue."

86 Gene Quinn, "Hatch says patent venue reform likely regardless of SCOTUS decision in TC Heartland," IPWatchDog, February 16, 2017, http://www.ipwatchdog.com/2017/02/16/hatch-venue-reform-likely-scotus-tc-heartland/id=78495/.

87 Richard Florida is best known for *The Rise of the Creative Class* (New York: Basic Books, 2004).

88 This analysis is from Richard Florida, "Where America's Inventors Are: The Geography of American Innovation over the Last Decade," *CityLab*, October 9, 2013, http://www.citylab.com/work/2013/10/where-americas-inventors-ara/7069/.

89 Ramya M. Vijaya, *Broken Buffer: How Trade Adjustment Assistance Fails American Workers*, Demos, 2010, http://www.demos.org/sites/default/files/publications/Broken_Buffer_FINAL.pdf.

90 Michael J. Hicks and Srikant Devaraj, *The Myth and the Reality of Manufacturing in America*, Conexus Indiana and Ball State University, Center for Business and Economic Research, 2015, http://projects.cberdata.org/reports/MfgReality.pdf.

91 "This Is the Future of Tech," Code2040, http://www.code2040.org.

92 Ankita Saxena, "Workforce Diversity: A Key to Improve Productivity," *Procedia Economics and Finance*, vol. 11, 2014, 76-85, http://www.sciencedirect.com/science/article/pii/S2212567114001786; Peter Dizikes, "Study: Workplace Diversity Can Help the Bottom Line," MIT News, October 7, 2014, http://news.mit.edu/2014/workplace-diversity-can-help-bottom-line-1007; Vivian Hunt, Dennis Layton, and Sara Prince, "Why Diversity Matters," McKinsey & Company, January 2015, http://www.mckinsey.com/business-functions/organization/our-insights/why-diversity-matters.

93 Richard Waters, "Bill Gates Calls for Income Tax on Robots," *Financial Times*, February 18, 2017, https://www.ft.com/content/d04a89c2-f6c8-11e6-9516-2d969e0d3b65.

94 For a short history and advocacy of the guaranteed national income idea, see Noah Gordon, "The Conservative Case for a Guaranteed Basic Income," *The Atlantic*, August 6, 2014, http://www.theatlantic.com/politics/archive/2014/08/why-arent-reformicons-pushing-a-guaranteed-basic-income/375600/.

95 *Report to the President: Ensuring Long-Term US Leadership in Semiconductors*, President's Council of Advisors on Science and Technology, White House, January 2017, https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/PCAST/pcast_ensuring_long-term_us_leadership_in_semiconductors.pdf.

96 Jason Koebler, "The City That Was Saved by the Internet," *Motherboard*, October 27, 2016, http://motherboard.vice.com/read/chattanooga-gigabit-fiber-network; "EPB Awarded $111 Million Grant for Smart Grid," *The Chattanoogan*, October 27, 2009, http://www.chattanoogan.com/2009/10/27/161784/EPB-Awarded-111-Million-Grant-For.aspx.

97 Claire Zillman, "Massachusetts' Clever Immigration Reform Workaround," *Fortune*, April 14, 2014, http://fortune.com/2014/04/14/massachusetts-clever-immigration-

reform-workaround/.

98 *Ensuring Long-Term US Leadership in Semiconductors*, President's Council of Advisors on Science and Technology.

99 "Manufacturing USA — The National Network for Manufacturing Innovation," Advanced Manufacturing National Program Office, https://www.manufacturing.gov/nnmi/; "FACT SHEET: The White House Releases New Strategy for American Innovation, Announces Areas of Opportunity from Self-Driving Cars to Smart Cities," White House, October 21, 2015, https://www.whitehouse.gov/the-press-office/2015/10/21/fact-sheet-white-house-releases-new-strategy-american-innovation; "FACT SHEET: White House Launches 'Startup America' Initiative," White House, January 31, 2011, https://obamawhitehouse.archives.gov/the-press-office/2011/01/31/white-house-launch-startup-america-initiative; For a thorough discussion of Obama's Network for Manufacturing Innovation and the role of government, finance, and regulation in shaping innovation, see Franklin D. Kramer and James A. Wrightson, Jr., *Innovation, Leadership, and National Security*, Atlantic Council, 2016, http://www.atlanticcouncil.org/images/publications/Innovation_Leadership_and_National_Security_web_0411.pdf.

