25 Recommendations for the Reauthorization of the 2013 America COMPETES Act

BY STEPHEN J. EZELL AND ROBERT D. ATKINSON | APRIL 2013

Reauthorization of the America COMPETES Act in 2013 provides a prime opportunity to bolster federal programs and policies supporting science, technology, innovation, and STEM education.

The America COMPETES Act, originally enacted in 2007 and reauthorized in 2010, has helped support the science, technology, and innovation enterprise that underpins U.S. economic growth. The impending 2013 Reauthorization of the America COMPETES Act affords an opportunity to introduce new or extend effective existing programs and initiatives related to: innovation and technology commercialization; federal institutional reforms to spur innovation; and science, technology, engineering, and mathematics (STEM) education.

INTRODUCTION

America's economy has changed substantially over the last 20 years. Innovation—the development of new products, services, and business models—has become the key factor in long-term U.S. competitiveness in a globalized world. Hopefully 2013 will be a year of renewed attention to the creation of a more robust national innovation policy. In particular, the America COMPETES Act is up for reauthorization after being initially passed unanimously in 2007, in part in response to the National Academies' report *Rising Above The Gathering Storm*, and reauthorized on January 4, 2011.

However, while the COMPETES Acts have contributed to improving federal innovation policy, much more can be done to improve the implementation, coordination, and overall success of science and technology policy and further its impact on the economy. In particular, the 2013 reauthorization of the America COMPETES Act should focus foremost on introducing policy initiatives and reforms that can better translate science and engineering research into U.S. economic development.

The paradigm that defined the U.S. science, technology, and innovation system in the post-World War II era is simply no longer tenable. That approach was predicated on a "linear model" of innovation that pumped seemingly limitless funding for basic research into U.S. universities and government labs on the front-end with the expectation that industry virtually alone would conduct the applied and translational work needed to transform basic research into technologies and products that could be commercialized (and manufactured at scale in the United States) on the back-end. That approach also viewed all scientific research as equal and didn't prioritize scientific research funding based on its ability or likelihood to help support U.S. economic competitiveness, which was taken as a given. While this model worked for a time—when many fewer other nations had the technological capabilities to translate basic research into commercial products—it's ill-suited to today's intensely competitive global economy. A new approach is needed to transform the U.S. innovation system, and it should embrace four key principles:

1. Increased funding is not enough; institutional reform is also needed. Still today many think the answer to the challenges confronting the U.S. innovation system, especially given the recent sequestration, is more money for basic research. But while it's true that more investment is needed, this alone will not be sufficient. It's not enough to simply increase funding for existing initiatives; rather, we need institutional reform in the U.S. innovation system. In particular, policies should provide more incentives for increased public-private collaboration around innovation, in particular by: 1) leveraging non-federal resources, when possible; 2) spurring more collaboration between actors in the innovation system; and 3) holding research performers more accountable for results. The first technique is important because in an era of fiscal constraint, an effective national innovation policy should provide incentives for other players, especially the private sector, to increase funding for innovation. The second matters because, as Fred Block and Matthew Keller have documented, U.S. innovations increasingly come from collaborations between universities, federal labs, and small and large firms.[1] Federal innovation policies should explicitly support and incent such collaborations. And the third matters because U.S. research institutions differ in terms of their success in translating knowledge into commercial activities in America to create jobs and competitiveness; that difference exists in part because of the limited motivation of many research performers to translate knowledge.

2. The prevailing linear innovation approach is ineffective and incomplete. The "universities perform only basic research while industry performs only applied research" paradigm is woefully outdated. The notion that the U.S. innovation system produces the biggest bang for the buck with universities (and national laboratories) solely performing basic research, and with industry solely primarily performing applied research, suffers from several shortcomings. First, U.S. basic research is a non-rivalrous global public good that other nations free ride upon by focusing on applied research.[2] Second, U.S. industry does not perform nearly enough applied research. In reality, U.S. enterprises have not only cut back on the growth of their research budgets but have also reallocated their research portfolios more toward product development efforts and away from longer-term and more speculative basic and applied research. In fact, from 1991 to 2008, basic research as a share of corporate R&D conducted in the United States fell by 3.6 percent and applied research fell by roughly the same amount, 3.5 percent, while development's share increased by 7.1 percent.[3]

3. The belief that if all policy does is fund basic research that commercialization will naturally come out the other end of the pipeline assumes that there are no barriers or problems. But the reality is that the commercialization process is choked with barriers, including institutional inertia, coordination and communication challenges, and lack of funding for proof of concept research and other "valley of death" activities.

4. Not all scientific research funding is created equal. The United States can simply no longer afford the post-war consensus that postulated a seemingly unlimited amount of money to fund basic science, especially when much of the rest of the world free rides off of it. It's time to recognize that certain research programs are much more important to our country's economic well-being and competitiveness than others, and policy should favor research in the fields of science most likely to produce direct economic and industrial benefits for the United States. In particular, the United States should increase research investments in math and the physical sciences, engineering, computer and information sciences, and biological sciences.

5. Certain research programs are much more important to our country's economic well-being and competitiveness than others. Policy should favor research in the fields of science most likely to produce direct economic and industrial benefits for the United States.

6. Not all students are likely to become scientists or engineers. With regard to STEM education, the prevalent view has been that it should be approached probabilistically, with every student having the same odds of being a STEM professional as every other, and therefore America has designed an across-the-board, broad-based STEM education system. But in reality, even with the best STEM education for every American child, not that many students are either interested in or capable of excelling in STEM fields. Instead the system should focus on those students most interested in and motivated to pursue STEM fields. In short, America needs to move from a "some STEM for all" to an "all STEM for some" approach to STEM education.[4]

It is with these guiding principles in mind that this report provides 25 policy recommendations for the 2013 America COMPETES Act reauthorization. The recommendations are organized into three key areas: 1) spurring innovation and technology commercialization; 2) introducing federal institutional reforms to spur innovation; and 3) enhancing STEM education. In particular, we urge Congress to:

Innovation and Technology Commercialization

1. Continue the R&D doubling path for core science programs
2. Create a university-industry collaborative R&D tax credit
3. Increase funding for ERCs and I/UCRCs
4. Support the designation of at least 20 U.S. "manufacturing universities"
5. Create a National Network for Manufacturing Innovation
6. Increase funding for the Manufacturing Extension Partnership

7. Create a Spurring Commercialization of Our Nation's Research program to support technology commercialization initiatives
8. Fund a pilot program supporting experimental approaches to technology transfer and commercialization
9. Fund the Regional Innovation Program
10. Add more weight for technology transfer measures in the Department of Energy's National Laboratories Performance and Evaluation Measurement Plans
11. Improve accounting rules for national laboratories overhead
12. Allow the national laboratories to take an equity stake in startups

Federal Institutional Reforms to Spur Innovation

13. Reallocate NSF monies to areas with stronger national economic impacts
14. Create a National Engineering and Innovation Foundation alongside NSF (or); Change NSF's name to the National Science and Engineering Foundation
15. Create a Deputy Director for Economic Growth and Innovation position at NSF
16. Allocate a share of federal university R&D funding based on performance
17. Establish an Office of Innovation Review in OMB

Science, Technology, Engineering and Math (STEM) Education and Skills

18. Fund specialty math and science high schools
19. Offer planning grants for regions that want to create alternative types of STEM high schools or universities
20. Provide prizes to colleges and universities doing best at retaining STEM students
21. Expand undergraduate research opportunities, especially during freshman year
22. Require colleges to report "National Survey of Student Engagement" scores
23. Expand interdisciplinary higher education learning
24. Fund joint government-industry STEM PhD fellowships
25. Allow foreign students receiving STEM PhDs from U.S. universities to automatically qualify for green cards

Table 1 summarizes these policy recommendations, listing them in order of investment level required to implement, sorted from lowest to highest.

Recommendation	New Investment
Reallocate NSF monies to areas with stronger national economic impacts	$0
Allocate a share of federal university R&D funding based on performance	$0
Change the name of the National Science Foundation to the National Science and Engineering Foundation	$0
Create a Spurring Commercialization of our Nation's Research program	$0
Create a Federal Acceleration of State Technologies Deployment program	$0
Increase funding for ERCs and I/UCRCs	$0
Allow foreign students receiving STEM PhDs from U.S. universities to automatically qualify for green cards	$0
Require colleges to report "National Survey of Student Engagement" scores	$0
Expand undergraduate research opportunities, especially freshman year	$0
Add more weight for technology transfer measures in the Department of Energy's National Laboratories' PEMPs	$0
Improve accounting rules for national laboratories overhead	$0
Allow the national laboratories to take an equity stake in startups	$0
Create a Deputy Director for Economic Growth and Innovation position at NSF	$250K
Establish an Office of Innovation Policy in OMB (i.e., an Office of Information and Regulatory Affairs for Innovation)	$3M
Fund a pilot program supporting experimental approaches to technology transfer and commercialization	$5M
Offer planning grants for regions that want to create alternative types of STEM high schools or universities	$10M
Fund more joint government-industry STEM PhD fellowships	$21M
Expand interdisciplinary higher education learning	$30M
Increase funding for the Manufacturing Extension Partnership	$50M
Fund more specialty math and science high schools	$50M/yr (5 yrs)
Provide prizes to colleges and universities doing best at retaining STEM students	$66M/yr (5 yrs)
Fund the Regional Innovation Program	$100M
Create a National Engineering and Innovation Foundation alongside NSF	$300M
Support the designation of at least 20 U.S. "manufacturing universities"	@$500M
Create a National Network for Manufacturing Innovation	$1B (one time)
Create a university-industry collaborative R&D tax credit	@$1.5B[5]
Reinstate doubling path for three core science programs	$3.8B

Table 1: Summary of Policy Recommendations/Attendant New Investment Levels

If in the interest of controlling deficits the country sacrifices the very investments needed to position our economy and workforce to innovate and compete in the future, then the interests of future generations will be compromised just the same.

Before proceeding, it's important to acknowledge that while many of the recommendations in this report can be implemented at no cost, some will require increased investment by the federal government, a contentious notion in a tight budgetary environment. But the reality is that if the United States wants a globally competitive economy going forward, the country has no choice but to invest in its future. Our competitors are not standing still; in fact, they have been strategically ramping up their public investments in research over the last two decades while U.S. investments have grown much more slowly.

For instance, in January 2013, the European Union announced a new budget in which the only line item that saw increased investment over the next six years is funding for Horizon 2020, the European Union's investment vehicle for research and innovation, which is slated for an increase of 25 percent, or $14 billion.[6] Likewise, Sweden's new Research and Innovation legislation, introduced in November 2012, will increase the Swedish government's investment in research and innovation by 25 percent (over the prior baseline) from the years 2013-2016, amounting to a 10 percent increase in Sweden's R&D investment.[7] (And this on top of the fact that Sweden already ranks fourth in the world with a national R&D intensity of 3.6 percent.)

Meanwhile, China's Innovation 2020 strategy intends to invest $1.7 trillion (over the next seven years) on seven "strategic emerging industries": 1) energy saving and environmental protection; 2) new generation of information technology; 3) biotechnology; 4) high-end equipment manufacturing; 5) new energy; 6) new materials; and 7) new energy vehicles.[8] To get a sense of the level of this investment, for the United States to match this on a per-GDP basis, it would have to pass an American Recovery and Reinvestment Act (the 2008 "stimulus bill" that appropriated over $800 billion) every year for the next five years and have all the funds (and more) go to making U.S. industries more competitive.[9]

The message is clear: more robust investment in science, research, innovation, and STEM education must be a priority if the United States wishes to leave the next generation of its citizens with a globally competitive economy. While the laudable intent of controlling U.S. budget deficits is to ensure that the next generation of Americans is not saddled with crushing debts, if in the name of doing so the country sacrifices the very investments needed to position our economy and workforce to innovate and compete, then future generations will be saddled with a relatively smaller and less innovative economy.