100 "FACT SHEET: White House Launches 'Startup America' Initiative," White House.

101 In 2015, the San Francisco/Oakland region (Metropolitan Statistical Area, or MSA) plus the Silicon Valley MSA (San Jose and environs) had 6,632,968 people, meaning that together the entire region would be seventh in size nationally. See US Census, https://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml. On GDP, see *Promise and Perils of an Accelerated Economy: Bay Area Economic Profile*, Bay Area Council Economic Institute, Ninth in a Series, May 2016, 5, http://www.bayareaeconomy.org/publications-list/.

102 *Promise and Perils of an Accelerated Economy*, Bay Area Council Economic Institute, 19-21.

103 Compass.co, *The Global Startup Ecosystem Ranking 2015* (Startup Compass Inc., 2015), 32. Global rankings are on page 24.

104 Ibid., 33.

105 *Q3 2016 MoneyTree Report*, PwC, October 2016, 7, http://www.pwc.com/us/en/technology/moneytree.html.

106 Rhett Morris and Mariana Penido, *How Did Silicon Valley Become Silicon Valley? Three Surprising Lessons for Other Cities and Regions*, Endeavor Global, 2014.

107 See John Markoff, *What the Dormouse Said: How the Sixties Counterculture Shaped the Personal Computer Industry* (New York: Viking, 2005).

108 Vivek Wadhwa, "Silicon Valley Can't Be Copied," *A Business Report on the Next Silicon Valley*, MIT Technology Review, July 2013, 3-4, http://www.technologyreview.com/news/516501/in-innovation-quest-regions-seek-critical-mass/.

109 Compass.co, *The Global Startup Ecosystem Ranking* 2015, 33.

110 *Promise and Perils of an Accelerated Economy*, Bay Area Council Economic Institute, 23-34.

111 "Economic Impacts and Business Opportunities," National Renewable Energy Lab, http://www.nrel.gov/about/business.html.

112 This history is detailed in *Brad Feld, Startup Communities: Building an Entrepreneurial Ecosystem in Your City* (John Wily & Sons: New York, 2012), chapter two

113 Ibid.

114 Ibid. Some of this data can be found at Techstars' website, http://www.techstars.com/faq/.

115 See the Wells Fargo program's website, http://in2.wf.com.

116 Boulder: Shay Castle, "$1 Million Average Home Price in Boulder? No Way, Says Local Realtors," Daily Camera, December 1, 2015, http://www.dailycamera.com/boulder-business/ci_29188490/1-million-average-home-price-boulder-no-way; Palo Alto: "Palo Alto Home Prices & Values," Zillow, http://www.zillow.com/palo-alto-ca/home-values/, data through January 31, 2017.

117 The University of Wisconsin-Madison is by far the largest campus within the University of Wisconsin System, which consists of more than two dozen campuses statewide: "What Is the UW System," University of Wisconsin System, https://www.wisconsin.edu/about-the-uw-system/.

118 The US Census Bureau estimated a 2015 population of 641,385 for the Madison Metropolitan Statistical Area. Data derived from American FactFinder, US Census, https://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml.

119 Epic, http://www.epic.com/about; "History of Ultratec," Ultratec, http://www.ultratec.com/about/years.php. Ultratec spun off CapTel, which now employs more people in Madison. In the interest of full disclosure, Robert Engelke, Ultratec's founder, is related to the report author.

120 All data from WARF's homepage at www.warf.org.

121 Data provided by the Greater Madison Chamber of Commerce in June 2016.

122 On University Research Park, see "Strategic Plan," University Research Park, http://universityresearchpark.org/about/strategic-plan/. On discovery to product, see "About D2P," D2P, https://d2p.wisc.edu/lean-start-ups-and-entrepreneurs/. For a thorough review of UW partnerships and initiatives, see the UW School of Business guide: "INSITE Entrepreneurship Guide," UW School of Business, https://apps.bus.wisc.edu/insite-entrepreneurship-guide/.