Thus, Congress should not draft the COMPETES reauthorization on a "pay-go basis" from funds within the existing science authorization, as some in the House of Representatives have advocated. First, COMPETES represents an investment in America's future, which should not be approached on a pay-go basis. But to the extent that existing funds need to be identified to support new initiatives in the COMPETES reauthorization, Congress should look to other sources, such as cutting entitlements (e.g., by raising the retirement age sooner and higher than currently planned), or cutting subsidies for the oil and gas industries, agriculture, or flood insurance. In particular, policymakers should distinguish between productive investment—expenditures that expand the productive capacity of the country, drive economic growth, and increase future incomes—and consumptive spending—government expenditures that finance present consumption of goods and services but that do not position the country to create future wealth (such as the subsidies listed above).[10]

To distinguish between productive investment and consumptive spending, policymakers should consider the three following criteria, which are met in ITIF's policy recommendations throughout this report:

- Innovation: Does the program or policy help spur innovation to create new products, processes, technologies, or knowledge that in turn adds value or creates new industries?

- Productivity: Does the program or policy increase the productivity (i.e., output per worker hour) of organizations and the economy as a whole?

- Competitiveness: Does the program or policy reduce the trade deficit by making enterprises in the United States more globally competitive, thereby increasing exports or reducing imports?

Innovation and Technology Commercialization

While the United States has strengths in nurturing innovation and commercializing new inventions, the process can and should be improved. The United States will further forfeit technology leadership unless it finds ways to accelerate entry of new growth sectors. The U.S. innovation system separates fundamental research from incremental development, with the former increasingly performed at research universities and labs with federal support, and the latter performed by industry. Connections between these sectors need significant strengthening, so there is a smoother and more active hand-off process. Recommendations to facilitate innovation and technology commercialization include:

Continue the R&D Doubling Path for Core Science Programs

America once led the world in investment in innovation as a share of its economy. But the United States has fallen to ninth place among OECD countries in R&D intensity, as U.S. investment in R&D as a share of GDP increased by just 3 percent from 1987 to 2008.[11] One major reason for this slippage has been a significant slowdown in federal R&D investment; it grew in constant dollars at just 0.3 percent per year from 1987 to 2008—much lower than its average annual growth rate of 4.9 percent from 1953 to 1987, and 10 times lower than the rate of GDP growth over that time period.[12] In fact, to restore federal support for research as a share of GDP to 1987 levels, Congress would have to increase federal support for R&D by almost $110 billion *per year*.

Accordingly, the reauthorized America COMPETES Act should restore the goal of achieving doubled funding for core science agencies over the ten-year period from 2008 to 2018. In fact, that approach has been advocated on a bipartisan basis by the two most recent presidents. As President George W. Bush affirmed in his final State of the Union Address in 2008, "To keep America competitive into the future, we must trust in the skill of our scientists and engineers and empower them to pursue the breakthroughs of tomorrow. So I ask the Congress to double federal support for critical basic research in the physical sciences and ensure America remains the most dynamic nation on earth."[13] Likewise, in 2008, then-candidate Barack Obama pledged to double federal funding for basic research over the next 10 years, focusing on physical and life sciences, with the agencies to experience this doubling including the National Institute of Standards and Technology (NIST), the National Science Foundation (NSF), and the Office of Science at the Department of Energy.[14] It's important that this doubling concept not be lost, for even in a tight fiscal environment, it's vital to continue to invest in research and development.

To achieve doubling, the budget for the Department of Energy's Office of Science (which was $4.08 billion in FY 2008) should be funded at a rate that would keep it on pace to increase to $8.16 billion by 2018. Unfortunately, the president's FY 2014 budget requests just $5.15 billion for the agency, 21 percent short of what the agency's budget would need to be ($6.53 billion in FY 2014) to keep it on a straight line doubling path by 2018, as Table 2 illustrates.[15] The National Science Foundation's budget, which was $6.08 billion in FY 2008, rises to just $7.6 billion in the president's FY 2014 budget request—likewise 22 percent short of the amount it would need to be in FY 2014 ($9.73 billion) to remain on the ten-year doubling path.[16] The president's FY 2014 budget requests $934 million for the National Institute of Standards and Technology.[17] However, this is 23 percent short of the amount NIST would need to be funded in 2014, $1.21 billion, to maintain a doubling of the agency's budget by 2018.[18]

Core Science Agency	FY 2008 Funding	FY 2014 Request	FY 2014 Doubling Path Goal	% 2014 Request Short Goal	FY 2018 Target
DOE Office of Science	$4.08B	$5.15B	$6.53B	-21.1%	$8.16B
NSF	$6.08B	$7.60B	$9.73B	-21.9%	$12.16B
NIST	$.756B	$.934B	$1.21B	-22.8%	$1.51B

Table 2: Shortfall in Funding for Core Science Agencies per 2018 Doubling Path

The United States is also falling behind in funding for life sciences research. In fact, as ITIF writes in *Leadership in Decline: Assessing U.S. International Competitiveness in Biomedical Research*, federal funding for biomedical research peaked in 2003—in both inflation-adjusted dollars and as a share of GDP—and has been slipping in virtually every year since.[19] Across the board, federal investment in R&D is not keeping pace, and in fact has only been made worse by the recent sequestration.[20]

To reverse faltering federal R&D support, Congress should restore the 10-year doubling path for core science agencies and increase aggregate federal investment in R&D by $50 billion over FY 2011 levels by 2015.

Create a University-Industry Collaborative R&D Tax Credit

Increasingly, firms are collaborating with other firms or institutions in order to lower the cost of research and increase effectiveness by maximizing idea flow and creativity. Indeed, a growing share of research is now conducted not only on the basis of strategic alliances and partnerships but also through ongoing networks of learning and innovation.[21] Participation in research consortia has a positive impact on firms' own R&D expenditures and research productivity.[22]

Most collaborative research, whether in partnership with a university, national laboratory, or industry consortium, is more basic and exploratory than research typically conducted by a single company. The research results are usually shared, often through scientific publications. As a result, firms are less able to capture the benefits of collaborative research, leading them to underinvest in such research relative to socially optimal levels.[23] Moreover, in a difficult economic climate, enterprises are often more reluctant to invest in university-conducted research, as reflected in the fact that university contracts are often undertaken as discretionary activities and are the first to be cut when revenues are down.[24]

Congress should provide a more generous tax credit for collaborative research conducted in partnership between industry and universities.

In fact, the evidence shows the United States falling behind peer nations in U.S. university research funded by business. In 2008, funding of U.S. university research by business was just 0.020 percent of GDP, less than two-thirds of a 30-country average of 0.032 percent of GDP. This placed the United States just 21st out of 30 nations in business-funded research performed in the higher education sector as a share of GDP.[25] Worse, from 2000 to 2008, the United States ranked just 23rd out of 30 nations in the rate of change in business-funded university research. Business-funded research performed at U.S. higher education institutions as a percentage of GDP actually declined over this time period in the United States even as it rose by 211 percent in Hungary, 95 percent in Israel, and 72 percent in Spain and China.[26]

Meanwhile, as ITIF writes in *Creating a Collaborative R&D Tax Credit*, other countries, including Denmark, France, Hungary, Japan, Norway, Spain, and the United Kingdom provide firms more generous tax incentives for collaborative R&D.[27] Denmark and Hungary provide more generous tax deductions for collaborative R&D with public research institutions.[28] Japan's R&D incentive is almost twice as generous for research expenditures companies make with universities and other research institutes.[29] France provides a 60 percent flat tax credit for business-funded research conducted at national laboratories.

The U.S. tax code allows firms a basic research credit of 20 percent of expenses above a base period amount.[30] But the credit is not significantly more generous than the regular credit. Moreover, its applicability is limited because rules require that such research not have any "specific commercial objective." At a minimum, Congress should delete this restrictive language from current law and allow any research expenditures at universities to qualify for the basic research credit.

But Congress should go further by not only expanding the R&D credit, but also providing a more generous incentive for collaborative research.[31] As part of the Energy Policy Act of 2005, Congress created an energy research credit that allowed companies to claim a credit equal to 20 percent of the payments to qualified research consortia (consisting of five or more firms, universities, and federal laboratories) for energy research. In 2006, several bills were proposed allowing all research consortia, not just energy-related ones, to become eligible for a 20 percent flat credit.[32] Congress should allow firms to take a flat credit of 20 percent for collaborative research conducted at universities, federal laboratories, and research consortia.

Increase Funding for ERC and I/UCRC Programs

Industry-university partnerships spur commercialization and innovation. The National Science Foundation's Engineering Directorate operates two kinds of industry-university partnerships: Engineering Research Centers (ERCs) and Industry/University Cooperative Research Centers (I/UCRCs). ERCs are a group of interdisciplinary centers located at universities, where academe and industry can collaborate in pursuing strategic advances in complex engineered systems and systems-level technologies that have the potential to spawn whole new industries or to radically transform the product lines, processing technologies, or service delivery methodologies of current industries.[33] The I/UCRC program forges partnerships between universities and industry, featuring industrially relevant fundamental research, industrial support of and collaboration in research and education, and direct transfer of university-developed ideas, research results, and technology to U.S. industry to improve its competitive posture in global markets.[34]

Unfortunately, both programs are quite small. Moreover, the ERCs engage with industry only weakly and too often conduct academic research of limited relevance to industry. Very few ERCs are truly engaged in engineering R&D and transitioning technologies to the marketplace as opposed to simply producing more journal papers. To ensure that ERCs represent a true joint university-industry research partnership, Congress should require that federal funding for all ERCs be matched at least 40 percent by industry by 2018. (The required industry match could include "in-kind" contributions.) ERCs failing to attract at least a 40 percent industry match within five years should lose their federal funding. This proposal would ensure more meaningful industry-university research partnerships. It would also bring the United States more closely in line with university research funding policy in countries like Germany, where most of the German government's extramural research funding to universities (outside of the German Research Foundation, Germany's equivalent of the NSF) requires a 50 percent industry match.[35]

Congress should also increase funding for these programs by allocating a larger share of NSF funding to the ERC and I/UCRC programs.[36] Specifically, Congress should increase I/UCRC funding from its FY 2010 level of $7.85 million to at least $50 million per year.[37] Likewise, Congress should double NSF's funding for ERCs from the FY 2010 level of $54.9 million to $110 million per year.[38] This would support the creation of additional ERCs and I/UCRCs and increase NSF support to each center. To achieve this doubling, Congress could reallocate existing NSF funds from other programs.

Finally, current regulations perversely require that proposals for new ERCs include an international partner. This is in part a reflection of the NSF culture which views its mission as advocacy of science—because science is internationalized, NSF wants to fund international collaborations. While certainly policy should not prohibit ERCs from including international partners, NSF should eliminate the requirement that an international partner must be involved, since the primary goal of ERCs should be to strengthen U.S. engineering and manufacturing. The ERCs could also be more effective if they regularly developed strategic plans to transition technology advances into products made in the United States.

Support the Designation of at Least 20 U.S. "Manufacturing Universities"

If the United States wants to win in the advanced manufacturing economy of tomorrow, it must transform university culture away from its "research for the sake of research and knowledge accumulation" approach and align it much more with industry's knowledge needs. The United States needs to forge more and stronger industry-university research collaborations and incentivize universities to focus more on training students with the requisite skills to support U.S. engineering-based industries.[39] Unfortunately, university engineering programs have evolved in a troubling direction over the past several decades. The focus on "engineering as a science" has increasingly moved university engineering education away from a focus on real problem solving toward more abstract engineering science, leaving university engineering departments more concerned with producing pure knowledge than working with industry to help them solve real problems.

The United States must transform university culture away from its "research for the sake of research and knowledge accumulation" approach and align it much more with industry's needs.