123 On the 2005 state law, see "Governor Doyle Announces Wisconsin Angel Network to Connect Entrepreneurs with Early-Stage Investors," Wisconsin Governor's Office, January 4, 2005, https://www.wdfi.org/newsroom/press/2005/AngelInvestmentNetwork.pdf. On HealthX Ventures, see "About HealthX Ventures," HealthX Ventures, https://www.healthxventures.com/#about.

124 Judy Newman, "Stratatech Lands $247 Million Contract for Burn Victim Treatments," Wisconsin State Journal, October 6, 2015, http://host.madison.com/wsj/business/stratatech-lands-m-federal-contract-for-burn-victim-treatments/article_cc9a8711-1b20-50ff-9d50-6d1eb1ae2463.html; Judy Newman, "Madison's Stratatech to Be Acquired by UK Firm," Wisconsin State Journal, August 12, 2016, http://host.madison.com/wsj/business/madison-s-stratatech-to-be-acquired-by-uk-firm/article_c4e884bf-4962-57a5-abd6-434690a1395b.html. See also a description of the science on the company's website: "Core

Technology," Stratatech Corp., http://www.stratatechcorp.com/science/index.php.

125 In 2015, the Austin region (Metropolitan Statistical Area) had 2,000,860 people, putting it thirty-fourth in size nationally. The 2010 Census counted 1.7 million people in the region. Data derived from U.S. Census Bureau, https://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml.

126 For a review of Austin's food culture, see Peter Jon Lindberg, "It's Official: Austin Is America's Next Great Food Town," *Travel + Leisure* (undated), http://www.travelandleisure.com/articles/austin-food-travel.

127 E.J. Reedy et al., *The 2016 Kauffman Index of Startup Activity: Metropolitan Area and City Trends*, Ewing Marion Kauffman Foundation, August 2016, Table 1, 11, http://www.kauffman.org/~/media/kauffman_org/microsites/kauffman_index/startup_activity_2016/kauffman_index_startup_activity_metro_trends_2016.pdf.

128 Jonha Richman, "Here's Why Tech Startups Are Flocking to Austin," Tech.co, April 19, 2015, http://tech.co/make-way-silicon-valley-heres-tech-startups-flocking-austin-2015-04. In 2013, the New York Times estimated there were "at least" fifteen accelerators and incubators in Austin. See Eilene Zimmerman, "Austin's 'Silicon Hills' Builds on Its Infrastructure," *New York Times*, July 17, 2013, http://boss.blogs.nytimes.com/2013/07/17/austins-silicon-hills-builds-on-its-infrastructure/?_r=4.

129 Colin Morris, "2015 Austin Startup Report: $966M in Fundings and a $3.9B Exit," Built in Austin, January 22, 2016, http://www.builtinaustin.com/2016/01/19/2015-annual-report. HomeAway was founded in Austin in 2005. See "Corporate Timeline," HomeAway, https://www.homeaway.com/info/media-center/more-info/ha-timeline.

130 Richman, "Here's Why Tech Startups Are Flocking to Austin."

131 Mike Montgomery, "Tech Startups Weigh the Merits of Austin vs. Silicon Valley," *Forbes*, March 19, 2015, http://www.forbes.com/sites/mikemontgomery/2015/03/19/tech-startups-weigh-the-merits-of-austin-vs-silicon-valley/#34f1e1b7df74.

132 "How South By Southwest Has Made Austin a Technology Powerhouse," Snyxius.com, March 1, 2016, https://www.snyxius.com/blog/how-south-by-southwest-has-made-austin-a-technology-powerhouse/#.WE2Y_2cVDIU. On Twitter and SXSW, see Sarah Kessler, "6 Successful SXSW Startup Launch Stories," mashable.com, March 5, 2011, http://mashable.com/2011/03/05/sxsw-launches/#2EvM1Y2Md5qu. See also "26 Years at SXSW: A Q&A with Festival Director Hugh Forrest," Freeenterprise.com, March 13, 2015, https://www.freeenterprise.com/26-years-at-sxsw-a-qa-with-festival-director-hugh-forrest/.

133 For a history of Dell's early years, see "Dell Computer Company," Texas State Historical Association, (undated), https://tshaonline.org/handbook/online/articles/dndyy.

134 "About the IC2 Institute," UT-Austin, http://ic2.utexas.edu/about/.

135 "Innovation Center," UT-Austin Cockrell School of Engineering, http://www.engr.utexas.edu/innovation.

136 The University's Office of Technology Commercialization, which is responsible for tech transfer, reports that over a decade ending in 2015, it has received $156 million in licensing revenue; in 2015 that figure was $22.7 million. See "OTC Metrics," UT-Austin, Office of Technology Commercialization, https://research.utexas.edu/otc/about-otc/otc-metrics/. In comparison, the Wisconsin Alumni Research Foundation at the University of Wisconsin has a $2.6 billion endowment and returns some $100 million in royalties annually to the university.

137 According to the latest version of the MoneyTree report by the consultancy PwC, in the third quarter of 2016, Silicon Valley firms attracted $4.6 billion in venture capital investment compared with $211 million for all of Texas. See *Q3 2016 MoneyTree*, PwC, 7.

138 This controversy was known as the Proposition 1 debate. Uber and Lyft spent an estimated $8 million in advertising and public relations trying to convince locals to not regulate the car-sharing industry. See Fitz Tepper, "Uber and Lyft Shut Down in Austin after Voters Defeat Proposition 1," *TechCrunch*, May 7, 2016, https://techcrunch.com/2016/05/07/uber-and-lyft-shutdown-in-austin-after-voters-defeat-proposition-1/.

139 Steve Lohr, "G.E. Is Moving Headquarters to Boston and Itself into the Digital Era," *New York Times*, January 13, 2016, http://www.nytimes.com/2016/01/14/technology/ge-boston-headquarters.html.

140 Devin Coldewey, "'The Engine' Is MIT's Incubator for Tech and Science Companies Straight Out of the Lab," TechCrunch, October 26, 2016, https://techcrunch.com/2016/10/26/the-engine-is-mits-incubator-for-tech-and-science-companies-straight-out-of-the-lab/.

141 Nick Wingfield, "The Silicon Valley of Space Start-Ups? It Could Be Seattle," *New York Times*, July 29, 2016, http://www.nytimes.com/2016/08/02/science/seattle-space-flight-innovation-center.html?ref=todayspaper.

142 Nick Wingfield, "Seattle, in Midst of Tech Boom, Tries to Keep Its Soul," *New York Times*, October 8, 2015, http://www.nytimes.com/2015/10/09/technology/seattle-in-midst-of-tech-boom-tries-to-keep-its-soul.html.

143 Antoine van Agtmael and Fred Bakker, *The Smartest Places on Earth: Why Rustbelts Are the Emerging Hotspots of Global Innovation* (New York: PublicAffairs, 2016), 107-115.

144 David Kroll, "7 Reasons It's Finally Time to Live in Research Triangle Park," *Forbes*, February 4, 2014, http://www.forbes.com/sites/davidkroll/2014/02/04/7-reasons-its-finally-time-to-live-in-research-triangle-park/.

145 Andrew Zaleski, "A High Tech Mecca Rises to Rival Silicon Valley," CNBC.com, July 13, 2016, http://www.cnbc.com/2016/07/13/a-high-tech-mecca-rises-to-rival-silicon-valley.html.

146 Caroline O'Donovan, "A Tech Boom Is Coming for Utah" Buzzfeed, May 1, 2016, https://www.buzzfeed.com/carolineodonovan/a-tech-boom-is-coming-for-utah?utm_term=.xvLNvGmWE#.bd80qyQGv.

147 Ben Veghte, National Venture Capital Association, "EcoSystem Spotlight: Utah Punches above Its Weight" National Venture Capital Association, May 31, 2016, http://nvca.org/blog/ecosystem-spotlight-utah-punches-weight/.