To address this, the United States should create a core of at least 20 universities that brand themselves as leading manufacturing universities.[40] These universities would revamp their engineering programs and focus much more on manufacturing engineering and in particular work that is more relevant to industry. This would include more joint industry-university research projects, more student training that incorporates manufacturing experiences through co-ops or other programs, and a PhD education program focused on turning out more engineering graduates who work in industry. These universities would view PhDs as akin to high-level apprenticeships (as they often are in Germany), where industry experience is required as part of the degree. Likewise, criteria for faculty tenure would consider professors' work with and/or in industry as much as their number of scholarly publications. In addition, these universities' business schools would integrate closely with engineering and focus on manufacturing issues, including management of production. The schools would also appoint a Chief Manufacturing Officer, as Georgia Tech has done, to oversee universities' interdisciplinary manufacturing programs and ascertain how they can maximize their impact on economic development.[41] As part of this designation, academic institutions would receive an annual award from the National Science Foundation—ideally at least $25 million—plus priority on their applications for NSF grants. One can imagine a number of leading engineering universities—CalTech, Carnegie Mellon, Georgia Tech, Lehigh, the Massachusetts Institute of Technology (MIT), Michigan, Purdue, Stanford, and others—readily transforming themselves to embrace this designation.

One model for these manufacturing universities is the Olin College of Engineering in Massachusetts, which reimagined engineering education and curriculum to prepare students "to become exemplary engineering innovators who recognize needs, design solutions, and engage in creative enterprises for the good of the world." Olin's results have been impressive. Its new method of teaching engineering has been widely praised among engineering firms, and on a per-student-graduated basis, Olin graduates start more new businesses than even MIT graduates.[42] Olin is a good model for how the United States can transform its colleges into entrepreneurial factories while encouraging the development of completely new schools based on the needs of the current workforce.[43]

In 1862, Congress passed the Morrill Act, establishing land-grant colleges with a mission of promoting learning in agriculture and the mechanic arts. These colleges played a key role in enabling the United States to later lead in the mechanization of agriculture and the industrialization of the economy. Today, the challenge is even greater as America is competing against a wide array of nations seeking to win the race for global innovation advantage, particularly in manufacturing. The United States needs a 21st-century Morrill Act vision, reconnecting land-grant colleges to the nation's economy and requiring their commitment to driving the nation's global innovation advantage in wealth-creating industries like advanced manufacturing and energy. A new cadre of "manufacturing universities" can be an important part of the solution.

Create a National Network for Manufacturing Innovation

If the United States wishes to more consistently "bridge the gap" to transform basic scientific discoveries into useful technologies and on into commercializable products that can be manufactured at scale, it needs to provide a much stronger institutional platform through which universities and industry can enter into public-private partnerships to conduct applied (or "translational") R&D activity. Unfortunately, the United States lacks an institutional framework in which industrially relevant applied research can occur, as ITIF writes in *A National Network for Manufacturing Innovation: Why America Needs It and How It Should Work*.[44] This matters because, by itself, investing in basic research simply does not ensure that a new technology can cross the bridge from invention or discovery to product development and manufacturing at scale.

A National Network for Manufacturing Innovation would enhance U.S. industrial competitiveness by supporting development of technologies enabling U.S. production facilities to gain global market share.[45] It would be comprised of 15 to 25 industry-defined Institutes of Manufacturing Innovation (IMIs) serving as hubs of manufacturing and engineering excellence around well-defined technology areas. The IMIs would provide shared assets to help companies (including small- to medium-sized enterprises, or SMEs) access cutting-edge capabilities and equipment, serve as test beds, and create a compelling environment in which to educate and train students and workers in advanced manufacturing skills.[46] President Obama's FY 2014 budget proposal calls for a one-time $1 billion investment to stand-up at least 15 manufacturing institutes.[47]

Many countries have developed similar institutional approaches to facilitate government-supported industry-university public-private partnerships undertaking applied research activities. Both Taiwan's Industrial Technology Research Institute (ITRI) and Germany's 60 Fraunhofer Institutes have long provided a compelling model for performing applied research of direct utility.[48] But in January 2013, the United Kingdom announced a £1 billion ($1.53 billion) investment to create *UK Catapult*, a nationwide network of technology and innovation centers. One of the first of these will be the High-Value Manufacturing Catapult, "a catalyst that transforms brilliant manufacturing into valuable products and services."[49] Likewise, Japan's new economic stimulus package (also announced in January 2013) includes as its largest single line-item $2 billion to promote university-industry collaboration, including funding to conduct industrially relevant research.[50]

Thus, even though countries such as Japan or the United Kingdom face budgetary environments as constrained as those in the United States (if not more so), policymakers are making the tough choice to invest in the future. While the America COMPETES reauthorization may not be the appropriate venue to introduce a National Network for Manufacturing Innovation (a separate piece of authorizing legislation is likely required), NNMI should be on Congress's radar screen as a key instrument poised to play a pivotal role in spurring U.S. industrial competitiveness and revitalizing American manufacturing. Therefore, Congress should pass legislation to authorize the National Network for Manufacturing Innovation and allocate a one-time $1 billion investment to launch at least 15 Institutes of Manufacturing Innovation.

Increase Funding for the Manufacturing Extension Partnership

Other nations invest much more as a share of GDP in their respective manufacturing extension services than does the United States.

The National Institute of Standards and Technology's Manufacturing Extension Partnership plays a vital role in enhancing the productivity, competitiveness, and innovation potential of U.S. SME manufacturers. MEP's field staff features over 1,300 technical experts, located in every state and serving as trusted business advisors focused on solving manufacturers' challenges and identifying opportunities for growth. MEP serves an essential role in sustaining and growing America's manufacturing base by placing technologies and innovations developed through research at federal laboratories, educational institutions, and corporations directly into the hands of U.S. manufacturers.

MEP has proven successful in helping manufacturers achieve new sales, leading to higher tax receipts and new, sustainable jobs in the high-paying advanced manufacturing sector. In fact, MEP has been one of the most impactful federal programs in terms of boosting employment and economic growth. For instance, a January 2012 report issued by the Manufacturing Extension Partnership found that every $1 of federal investment in MEP generates $30 of return in economic growth, translating into $3.6 billion in total new sales annually for U.S. SME manufacturers.[51] Moreover, client surveys indicate that MEP centers create or retain one manufacturing job for every $1,570 of federal investment, one of the highest job growth returns out of all federal funds.[52] 2010 impact data show that the MEP program created or retained over 60,000 jobs. These impressive returns mirror and even exceed those seen in other countries' manufacturing extension programs. For example, a 2010 review of Canada's Industrial Research Assistance Program (IRAP) found that each $1 of public investment in IRAP resulted in a $12 impact on the Canadian economy.[53] Moreover, a 1 percent increase in IRAP assistance led to an 11 percent increase in firm sales, a 14 percent increase in firm employment, and a 12 percent increase in firm productivity. Likewise, a 1 percent increase in IRAP funding to a firm led to a 13 percent increase in the firm's R&D spending and a 3 percent increase in its R&D staff.[54]

Despite these impressive returns, MEP funding as a share of U.S. GDP has decreased since 1998, when the program began. As a share of GDP, the federal government invested 1.28 times more in MEP in 1998 than in 2009.[55] Other nations invest much more as a share of GDP in their respective manufacturing extension services. Japan invests 30 times more than the United States, Germany approximately 20 times more, and Canada almost 10 times more in its principal SME manufacturing support program.[56] MEP could work with substantially more SME manufacturers and have even greater impact at enhancing their competitiveness, productivity, and innovation potential if its funding increased. Laudably, the president's FY 2014 budget does request a $25 million increase in the Manufacturing Extension Partnership's budget over the 2012 enacted level of $128 billion, in part for the Manufacturing Extension Partnership to establish Manufacturing Technology Acceleration Centers that would assist manufacturers in adopting new technologies to improve their competitiveness.[57] Still, MEP is underfunded relative to its impact, and Congress should increase funding for the Manufacturing Extension Partnership to $175 million in FY 2014 and $200 million in FY 2015.

Create an SCNR (Spurring Commercialization of Our Nation's Research) Program to Support University, State, and Federal Laboratory Technology Commercialization Initiatives

The current federal system for funding research pays too little attention to commercialization of technology, and is still based on the linear model of research that assumes that basic research gets easily translated into commercial activity.

The current federal system for funding research pays too little attention to commercialization of technology, and is still based on the linear model of research that assumes that basic research gets easily translated into commercial activity. Indeed, many argue that all the federal government needs to do vis-à-vis innovation is to fund basic research, believing that this research will automatically translate into innovation in the American economy. In fact, the innovation process is choked with barriers, including institutional inertia, coordination and communication challenges, and lack of funding for proof of concept research and other "valley of death" activities. It is time for federal policy to explicitly address this challenge and allocate more funding to commercialization activities.

To address this, Congress could establish an automatic set-aside program that takes a modest percentage of federal research budgets and allocates this money to a technology commercialization fund. Currently the Small Business Innovation Research (SBIR) program allocates 2.5 percent of agency research budgets to small business research projects while the Small Business Technology Transfer (STTR) program allocates 0.3 percent to universities or nonprofit research institutions that work in partnership with small businesses. Congress should allocate 0.15 percent of agency research budgets (about $110 million per year) to fund university, federal laboratory, and state government technology commercialization and innovation efforts. The 0.15 percent share could either be added on top of the existing 2.8 percent allocation currently going to SBIR and STTR, or it could be taken from the SBIR share.

This program would be different than the STTR program which funds small businesses working with universities.[58] Half the funds would go to universities and federal laboratories that could use the funds to create a variety of different initiatives, including mentoring programs for researcher entrepreneurs, student entrepreneurship clubs and entrepreneurship curriculum, industry outreach programs, seed grants for researchers to develop commercialization plans, etc.

The other half would go to match state technology-based economic development (TBED) programs. Since the 1980s, when the United States first began to face global competitiveness challenges, all states have established TBED programs. Republican and Democratic governors and legislators support these programs because they recognize that businesses will not always create enough high-productivity jobs in their states without government support. State and local governments now invest about $5 billion per year in a variety of different TBED activities.[59] But this is a pittance compared to the approximately $47 billion per year that state and local governments spend on zero-sum location subsidies (i.e., "smokestack chasing") that seek to induce the shift of enterprises' facilities or operations from one state to another.[60]

State TBED programs spur the development of cutting-edge, science-based industries by boosting research funding. For example, Oregon's NanoScience and Microtechnologies Institute serves as a forum for R&D synergy among Oregon's three public research universities, the Pacific Northwest National Laboratory, the state, and the "Silicon Forest" high technology industry cluster. States also try to ensure that research is commercialized and good jobs are created in both cutting-edge, science-based industries and industries engaging in related diversification. For example, the Georgia Advanced Technology Development Center at Georgia Tech is a technology incubator that offers services including consulting, connections to university researchers, and networking with other entrepreneurs and service providers. States have also established programs to help small and mid-sized firms support collaborative research at universities. For example, Maryland's Industrial Partnerships program provides funding, matched by participating companies, for university-based research projects that help companies develop new products or solve technical challenges.[61] Finally, states have established initiatives to help firms commercialize research into new business opportunities. For example, Oklahoma's nonprofit i2E organization helps Oklahoma companies with strategic planning assistance, networking opportunities, and access to capital. i2E's Oklahoma Technology Commercialization Center assists researchers, inventors, entrepreneurs, and companies in turning advanced technologies and high-tech startup companies into growing companies.[62] But without assistance from the federal government, states will invest less in TBED activities than is in the national interest. A performance-based allocation to help fund state TBED efforts would help correct this limitation.

A similar proposal is contained in the House version of the Startup America Act 3.0 (H.R. 714) introduced in the House of Representatives by Congressmembers Michael Grimm (R-NY), Loretta Sanchez (D-CA), Devin Nunes (R-CA), Gerald Connolly (D-VA), Kevin Yoder (R-KS), Jared Polis (D-CO), and Steve Chabot (R-OH).[63] Section 8 of the Act, titled "Accelerating Commercialization of Taxpayer Funded Research," would set aside 0.15 percent of federal agencies' extramural research budgets from 2014 to 2018 to offer: 1) "commercialization capacity building grants" to institutes of higher education pursuing specific innovative initiatives to improve an institution's capacity to commercialize faculty research; and 2) "commercialization accelerator grants" to support institutions of higher education pursuing initiatives that allow faculty to directly commercialize research in an effort to accelerate research breakthroughs. Collaborative initiatives would be favored as would grants going to institutions of higher education (or other entities) with demonstrated proficiency in creating new companies.

Another legislative draft addressing the commercialization challenge is S. 4047, which would create a Federal Acceleration of State Technologies Deployment Program, or "FAST," a federal funding strategy for accelerating the local commercialization of newly developed technologies by matching cash-poor state programs.[64] The program would leverage federal resources to match states' investments in their technology commercialization programs. Matching federal funds would be available concomitant with a state's level of investment (prorated against state population with a maximum cap) in its technology commercialization programs. States would use the money for direct, merit-based project grants to existing SMEs or to startup companies looking to commercialize new products or technologies (with the expectation that a major source for those technologies would be ones currently sitting untapped at America's colleges and universities). As Mike Alder, Chairman of the National Centers of Excellence, notes, "Universities' technology transfer offices are like supermarkets of technology with loaded shelves but no shoppers. Worse (to extend the analogy) the technologies sit in dimly lit aisles and dark corners in the vast recesses of the supermarket making them very difficult to find and leverage."[65] FAST would be somewhat akin to SBIR, but it would not be the same. Whereas the federal agencies are trying to advance their missions with the SBIR and the STTR, FAST's objective would not be to specifically advance any federal mission, rather it would be a federal-state partnership seeking to encourage the development and deployment of technologies through direct grants to companies. In this regard, FAST would be most similar to programs operated by Canada's Industrial Research Assistance Program (IRAP) or Germany's Central Innovation Program for SMEs—both of which are specifically designed to bolster the innovation capacity of their countries' high-tech, high-potential startups and SMEs, as ITIF documents in *International Benchmarking of Countries' Policies and Programs Supporting SME Manufacturers*.[66] In addition to the SCNR program, Congress could allocate 0.3 to 0.6 percent of federal agency research budgets (in the range of $225 to $450 million) to a FAST program.

Investing in basic research alone simply does not ensure that a new technology can cross the bridge from invention or discovery to product development and manufacturing at scale.

Fund a Pilot Program Supporting Experimental Approaches to Technology Transfer and Commercialization

A number of organizations throughout the United States are experimenting with novel approaches to bolster technology transfer from universities (and national laboratories) to industry and to accelerate the commercialization of university-developed technologies. For example, the Applied Physics Laboratory (APL) at Johns Hopkins University is considering an Innovation Launch Program that would leverage a $110,000 investment to support 10 entrepreneurial student teams in commercializing intellectual property developed at APL. The program supports the student teams by: recruiting world-class entrepreneurs to lead teams; vetting technologies for their commercialization potential; providing business and product development guidance; supporting the legal and financial formation of the startup; providing back-office support; and connecting the entrepreneurs to investors.

The America COMPETES Act should support these types of novel approaches by including $5 million to fund experimental programs exploring new approaches to university and federal laboratory technology transfer programs. The program should be managed by the Department of Commerce's Office of Innovation and Entrepreneurship. Organizations would apply for the grants and winning proposals would be selected on criteria such as: 1) how innovative they are in demonstrating a new model; 2) recent documented success of their program; and 3) willingness to publicly disclose best practices learned from their programs.

Fund the Regional Innovation Program

As ITIF writes in *Innovation Economics: The Race for Global Advantage*, the innovation-producing benefits of regional industry clusters (RICs) are under-realized.[67] RICs are geographic concentrations of firms and industries that do business with each other and have common needs for talent, technology, and infrastructure. Because the benefits of geographic clustering spill over beyond the boundaries of the firm, market forces produce less geographic clustering than society needs. Each firm in a cluster confers benefits on other firms in the cluster—for example, clusters create cost and innovation advantages for participants by giving them access to high-caliber human capital and R&D collaboration—but no individual firm takes the "external" benefits it produces into account when making its own location decisions. In addition, the firms in a cluster usually have common needs (e.g., for worker training or infrastructure) that they have a harder time meeting on their own. Clustered firms, therefore, usually require external coordination (from governments or industry associations) to effectively meet these needs. For this reason, there's a strong role for public policy to play in supporting regional innovation clusters.

A high-performing RIC includes an active network of public, private, and nonprofit organizations that leverage a region's unique competitive strengths and capabilities to create jobs and broad economic prosperity. RICs play a key role in spurring innovation by linking and aligning regional assets, institutions, and services, thus creating an open environment of knowledge creation and exchange.[68]

Regional innovation programs have proven a highly successful form of economic development for communities across the United States. Programs such as the i6 Challenge and the Jobs and Innovation Accelerator Challenge have helped local, regional, and state entities leverage existing resources, spur regional collaboration, and support economic recovery and job creation in high-growth industries. For example, the i6 Challenge and Jobs Accelerator have supported programs such as Pennsylvania's Ben Franklin Technology Partnership, Northeast Ohio's JumpStart, Inc., and BioSTL, a regional organization that champions St. Louis bioscience, with all achieving outstanding results. The Ben Franklin Technology Partnerships have helped create over 32,000 jobs since 2002 and boosted the Gross State Product (GSP) of Pennsylvania by over $9.3 billion while Ohio's JumpStart has created some 2,600 jobs over the past six years, helping launch 90 companies that have generated $155 million in economic impact.

The Economic Development Administration (EDA) does operate a regional innovation cluster program that identifies and supports RICs, convenes relevant stakeholders, creates a cluster support framework, disseminates information, and provides targeted capital investments to spur economic growth.[69] But it is underfunded and much more needs to be done to support regional innovation programs in the United States. In particular, the 2010 Reauthorization of the America COMPETES Act authorized the Department of Commerce "to establish a regional innovation program to encourage and support the development of regional innovation strategies." The administration allocated $5 million in its FY 2012 budget for the Regional Innovation Program, but it was never funded. The 2013 Reauthorization of the America COMPETES Act should include at least $100 million for the regional innovation strategies program.

Add more Weight for Technology Transfer Measures in the Department of Energy's National Laboratories Performance and Evaluation Measurement Plans

Despite the congressional mandate to promote technology transfer and economic outcomes, the Department of Energy (DOE) holds technology transfer as a relatively low priority on the National Laboratories Performance Evaluation and Measurement Plans (PEMPs), otherwise known as the labs' report card.

The PEMPS are the primary way the DOE stewarding office evaluates the performance of national lab contractors during the course of a year, and it includes a number of metrics to rate lab performance, including worker safety, research management, leadership ranking, and budgeting. A good score means a slightly higher management fee is paid to the operator, and a worse score means the contractor will walk away poorer (though these small bonuses typically pale in comparison to the overall operating budget of the lab itself).

Technology transfer should be elevated as a criteria in determining the annual performance of America's national laboratories.

While technology transfer metrics are included in the report card, they only account for a very small share of the overall grade, demoting it to a relative afterthought. In fact, technology transfer is not even one of the main eight criteria used for evaluation and is instead listed as the fifth bullet point underneath the sixth criteria on the list, carrying scant weight. As a result, the national labs are not incentivized to invest time, energy, or resources in facilitating technology transfer, despite potential financial upsides. Elevating this important function to its own category would have significant impacts on the management of the labs, and help to reverse the buildup of decades of skepticism and intransigence toward commercialization. Congress could quickly change the lack of incentive for technology transfer by requiring DOE to rank it as one of the key mission accomplishments under Section 1.0 of the National Laboratories' PEMP.

Improve Accounting Rules for National Laboratories Overhead

The Institute for Defense Analysis has found that national laboratories' "technology transfer is an underfunded legislative mandate that can adversely affect technology transfer activities."[70] The reason is simple: technology transfer activities are seen as a "tax" on existing research budgets. For example, lab Technology Transfer Offices (TTOs) act as gatekeepers for technology transfer activities and are most often funded from overhead costs, a percentage of revenues from licensing agreements with industry, or the research budgets themselves. In a time of shrinking public research budgets, technology transfer is viewed as siphoning public dollars from the labs' underlying research priorities. Underfunded and understaffed technology transfer operations at the national laboratories means there is a tremendous amount of idle intellectual property "sitting on the shelf."

A common refrain from those working within the lab ecosystem is that the act of transferring research to market is more or less serendipitous. Certainly there are occasions in which research of any kind can become commercially applicable by happenstance. But a more formally structured process of technology transfer ensures that more research has the potential to impact commercial markets if applicable.

In many cases, the national laboratories' research is very early stage and requires additional investment to move it closer in development to where industry is comfortable working with it. For its part, the DOE has tried to augment situations like this by investing in limited commercialization activities, such as the Department of Energy's Energy Efficiency and Renewable Energy (EERE) Commercialization and Development Team, which invests in getting emerging technologies into the hands of industry on a budget of roughly $14 million. But programs such as EERE typically have small budgets and are not close enough to the research to address the systemic gaps that prevent research from reaching the private sector.

Without additional research and technology transfer funding, the labs are largely left to invest through their overhead accounts. While the lion's share of lab funding goes into congressionally mandated research operations, a small percentage of research budgets—defined as "overhead"—goes into other accounts to cover management costs, facility upkeep, and other lab-directed investments. Tight restrictions on these overhead accounts limit contractor flexibility and make it difficult for managers to strategically invest in advancing promising research or strengthening lab infrastructure.

Recognizing this policy limitation, Congress can increase technology transfer support by providing the labs additional overhead flexibility in two ways. First, Congress should remove the rigid accounting buckets from lab overhead and instead simply provide accounting rules for what the single tranche of overhead funds can be used for. Second, to increase support for technology transfer, Congress should take this reform a step forward by explicitly defining technology transfer to include early stage technology maturation. In practice, this means the labs are capable of investing in lab overhead in early stage demonstrations that either remove technology barriers limiting private sector interest or re-purpose original research for new problems. In either case, these funds would leverage publicly funded research results that would normally sit on the lab shelf and instead move them closer to potentially successful market outcomes.

Allow Government Labs to Take an Equity Stake in Startups

A significant barrier to government labs partnering with industry is that small businesses and startups often aren't capable of working with the labs due to the cost of procuring lab expertise and access to facilities. Yet, in many cases, even a small amount of lab interaction with a small business or startup could greatly impact a nascent company's growth and could be the deciding factor between a startup failing or not. Yet, in many cases, venture capital—typically the source of commercialization support—won't invest in an emerging company because the research is too early in development.

Congress could ameliorate this issue by providing the labs with the ability to take an equity stake in a startup that is interested in utilizing lab infrastructure to advance development of its proprietary technology. One option is to allow federal labs to trade use of lab research infrastructure for a small equity stake in startups under the strictest of transparency. It would be the equivalent of providing advanced lab services in lieu of payment; in return, the labs would receive royalties once startups advance into the market at very little, if any, risk to the taxpayers.