148 Carmen Gentile, "Pittsburgh Flexes Its Technology Muscle," *USA Today*, August 16, 2014, http://www.usatoday.com/story/money/markets/2014/08/16/pittsburgh-tech-innovation-leaders/13812561/.

149 Angelo Young, "Uber Got This Right: Pittsburgh Is America's City of the Future," *Salon*, August 19, 2016, http://www.salon.com/2016/08/19/uber-got-this-right-pittsburgh-is-americas-city-of-the-future/.

150 Edward Wyatt, "Fast Internet Is Chattanooga's New Locomotive," *New York Times*, February 4, 2014, http://www.nytimes.com/2014/02/04/technology/fast-internet-service-speeds-business-development-in-chattanooga.html.

151 Sam Sturgis, "Why Housing Is Key to Chattanooga's Tech Hub Ambitions," CityLab, March 6, 2015, http://www.citylab.com/housing/2015/03/why-housing-is-key-to-chattanoogas-tech-hub-ambitions/386776/.

152 "Oak Ridge National Laboratory Opening Chattanooga Office," Oak Ridge National Laboratory, https://www.ornl.gov/news/oak-ridge-national-laboratory-opening-chattanooga-office; Dave Flessner, "One of America's Biggest Research Labs to Open in Chattanooga," *Chattanooga Times Free-Press*, May 22, 2016, http://www.timesfreepress.com/news/business/aroundregion/story/2016/may/22/oak-ridge-lab-open-office-chattanoogaformer-s/366879/.

153 Edward Wyatt, "Fast Internet Is Chattanooga's New Locomotive," *New York Times*, February 3, 2014, http://www.nytimes.com/2014/02/04/technology/fast-internet-service-speeds-business-development-in-chattanooga.html?_r=0.

154 Yann Ranovio, "One Alabama City Named Promising Tech Hub to Watch in 2014," *Birmingham Business Journal*, January 7, 2014, http://www.bizjournals.com/birmingham/news/2014/01/07/one-alabama-city-named-promising-tech.html.

155 Chiristopher Cannon et al., "The Unlikely Cities That Will Power the U.S. Economy," *Bloomberg*, September 3, 2015, https://www.bloomberg.com/graphics/2015-stem-jobs/.

156 Ibid.

157 John Eligon, "Tech Start-Ups Find a Home on the Prairie," *New York Times*, November 21, 2012, http://www.nytimes.com/2012/11/22/us/silicon-prairie-takes-root-in-the-great-plains.html.

158 David Schaper, "Silicon Prairie: Tech Startups Find a Welcoming Home in the Midwest," NPR, March 12, 2015, http://www.npr.org/sections/alltechconsidered/2015/03/12/392136573/silicon-prairie-tech-startups-find-a-welcoming-home-in-the-midwest.

159 Ibid.

160 Ibid.

161 Kim Fields, "City Center Plaza: An Exclusive Look at Gardner Company's Most Ambitious Project," KTVB Channel 7 Idaho, September 6, 2016, http://www.ktvb.com/news/local/families-jobs-and-education-an-exclusive-sneak-peak-of-boises-city-center-plaza/313534094.

162 Tommy Ahlquist, "Boise's Downtown Tech Hub Drives Vital Growth," Idaho Statesman, June 17, 2015, http://www.idahostatesman.com/news/business/business-insider/article40863417.html.

163 "About Clearwater Analytics," Clearwater Analytics, http://clearwater-analytics.com/about; "Preliminary Worldwide Ranking of the Top 20 Suppliers of Semiconductors in 2014," IHS Markit, Press Release, December 18, 2014, http://news.ihsmarkit.com/sites/ihs.newshq.businesswire.com/files/press_release/file/2014-12-18_Semi_Ranking_Final.jpg.

164 Zach Kyle, "A Tech Corridor Takes Shape along a Downtown Boise Street," *Idaho Statesman*, August 30, 2016, http://www.idahostatesman.com/news/business/article98977927.html.

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