Federal Institutional Reforms to Spur Innovation

Innovation policy is not just about tax incentives or funding for government programs. It is about a wide array of government actions that can have an impact on innovation. But currently, the institutional ability of the federal government to strategically and comprehensively spur innovation is too limited. To remedy that we propose several recommendations:

Reallocate NSF Monies to Areas with Stronger National Economic Impacts

The allocation of budgetary funding within the National Science Foundation is an issue that deserves more public policy scrutiny. The United States can simply no longer afford the post-war science consensus that postulated an unlimited amount of money to fund basic scientific research, especially when the rest of the world free rides on U.S. basic scientific research in the same way many nations have long free ridden on U.S. defense spending. As the Institute for Defense Analysis's *Emerging Global Trends in Advanced Manufacturing* report clearly puts it, "countries often rely on the basic research discoveries coming out of U.S. universities and national laboratories, which allows them to concentrate their efforts on turning U.S. scientific discoveries into their own innovative technologies and products which they sell to other nations, including the United States."[71]

It's time to clearly recognize that certain research programs the National Science Foundation in particular supports are much more important to our country's economic well-being and competitiveness than others, and explicitly take this into account when making budgetary allocation decisions. In particular, Congress should direct, and the administration should implement, a reallocation of NSF resources toward the kinds of science that has direct economic and industrial benefits for the United States. In particular, this means increasing NSF budgets for four key directorates: 1) math and physical sciences; 2) engineering; 3) computer and information sciences and engineering (CISE); and 4) biological sciences, while permitting research budgets for the geosciences and social sciences to shrink. The issue isn't that these fields are not useful (nor that their budgets should necessarily be decreased) but it is that if American society (i.e., Congress) refuses to devote more funding for research, then the country must make tough prioritization choices, and we should prioritize those areas that will best help the U.S. win the global innovation race. This is not a call to shrink science funding, but it is a call to explicitly reorient it in such a way that best promotes U.S. national innovation-based economic competitiveness and the jobs and economic growth that stem from this.

Unfortunately, the president's FY 2014 budget request for the National Science Foundation does not get the allocations right in this regard. The largest component in the president's FY 2014 NSF budget request is for geosciences, at $1.39 billion, as Table 3 shows. But geosciences are all about knowledge creation, whereas engineering, which can produce appropriable gains in the U.S. economy, receives far less at $911 million.[72] Meanwhile, the computer and information sciences and engineering (CISE) directorate receives only a 1.4 percent increase, while the social, behavioral, and economic sciences (SBES) directorate was slated for a 7.1 percent increase. In other words, NSF's social sciences research activities received a budget increase four times larger than CISE's, and to perform studies such as one on Shoshone tribal customs.[73]

Directorate, Office or Commission	FY 2014 Request (millions)	Percent Change (From Actual FY 2012)
Geosciences	$1,393.9	5.5
Mathematical and Physical Sciences	$1,386.1	5.9
Computer & Information Science & Engineering (CISE)	$950.3	1.4
Engineering	$911.1	10.5
Biological Sciences	$760.6	6.8
Social, Behavioral & Economic Sciences	$272.4	7.1
Office of International and Integrative Activities	$536.6	3.3

Table 3: Administration's FY 2014 Budget Requests for NSF by Directorate[74]

Create a National Engineering and Innovation Foundation alongside NSF

To successfully compete globally, the United States will need to become much more of an engineering-based economy that embraces a real engineering culture.[75] At least since World War II, the United States has led the world in science-based innovation, as research from U.S. corporate, academic, and government laboratories contributed to a series of transformative innovations in everything from transistors and mobile phones, to lasers, graphical user interfaces, search engines, the Internet, and genetic sequencing. That approach worked well when few nations had the capacity to leverage U.S. scientific discoveries for their competitive advantage. But now U.S. federal R&D dollars for basic science generate knowledge that is essentially a non-rival, non-appropriable public good that can be quickly picked up and leveraged by foreign competitors. That's why many nations invest much less in basic research and more in applied research.[76] Instead, these countries often rely on the basic research discoveries coming out of U.S. universities and national laboratories, which allows them to concentrate their efforts on turning U.S. scientific discoveries into their own innovative technologies and products which they sell to other nations, including the United States.[77] In other words, investments in science create essential new knowledge that is freely traded around the world, but it is the application of that knowledge (e.g., engineering) that creates wealth through new products and processes.

That's why science-based discoveries aren't enough anymore. The United States must also be able to make things here. And that requires engineering-based innovation, an appropriable activity through which U.S. establishments can add and capture value. And it requires the United States getting better at generating pathways that turn science into U.S.-made high-technology products. The fundamental insight is that engineering is not science; the two have distinctly different purposes. As Sridhar Kota, formerly Assistant Director for Advanced Manufacturing at the Office of Science and Technology Policy, writes, "Science is about analysis and discovery and dissemination of knowledge. Engineering is about synthesis and invention and turning ideas into reality through a process called innovation and through translational research and entrepreneurship."[78] Both science and engineering are instrumental if American firms are to introduce successful innovations.

Unfortunately, the United States invests significantly more in scientific research than it does in engineering. Of the total federal research investments in science and engineering in 2008, approximately 1/7th was allocated to engineering development and 6/7th to the various scientific fields.[79] The National Science Foundation invests roughly 1/10th the amount on engineering education as it does on science and mathematics education.

It's time to raise the profile of engineering within our national innovation system. While NSF supports phenomenal work, its central purpose is belied by its title. NSF's primary mission is funding scientific research; its engineering support programs get shorter shrift. Therefore, Congress should create a National Engineering and Innovation Foundation as a separate entity operating alongside the National Science Foundation.[80] The new National Engineering and Innovation Foundation would consolidate the current Engineering Directorate within NSF including the ERC and I/UCRC programs, the functional parts of the National Institute of Standards and Technology, the Department of Defense's Manufacturing Technology (ManTech) program, and the Department of Energy's Advanced Manufacturing office into a single entity with an engineering focus. The new National Engineering and Innovation Foundation would consolidate existing budgets from the merged programs and also add $300 million per year to ongoing funding.

Congress should create a National Engineering and Innovation Foundation as a separate entity operating alongside the National Science Foundation.

If Congress wants to take a step short of standing up a new National Engineering and Innovation Foundation, then at the very least Congress should change the name of the National Science Foundation to the National Science and Engineering Foundation (NSEF). Doing so would make it clear to NSF leadership and the research community that NSF should give engineering more emphasis and visibility. And Congress should shift more of the NSEF's funding toward engineering, even if that means cutting science funding.

Create a Deputy Director for Economic Growth and Innovation Position at NSF

The National Science Foundation needs more resources devoted to assessing the agency's impact on economic growth and innovation. Accordingly, NSF should create a new position for a Deputy Director of Economic Growth and Innovation, as Lloyd Etheredge of the Policy Sciences Center has suggested. The position should be filled by an individual with professional competence in understanding the design of innovative systems, building rapid learning data systems, linking creative ideas from all disciplines, and organizing needed advisory committees. The Deputy Director should look to articulate policies that can accelerate recovery and sustain a GDP/per capita growth rate that is at least 1 percent above the pre-crash baseline.

Allocate a Share of Federal University R&D Funding Based on Performance

Many countries seek to increase their R&D efficiency by using existing funding for scientific research to incent universities to focus more on technology commercialization. For example, in Sweden, 10 percent of regular research funds allocated by the national government to universities are now distributed using performance indicators. Half of these funds are allocated based on the amount of external funding the institutions have been able to attract, with the other half based on the quality of scientific articles published by each institution (as determined through bibliometric measures such as the number of citations).[81] Finland also has started to base its university budgets on performance—25 percent of the research and research training budgets of Finnish universities are based on "quality and efficacy," including the quality of scientific and international publications and the university's ability to attract research investment from businesses.[82] In other words, without increasing government budgets, these nations are using existing funds to provide a strong incentive for universities to become greater engines of national innovation. Federal research agencies, particularly NSF, should use indicators of university effectiveness of commercialization and industry-relevance to allocate research funding.

As Sweden has done in its effort to make universities more accountable for results, the amount of industry-funded university research should be the first variable used to make allocation decisions. This could be done by requiring the inclusion of this factor in the evaluation of all NSF research grants.

Holding universities accountable matters because, as NIST Senior Economist Gregory Tassey writes in "Beyond the Business Cycle: The Need for a Technology-Based Growth Strategy," a country's R&D policy is based on three critical drivers: the amount of R&D, the composition of R&D, and the efficiency of R&D—in other words, the level of return from each dollar invested in R&D.[83] Raising R&D efficiency is increasingly important as research dollars become scarcer and as R&D cycle times shrink in an increasingly competitive global economy. As Tassey writes, "The increasingly diffuse distribution of R&D in high-tech supply chains also requires more cooperation among multiple industries, universities, and levels of government."[84] It's important to note that holding universities more accountable and increasing the extent of industry-university collaboration does not compromise academic integrity. Indeed, Dennis Gray at North Carolina State University has demonstrated that if industry-university research collaboration is structured right, there is no negative impact on academic freedom.[85]

Form an Office of Innovation Review in OMB

The relative absence of innovation from the agenda of many relevant federal agencies—as well as interagency processes such as the centralized cost-benefit review performed by the Office of Information and Regulatory Affairs (OIRA) within the Office of Management and Budget (OMB)—manifests the confluence of two regulatory challenges: first, the tendency of political actors to focus on short-term goals and consequences; and second, political actors' reluctance to threaten powerful incumbent actors. Courts, meanwhile, lack sufficient expertise and the ability to conduct the type of forward-looking policy planning that should be a hallmark of innovation policy.

To remedy these problems, Congress should create an Office of Innovation Review within OMB that would have the specific mission of being the "innovation champion" within these processes.[86] OIR would be an entity that would be independent of existing federal agencies and that would have more than mere hortatory influence. It would have some authority to push agencies to act in a manner that either affirmatively promoted innovation or achieved a particular regulatory objective in a manner least damaging to innovation. OIR would operate efficiently by drawing upon, and feeding into, existing interagency processes within OIRA and other relevant White House offices (e.g., the Office of Science and Technology Policy). It is important to note that OIR would not be designed to thwart federal regulation; as a matter of fact, in some cases, the existence of OIR might lead to increased federal regulation (e.g., more Environmental Protection Agency regulations might pass muster under cost-benefit analysis if innovation-related effects were calculated).

Some might question the significance of this proposal. Isn't creating OIR a fairly small change to the system? Certainly adding OIR to the existing mix is a smaller change than jettisoning the existing substantive agencies in favor of a new agency with authority to regulate, and promote, innovation across all government agencies. But implementing this proposal would significantly change the regulatory environment. First, an entity focused on innovation would add an important new voice to the regulatory conversation. There would now be an entity speaking clearly and forthrightly on the centrality of innovation. Second, and more important, OIR would not merely have a voice; it would be able to remand agency actions that harm innovation. It would also have as part of its mission proposing regulation that benefits innovation. This is no small matter. Indeed, it would change the regulatory playing field overnight.

To those who might oppose an OIR on the grounds that making predictions about the future is very difficult and that experts are often wrong when they make such predictions, our response is straightforward: agencies are already making predictions about the future (whether consciously or not) when they make laws that affect innovation. They are simply doing so in a manner that is unsystematic, haphazard, and subject to undue influence by well-funded incumbents. We can do better.

Science, Technology, Engineering, and Math (STEM) Education and Skills

The United States faces a new and pressing competitiveness challenge as a growing number of nations seek to gain global market share in technology-based economic activities. While the national policy response must be multi-faceted, ensuring an adequate supply of talented scientists and engineers is one key competitive response. However, on a host of science, math, and engineering metrics, America is falling behind. The United States now lags behind much of the world in the share of its college graduates majoring in science and technology. As a result, the United States ranks just 29th out of 109 countries in the percentage of 24-year olds with a math or science degree. Following are eight proposals to address the STEM challenge.

Fund Specialty Math and Science High Schools

When it comes to addressing America's STEM challenge, a wide array of proposals seek to intervene further upstream in the STEM pipeline at the K-12 level. These proposals include: expanding professional development programs for science teachers; enhancing science enrichment programs; using No Child Left Behind to judge scientific educational outcomes; measuring STEM course requirements in high school; and boosting science teacher quality, either through stricter requirements, providing incentives to attract higher quality teachers to science, and/or making it easier for scientists and engineers to become teachers.

While these proposals have received the lion's share of attention in the policy debates over STEM education, we believe that the focus is too broad. If funding were unlimited, such a broad-based strategy might make sense. But since funding is limited and since less than 10 percent of the U.S. workforce is engaged in STEM-related careers, it makes more sense to focus limited funds more narrowly. In particular, we believe that the most effective strategy to address the STEM challenge at the high school level is to significantly expand the number of specialty math and science high schools (MSHS).[87]

There are only about 100 math and science high schools across the nation, ranging from pull-out programs with 125 students, to full-day programs and dedicated high schools of over 4,000 students, to state-sponsored residential schools, enrolling over 47,000 students in total.[88] By creating an environment focused more intensely on science and technology, these schools have succeeded in enabling students to study science and math, often at levels far beyond those of students in conventional high schools. These students can then go on to degrees in math and science at relatively high levels. It's time to build upon this successful model and significantly expand the number and scope of our nation's math and science specialty high schools.

Mathematics, science, and technology high schools differ from the general education found in comprehensive high schools in key ways. First, as the name implies, MSHSs focus much more extensively on STEM curricula. For example, in addition to the three years of lab science and three years of mathematics required by the state for high school graduation, Florida's Center for Advanced Technologies offers students an opportunity to declare a mathematics and science major by taking four additional courses in mathematics and science, often Advanced Placement Courses.[89]

Second, students don't just take more STEM courses; they take more advanced courses and do more advanced work. Indeed, the coursework and integrated curricula of MSHSs go over and above the normal graduation requirements for general education students. For example, students at the Arkansas School for Mathematics, Sciences, and the Arts can take courses in Biomedical Physics, Immunology, Microbiology, Multivariable Calculus, Number Theory, Differential Equations, Math Modeling, Computer Programming III, and Web Application Development.

A third distinguishing feature of these schools is their level of collaboration and coordination with other organizations. Collegiate, corporate, and alumni organizations have formed significant partnerships with these schools. While some partnerships have been in support of specific events, others have been long-term partnerships supporting research and innovation among students and faculty. Collegiate partners, for example, often provide classroom, dormitory, research, and financial support to these schools. For example, at the Governor's School of South Carolina, every rising senior is placed for six weeks of the summer at an off-campus program. Many of the students work with a research professor at an in-state university.

While the educational environments are exemplary, the key question is whether MSHSs produce results. While formal studies are few, there is some evidence that these schools are highly effective at producing graduates not only with high levels of aptitude in STEM, but who go on to further study and careers in STEM. For example, one study of 1,032 graduates finds 99 percent of graduates enroll in college within one year of high school (compared to 66 percent nationally) while 79 percent complete college in four years (compared to 65 percent in private universities and 38 percent in public universities).[90] Moreover, graduates earn undergraduate and graduate degrees in mathematics, science, and technology fields in significantly higher numbers than the general population. Approximately 56 percent of MSHS graduates earn undergraduate degrees in mathematics or science-related fields, compared to just over 20 percent of students who earn an undergraduate degree. Over 40 percent of females earn such degrees, nearly double the national average.

A key part of any solution to the STEM challenge needs to be the significant expansion of specialty math and science high schools.

A key part of any solution to the STEM challenge needs to be the significant expansion of specialty math and science high schools. But because more so than other high schools, math and science high schools produce benefits that local communities, and even states, will not capture, local school districts underinvest in them. Rather than be seen as solely the responsibility of local school districts, or even states, they should be seen for what they are: a critical part of the scientific and technological infrastructure of the nation. Thus, we believe that the National Science Foundation should play a key role in supporting and expanding such schools. As a result, Congress should set a goal of approximately quintupling enrollment at such high schools to approximately 250,000 students. This will require both the creation of a significant number of new high schools, but also expansion of others with room to grow. To do this, Congress should allocate $50 million a year for the next five years to the National Science Foundation to be matched with funding from states and local school districts and industry to invest in both the creation of new MSHSs and the expansion of existing ones.[91] Moreover, a share of these funds should go toward establishing MSHSs focused on under-represented populations. States and/or local school districts would be required to match every dollar of federal support with two dollars of state and local funding. Industry funding would count toward the state and/or local school district match.

Offer Planning Grants for Regions that Want to Create Alternative Types of STEM High Schools or Universities

In recent years, a number of new high schools and universities with unique approaches to STEM education have opened. The aforementioned Franklin W. Olin College of Engineering, which seeks to redefine engineering as a profession of innovation, is a strong example. Another is The Harrisburg University of Science and Technology which launched in 2001, making it the first independent science and technology-focused nonprofit university to be established in Pennsylvania in more than 100 years.[92] The university was conceptualized and championed primarily by regional business leaders to address the Pennsylvania state capitol region's need for increased educational opportunities in STEM careers, and as a concrete action to attract, educate, and retain a diverse 21st century knowledge-based workforce for Pennsylvania.[93] As at Olin, Harrisburg University has no tenured professors and no formal departments. The university champions an experiential learning model and all teaching is STEM- or technology-oriented and done on an interdisciplinary basis, with students required to complete internships with companies, helping them to solve real engineering and technical problems.

Public policy should support states and regions as they try to develop alternative types of STEM-oriented high schools and universities. Planning grants are needed, especially in the absence of the kinds of larger grants proposed above, because it's very difficult to conceptualize new approaches, coordinate a wide range of regional and state actors across industry, academia (including faculty and students), community, and government, construct new facilities, etc. Therefore, Congress should allocate $10 million for the National Science Foundation, through the existing Transforming Institution Grants program, to offer planning grants for regions looking to create new kinds of STEM high schools or universities.

If the United States could improve the STEM major switch out rate by just 10 percent, it could increase the number of scientists and engineers graduating from U.S. universities by 750,000 over the next decade.

Provide Prizes to Colleges and Universities that do Best at Retaining STEM Students

STEM BS degrees could be increased significantly if more freshmen who intended to major in STEM graduated with a STEM degree. Unfortunately, 60 percent of those who enter college intending to pursue a STEM degree fail to graduate with one, as noted in the February 2012 report *Engage to Excel* by the president's Council of Advisors on Science and Technology.[94] However, if the United States could improve the STEM major switch out rate by just 10 percent, so that half those who enter U.S. universities with the intention to do so do indeed graduate with a STEM degree, then the country could increase the number of scientists and engineers graduating from U.S. universities by 750,000 over the next decade, going a long way toward closing the deficit of one million science and engineering graduates expected over the coming decade.

The challenge of keeping young university students interested in STEM fields has been eloquently addressed in several compelling works, including David Lopatto's *Science in Solution: The Impact of Undergraduate Research on Student Learning* and *Undergraduate Research in the Sciences: Engaging Students in Real Science* by Sandra Laursen et al.[95] Elaine Seymour and Nancy Hewitt of the University of Colorado also tackle the challenge in *Talking About Leaving*, noting that many STEM students switch out because of poor teaching techniques on the part of STEM teachers. The authors note that faculty in STEM fields on average spend more time in traditional delivery modes as opposed to using evidence-based teaching practices, which have been more rapidly embraced by faculty in the humanities and social sciences.[96]

In fact, extensive survey work by Seymour and Hewitt across seven universities found that "poor teaching by faculty" was cited as a concern among 90 percent of all students who switched out of STEM majors and 98 percent of students who switched out of engineering.[97] Of the 23 most commonly cited reasons for switching out of STEM, all but 7 had something to do with the pedagogical experience. "Curriculum overload, fast pace overwhelming," "discouraged/lost confidence due to low grades in early years," "inadequate advising or help with academic problems," "unexpected length of SME degree: more than 4 years," and "lack of peer study group support" were a few of these items.

The lower grades awarded (on average) in STEM courses compared to non-STEM ones is a particularly significant factor contributing to STEM switch out. For example, Cs are rare grades in humanities courses, but commonplace in science courses.[98] At Cornell, one study found that the median grades in astronomy, chemistry, economics, mathematics, and physics were 0.2 out of 4.0 points lower than the median grade across all courses examined, which was 3.65.[99] A survey of seven other colleges showed introductory classes in chemistry, economics, and math offered an average grade of 2.67, compared to an average grade of 3.03 for introductory courses in art, English, music, philosophy, political science, and psychology.[100] Paul Romer cites data from a College Board survey of 21 selective universities showing that the share of students in English classes receiving an A or B was 85 percent while just 57 percent of students in math classes received an A or B.[101] Clearly these lower grades are not a result of the students taking STEM courses being less intelligent or diligent than students taking English or art. Yet the lower grades clearly do spur more students to switch out of STEM.

Why don't universities do more to try to preclude STEM switch out? As Stanford economist Paul Romer notes in a study of STEM education in the United States, "A liberal arts university that has fixed investment in faculty who teach in areas outside of the sciences and that faces internal political pressures to maintain the relative sizes of different departments may respond to this pressure by making it more difficult for students to complete a degree in science." As Romer continues, "The picture that emerges from this evidence is one dominated by undergraduate institutions that are a critical bottleneck in the training of scientists and engineers, and by graduate schools that produce people trained only for employment in academic institutions as a side effect of the production of basic research results."[102]

Clearly, much more can be done to keep students entering universities interested in STEM fields. Accordingly, Congress should appropriate $66 million a year to NSF, for five years; this would be matched one to one by foundations, to be awarded as prize funds to colleges and universities that have dramatically increased the rate at which their freshmen STEM students graduate with STEM degrees and that can demonstrably sustain that increase over five years. Awards would be offered in three tiers: $2.5 million for small colleges, $5 million for mid-size ones, and $25 million for large universities.[103]

Expand Undergraduate Research Opportunities, Particularly During Freshman Year

Because undergraduate research is a highly engaging experience with a track record of greatly diminishing student dropout/switch out from STEM, such experiences should be moved to a student's first year of college, as a prophylactic against the dropout/switch out endemic to the freshman year. Such an approach could increase national BS output by as much as 20 percent.

A number of programs have sought to increase undergraduate research opportunities in the first several years of college with tremendous success. For example, The Howard Hughes Medical Institute established the National Genomics Research Initiative (NGRI), as a national experiment in both research and education that revolves around a research course in genomics for undergraduate students. In the program's first full year of implementation, 270 students from 12 undergraduate institutions—including large research universities and small liberal arts colleges—participated. NGRI students participate in an authentic research experience—integrated into a laboratory course designed for freshmen—that will result in a significant contribution to the broader genomics field. The program is intended to "inspire students before they have a chance to become bored or overwhelmed by the typical large introductory science course. Students will catch the spark of enthusiasm for inquiry-based discovery and absorb the process of doing real science at a point that will influence their whole college experience."[104]

To facilitate a transition to expand undergraduate research opportunities, the president should issue an Executive Order requesting 30 percent or more of federal-agency-funded undergraduate research experiences be moved to the freshman year and summer following. Prior to the White House issuing the Order, the Office of Science and Technology Policy can be directed to arrive at a list of programs that would be affected by such an order, and asked for process suggestions that would allow for a smooth transition to the new model.[105]

Require Colleges to Report National Survey of Student Engagement Scores

When consumers have better information they make better decisions, which puts pressure on organizations to provide better services. Yet, in many areas of college education, including STEM, information is lacking. Policy needs to drive much better information about STEM educational institution performance and ensure that this information is widely available.

The National Survey of Student Engagement (NSSE) is designed to obtain, on an annual basis, information from more than 1,300 colleges about student participation in programs and activities that those institutions offer for learning and personal development. Unfortunately, few colleges and universities report their institution's scores. To change that, Congress should require that as a "check off" criterion in the certifications and representations section of any grant proposal that provides student support, universities assert that they have publicly posted their NSSE results. The release of this information would allow parents, teachers, students, funding agencies, and other stakeholders to ascertain that institution's level of student engagement in instructional practices.[106]

The Obama administration has also set some important targets in this regard. The administration's report *Cross-Agency Priority Goal: Science, Technology, Engineering, and Math Education* articulates several high-priority goals for undergraduate STEM education for 2013, one of which is that, by September 30, 2013, the federal government seeks to have 80 percent of institutions that receive federal funding for undergraduates report on their teaching practices.[107]

Expand Interdisciplinary Higher Education Learning

Approximately 75 percent of college students would prefer an interdisciplinary education, and such training is also needed to improve workforce skills.[108] In particular, better incorporation of educational experiences in design, innovation, entrepreneurship, and industrial research into graduate science and engineering programs is needed. The National Science Foundation's FY 2014 budget request proposes to evolve NSF's Integrative Graduate Education Research Training (IGERT) program into a new program, the NSF Research Traineeships (NRT), that will allow for institutional traineeship program applications, that will incorporate plans for transforming aspects of graduate programs and experiences at those institutions, and that will focus on specific areas of need for both the federal government and the STEM enterprise.[109] NSF's budget request notes that, "A total investment of $21.36 million for NRT aligns with the Administration's commitment to more coherence in STEM graduate education activities across the federal government."[110] To increase the number of interdisciplinary learning opportunities in graduate education, Congress should provide $30 million in funding for the Research Traineeships program.

Fund More Joint Government-Industry STEM PhD Fellowships

One key factor in producing more PhD degrees in STEM, especially by U.S. residents, is the ability to support doctoral fellowships. But as Harvard's Richard Freeman notes, the number of NSF graduate research fellowships awarded per thousand of college students graduating with degrees in science and engineering went from over seven in the early 1960s to just over two in 2005. Today, the same number of NSF graduate research fellowships are offered per year as in the early 1960s, despite the fact that the number of college students graduating with degrees in science and engineering has tripled.[111] But rather than simply expand funding for the NSF Graduate Research Fellowship program (funded at $102 million), Congress should create a new NSF-industry PhD fellows program. Currently the program provides up to three years of support over a five-year period and supports approximately 3,400 students per year at $40,500 per year.[112] The new NSF-industry program would work by enabling industry to fund individual fellowships of $20,250 with NSF to match industry funds dollar for dollar. Congress should allocate an additional $21 million to a joint industry-NSF STEM PhD fellowship program. This would allow NSF to support an additional 1,000 graduate fellows.

Individual companies could commit to supporting American residents in whatever fields interest the companies. Students would be under the supervision of their university faculty, and ultimately dissertation advisor, but industry would be able to build a relationship with the student. For example, a company might offer the student a summer internship at one of the company's laboratories, helping the student to get a better sense of actual research challenges the company faces.

To be sure, this program would be slightly more complicated to administer. First, companies would have to be informed of the program and propose graduate fellow areas of study. Prospective fellowship applicants would have to identify which awards they are most interested in applying for. However, with the Internet, such matching would be relatively straightforward, with students indicating their intended areas of study and the online program identifying relevant fellowship opportunities. If, after three years, it turns out that industry does not support the program in great enough numbers or students and universities are not interested in the program, then it could and should be terminated and the funding redirected into the regular fellows program.

However, this program would have two advantages over the regular NSF fellows program. First, by leveraging industry funds, federal dollars would go twice as far. Instead of having to appropriate $42 million to fund 1,000 additional fellowships, policymakers could appropriate $22 million instead. Second, and more important, engaging industry as a partner would help selected graduate students better understand how research is conducted in industry and better understand the interdisciplinary nature of today's innovation process. Both of these challenges have been the subject of increasing focus by scholars writing about STEM graduate education.

There have been several studies about the growing disconnect between the training that graduate students receive and their future job responsibilities.[113] Most doctoral programs still train students as if they were going into academic teaching and research careers, but increasingly this is not the case.[114] For example, one survey of doctoral chemistry found that only 36 percent intended to go into academia (compared to 76 percent of English students).[115] As Campbell, Fuller, and Patrick have argued, "graduate education needs to be broadened from its research focus to include a wider range of training for the careers students are pursuing and to reflect the versatility needed to work in an increasingly global job market, where collaboration between industry, universities, and government agencies is the norm rather than the exception."[116] Finally, for those who worry that industry funding will somehow taint the scientific learning process, it is important to remember that students would be guaranteed the funds as long as the university agreed that the student was performing up to standards.[117]

Allow Foreign Students Receiving STEM PhDs from U.S. Universities to Automatically Qualify for Green Cards

While ideally the supply of American STEM workers will expand to fill the needs gap, the likelihood of that happening in the near to moderate term is unlikely, even if federal efforts to support STEM education expand significantly. Yet welcoming the world's most skilled foreign-born scientists and engineers into the land of economic opportunity that America affords has long been one of the strengths of the U.S. national innovation system. The U.S. economy and the standard of living for American citizens have benefited enormously from this influx of foreign talent. For example, AnnaLee Saxenian, a professor at the University of California-Berkeley, has shown that Indian and Chinese entrepreneurs founded or co-founded roughly 30 percent of all Silicon Valley startups in the late 1990s.[118]

Recognizing this, over the last decade many nations have liberalized their policies regarding high-skill immigration, while the United States, in stark contrast, has restricted its policies. For example in a study benchmarking high-skill immigration policies in eight nations (Australia, Canada, France, Germany, Japan, New Zealand, the United Kingdom, and the United States), ITIF found that the United States trails other peer countries in developing a proactive approach to attracting high-skilled foreign workers.[119]

Moreover, the current system of employer sponsorship signals only that potential immigrants are desirable employees. A system that allowed additional criteria to be considered, like those used in the point systems of Australia, Canada, and New Zealand, would meet policy objectives better. (Applicants for immigration in these countries receive points for such characteristics as education, work experience, and language skills. Those surpassing an adjustable point threshold are admitted. Having a job offer in hand and meeting a designated occupational shortage may add points to an individual's application, but it is usually possible to meet the pass mark without either of these attributes.) Toward that end, foreign graduate students in STEM fields should be given special preference within such a system, even if they have not received job offers. To do this, Congress should automatically make recipients of advanced science and engineering degrees eligible for permanent residency. Providing additional opportunities for green cards not tied to employment could allow highly skilled foreign graduates to make more creative contributions to the economy more quickly by working in smaller and riskier businesses.

Various legislation now circulating on Capitol Hill seeks to address high-skill immigration issues. For example, the bipartisan Immigration Innovation Act of 2013 ("I-Squared Act"), co-authored by Senators Christopher Coons (D-DE), Orrin Hatch (R-UT), Amy Klobuchar (D-MN), and Marco Rubio (R-FL), would allow the H1-B cap to rise automatically, up to 300,000, based on demand, allowing employers to attract foreign skills if American workers cannot fill the requisite job openings. The Act would further allow dual intent for foreign students at U.S. colleges and universities to provide the certainty they need to ensure their future in the United States.[120]

Congress should automatically make recipients of advanced science and engineering degrees eligible for permanent residency.

In terms of allowing foreign-born students graduating with advanced STEM degrees from U.S. universities to receive citizenship, the STEM Jobs Act of 2012, sponsored by Representative Lamar Smith (R-TX), goes one step further by creating a new category of visas specifically for foreign students who graduate from an American research university with a doctorate or master's degree in a STEM field.[121] (The Act passed the House but has not been taken up by the Senate). There, the Senate's version of The Startup Act 3.0, S. 310, re-introduced in the 113th Congress by U.S. Senators Jerry Moran (R-KS) and Mark Warner (D-VA), along with Chris Coons (D-DE) and Roy Blunt (R-MO), would grant conditional permanent resident status for foreign-born residents with an advanced degree in STEM fields by creating a new visa for up to 50,000 foreign students who graduate from an American university with a Master's or PhD degree in science, technology, engineering, or mathematics.[122] Visa recipients would be granted conditional status contingent upon their remaining actively engaged in a STEM field for five consecutive years. Once conditional status is lifted, the visa holder becomes a permanent legal resident with the option to naturalize. Also, the "Gang of 8" Senators (comprised of Jeff Flake, R-AZ; Marco Rubio, R-FL; Richard Durbin, D-IL; John McCain, R-AZ; Charles Schumer, D-NY; Robert Menendez, D-NJ; Lindsey Graham, R-SC; and Michael Bennet, D-CO) have proposed immigration reform legislation that would increase the number of H-1B visas awarded annually from 65,000 to 110,000, in part to bump up to 25,000 visas available for those with degrees in science, technology, engineering and mathematics.[123] In short, the necessary legislation is there—it's time for Congress and the president to come together to pass it.

CONCLUSION

In the last two decades, there have been at least three major changes to the U.S. economy, as ITIF writes in *Innovation Economics: The Race for Global Advantage.*[124] The first is that it has become truly global. Fifty years ago states and regions (e.g., the Northeast) largely competed against each other. Today, the United States competes with nations around the globe. This fundamental change means that the United States needs to think of itself as a big state and proactively put in place a national economic development strategy.

The second big change is that innovation has become a more central driver of growth and competitiveness. In the old economy it was low costs, accumulation of large pools of capital, and economies of scale that drove competitive advantage. In that environment, places that wanted to succeed economically focused on offering firm-specific financial incentives designed to attract or retain establishments of large, multi-region firms. Today, innovation—the development of new products, new services, new or improved production processes, and new business models—drives growth. Indeed, the application of innovation throughout an economy is critical to prosperity and competitiveness.

The third big change is that the United States' position as the global innovation leader has been lost. As ITIF documented in its *The Atlantic Century II* report, the United States ranks 43rd out of 44 nations in the rate of progress over the last decade on innovation-based competitiveness (based on 16 indicators such as corporate R&D, venture capital, scientists and engineers, and others).[125] Absent robust policy changes, the United States will likely continue its relative decline in innovation performance. The result will be relatively slower growth in standards of living—and U.S. global power.

These three factors provide a compelling rationale for increased federal efforts to spur innovation. Both institutional innovation and increased funding will be required. To be sure, the recommendations in this proposal will entail some cost. But the reality is that the United States cannot afford *not* to invest in programs that spur innovation, productivity, and competitiveness and therefore drive economic growth. Indeed, if the United States wishes to reduce its budget deficit while also reducing the investment and trade deficits it faces, it must increase targeted investments that spur innovation, productivity, and competitiveness while cutting spending and raising taxes elsewhere.[126] Increasing these productive public investments will close the investment deficit, boost U.S. competitiveness and exports, and generate higher economic growth—a key way to close the budget deficit.[127] In fact, the Congressional Budget Office (CBO) estimates that an increase of just 0.1 percent in the GDP growth rate could reduce the budget deficit by as much as $310 billion cumulatively over the next decade.[128] Thus, an increase in the real rate of GDP growth from the CBO projection of 2.8 percent over the next decade to 4 percent—the U.S. growth rate from 1993 to 2000—would, all else equal, cut the cumulative budget deficit in half, or by $6.8 trillion, over the next decade.

Revamping the U.S. innovation infrastructure and spurring additional investment in science and technology can help create the new products, processes, and industries that will drive economic development, job growth, and enhanced quality of life for American citizens. A robust reauthorization of the America COMPETES Act in 2013 can play an important role in bolstering the STEM education, scientific research, technology commercialization, and innovation activities that underpin U.S. economic competitiveness and growth.

ENDNOTES

1. Fred Block and Matthew Keller, "Where Do Innovations Come From? Transformations in the U.S. National Innovation System, 1970-2006," (Washington, DC: ITIF, July 2006), http://www.itif.org/files/Where_do_innovations_come_from.pdf.
2. According to the National Science Foundation, the United States invests more in basic research as a share of total R&D than many other nations. At 19 percent, the U.S. share of total research (public and private) in basic research is higher than China (5 percent), Taiwan (10 percent), United Kingdom (11 percent), Japan (13 percent), and South Korea (16 percent). National Science Foundation, *Science and Engineering Indicators 2012* (Arlington, VA: National Science Foundation, 2012), 4-47, http://www.nsf.gov/statistics/seind12/pdf/seind12.pdf.
3. National Science Board, *Science and Engineering Indicators 2010* (Arlington, VA: National Science Foundation, 2010), http://www.nsf.gov/statistics/seind10/pdf/seind10.pdf.
4. Robert D. Atkinson and Merrilea Mayo, *Refueling the U.S. Innovation Economy: Fresh Approaches to Science, Technology, Engineering and Mathematics (STEM) Education* (Washington, DC: ITIF, 2010), http://www.itif.org/files/2010-refueling-innovation-economy.pdf.
5. Matthew Stepp and Robert D. Atkinson, "An Innovation Carbon Price: Spurring Clean Energy Innovation while Advancing U.S. Competitiveness" (Washington, DC: ITIF, March 2011), www.itif.org/files/2011-innovation-carbon-price.pdf.
6. Remarks of Robert-Jan Smits, Director General of DG Research and Innovation at the European Commission, at the European Institute, Washington, DC, February 13, 2013.
7. Government Office of Sweden, "The Government's Research and Innovation Bill," January 11, 2013, http://www.government.se/sb/d/16288.
8. Chris Buckley, "China Confirms $1.7 Trillion Spending Plan: U.S.," *Reuters,* November 21, 2011, http://mobile.reuters.com/article/idUSTRE7AK0MT20111121?irpc=932.
9. Robert D. Atkinson and Stephen J. Ezell, *Innovation Economics: The Race for Global Advantage* (New Haven, CT: Yale University Press, 2012), 164.
10. Robert D. Atkinson et al., *Taking on the Three Deficits: An Investment Guide to American Renewal* (Washington, DC: ITIF and the Breakthrough Institute, November 2011), 7, http://www.itif.org/files/2011-taking-three-deficits.pdf.
11. Atkinson and Ezell, *Innovation Economics: The Race for Global Advantage*, 245.
12. National Science Board, *Science and Engineering Indicators 2010*.
13. Ed Paisley, "Bush Asks Congress to Double Science Spending," *Science Progress*, January 29, 2008, http://scienceprogress.org/2008/01/bush-asks-congress-to-double-science-spending/.
14. Stephen J. Ezell and Robert D. Atkinson, "Comparing the Candidates' Technology and Innovation Policies" (Washington, DC: ITIF, September 2008), 4, http://www.itif.org/files/2008-CampaignTechAgenda.pdf.
15. U.S. Department of Energy, "Energy.gov: Office of Budget - CF-30," accessed September 5, 2012, http://www.cfo.doe.gov/crorg/cf30.htm.
16. U.S. Department of Commerce, National Institute of Standards and Technology, "President's FY 2013 Budget Request for NIST Targets Advanced Manufacturing, Critical Science and Technology Programs," news release, February 13, 2012, http://www.nist.gov/public_affairs/releases/budget_2013.cfm.
17. Executive Office of the President, *Fiscal Year 2014 Budget of the U.S. Government*, (Washington, DC: Office of Management and Budget, April 10, 2013), 66, http://www.whitehouse.gov/sites/default/files/omb/budget/fy2014/assets/budget.pdf.
18. State Science and Technology Institute, "FY14 Federal Budget Request Overview," *SSTI Weekly Digest* 18, no. 13 (April 17, 2013), http://www.ssti.org/Digest/2013/fy14budget.pdf.
19. Robert D. Atkinson et al, *Leadership in Decline: Assessing U.S. International Competitiveness in Biomedical Research* (Washington, DC: ITIF and United for Medical Research, May 2012), http://www2.itif.org/2012-leadership-in-decline.pdf.
20. Robert D. Atkinson and Justin Hicks, *Eroding Our Foundation: Sequestration, R&D, Innovation and U.S. Economic Growth* (Washington, DC: ITIF, September 20, 2012), http://www2.itif.org/2012-eroding-foundation.pdf.

21. Jane E. Fountain and Robert D. Atkinson, *Innovation, Social Capital, and the New Economy: New Federal Policies to Support Collaborative Research* (Washington, DC: Progressive Policy Institute, July 1998), http://www.ppionline.org/ppi_ci.cfm?knlgAreaID=140&subsecID=293&contentID=1371.
22. L. Branstetter and M. Sakakibara, "Japanese Research Consortia: A Microeconometric Analysis of Industrial Policy," *Journal of Industrial Economics* 46 (1998): 207–233.
23. For example, spillovers from company-funded basic research are very high—over 150 percent according to one study: Albert Link, "Basic Research and Productivity Increase in Manufacturing: Additional Evidence," *The American Economic Review* 71, no. 5 (December 1981): 1111-1112.
24. Barry Bozeman and Albert N. Link, "Tax Incentives for R&D: A Critical Evaluation," *Research Policy* 13, no. 1 (1984): 21-31.
25. Robert D. Atkinson and Luke Stewart, "University Research Funding: The United States is Behind and Falling" (Washington, DC: ITIF, May 2011), 6, http://www.itif.org/files/2011-university-research-funding.pdf.
26. Ibid., 6-7.
27. Matthew Stepp and Robert D. Atkinson, "Creating a Collaborative R&D Tax Credit" (Washington, DC: ITIF, June 2011), http://www.itif.org/files/2011-creating-r&d-credit.pdf.
28. Denmark looks to promote public and private cooperation in R&D by having a 150 percent deduction of investments co-financed by a public university or research institute and the industry.
29. Jacek Warda, "Tax Treatment of Investment in Intellectual Assets: An International Comparison," *OECD Science, Technology and Industry Working Papers* 4 (2006): Appendix 1.1.
30. Currently the expenditures firms make to outside organizations are treated two ways. Qualified expenses cover just 65 percent of payments for contract research, unless the payments are to a qualified nonprofit research consortium at which point the company can count 75 percent of the payments as qualified expenses. However, firms contracting with certain nonprofit organizations (e.g., universities) to perform basic research may claim a credit of 20 percent.
31. Robert D. Atkinson, "Create Jobs by Expanding the R&D Tax Credit" (Washington, DC: ITIF, January 26, 2010), http://www.itif.org/files/2010-01-26-RandD.pdf.
32. The 109th Senate considered versions of HR.4297 (Thomas, [R-CA]), S.14 (Stabenow [D-MI]), S.2199 (Domenici [R-NM]), and S.2357 (Kennedy [D-MA]). S.2357 would institute a flat credit for payments to qualified research consortia.
33. Engineering Research Centers Association, "About the ERCs," http://www.erc-assoc.org/.
34. National Science Foundation, "I/UCRC Model Partnerships," http://www.nsf.gov/eng/iip/iucrc/program.jsp.
35. In-person interview with Dr. Reinhard Huettl, President of the German National Academy of Science and Engineering, April 11, 2012.
36. Robert D. Atkinson, "Eight Ideas for Improving the America COMPETES Act" (Washington, DC: ITIF, March 2010), http://www.itif.org/files/2010-america-competes.pdf.
37. National Science Foundation, *FY 2012 Budget Request to Congress* (Arlington, VA: NSF, February 14, 2012), 96, http://nsf.gov/about/budget/fy2012/pdf/fy2012_rollup.pdf.
38. Ibid., 391.
39. Stephen J. Ezell and Robert D. Atkinson, *Fifty Ways to Leave Your Competitiveness Woes Behind: A National Traded Sector Competitiveness Strategy* (Washington, DC: ITIF, September 2012), http://www2.itif.org/2012-fifty-ways-competitiveness-woes-behind.pdf.
40. Robert D. Atkinson and Stephen J. Ezell, "Cut to Invest: Support the Designation of 20 'U.S. Manufacturing Universities'" (Washington, DC: Brookings, January 14, 2013), http://www.brookings.edu/research/papers/2013/01/14-federalism-series-manufacturing-universities.
41. Georgia Tech University, "Georgia Tech Names Chief Manufacturing Officer," news release, June 27, 2011, http://www.gatech.edu/newsroom/release.html?nid=68555.
42. Atkinson and Mayo, *Refueling the U.S. Innovation Economy,*107-108.
43. Ibid.,101-105.
44. David M. Hart, Stephen J. Ezell, and Robert D. Atkinson, "A National Network for Manufacturing Innovation: Why America Needs It and How It Should Work," (Washington, DC: ITIF, December 2012), http://www2.itif.org/2012-national-network-manufacturing-innovation.pdf.
45. Ibid.

46. The White House, Office of the Press Secretary, "President Obama to Announce New Efforts to Support Manufacturing Innovation, Encourage Insourcing," news release, March 19, 2012, http://www.whitehouse.gov/the-press-office/2012/03/09/president-obama-announce-new-efforts-support-manufacturing-innovation-en.
47. Executive Office of the President, *Fiscal Year 2014 Budget of the U.S. Government*, 8.
48. Fraunhofer Institute, "Fraunhofer Business Model," http://www.fraunhofer.de/en/about-fraunhofer/business-model.
49. United Kingdom Technology Strategy Board, "High-Value Manufacturing Catapult," https://catapult.innovateuk.org/en/high-value-manufacturing.
50. "Around the World," *Science* 339, no. 6118 (January 25, 2013): 378-379.
51. National Institute of Standards and Technology, "Manufacturing Extension Partnership: Making an Impact on U.S. Manufacturing" (Gaithersburg, MD: NIST, January 2012), http://www.nist.gov/mep/upload/MEP-PARTNERING-IMPACTS-2011-v2.pdf.
52. Ibid.
53. Phone interview with Tony Rahilly, Director General of the NRC Industrial Research Assistance Program, and Bogdan Ciobanu, Director Quebec Province Industrial Research Assistance Program, July 12, 2011.
54. Jason Charron, "NRC Industrial Research Assistance Program (NRC-IRAP) Overview," September 14, 2011, 14.
55. Stephen J. Ezell and Robert D. Atkinson, *International Benchmarking of Countries' Policies and Programs Supporting SME Manufacturers* (Washington, DC: ITIF, September 2011), 33, http://www.itif.org/files/2011-sme-manufacturing-tech-programss-new.pdf.
56. Ibid.
57. Jennifer Huergo, "President's FY 2014 Budget Request for NIST Supports Research in Advanced Manufacturing, Cybersecurity," (Gaithersburg, MD: NIST, April 10, 2013), http://www.nist.gov/public_affairs/releases/budget2014.cfm.
58. U.S. Small Business Administration, "Description of the Small Business Technology Transfer Program," STTR, http://www.sba.gov/aboutsba/sbaprograms/sbir/sbirstir/SBIR_STTR_DESCRIPTION.html.
59. Phone interview with Mike Alder, Chairman, WestCamp Inc., and Director Brigham Young University Technology Transfer Office, April 5, 2013.
60. Kenneth Thomas, *Investment Incentives and the Global Competition for Capital* (New York: Palgrave Macmillan, 2011), 2.
61. Connecticut's Yankee Ingenuity program and Pennsylvania's Ben Franklin Technology Partners program work in a similar manner. See Yankee Ingenuity Competition, http://www.ctinnovations.com/funding/ccef/yankee.php, and Ben Franklin Technology Partners, http://www.benfranklin.org/about/index.asp.
62. The Great Lakes Entrepreneur's Quest, a program in Michigan, is similar. Its organizers represent Michigan's entrepreneurial community: academics, investors, lawyers, CPAs, corporate executives and other entrepreneurs. The program gives competitors a chance to win seed capital and valuable services (e.g., legal, accounting, and consulting) and provides other opportunities to help entrepreneurs launch or grow a business.
63. Representative Michael Grimm et al., H.R. 714, "The Startup Act 3.0," http://www.gpo.gov/fdsys/pkg/BILLS-113hr714ih/pdf/BILLS-113hr714ih.pdf.
64. FAST Deployment Act of 2010," S. 4047, 111th Cong. (2010), http://www.gpo.gov/fdsys/pkg/BILLS-111s4047is/pdf/BILLS-111s4047is.pdf.
65. Phone interview with Mike Alder, Chairman, WestCamp Inc., and Director, Brigham Young University Technology Transfer Office, April 5, 2013.
66. Ezell and Atkinson, *International Benchmarking of Countries' Policies and Programs*.
67. Atkinson and Ezell, *Innovation Economics: The Race for Global Advantage*, 155-156.
68. Atkinson et al., *Taking on the Three Deficits: An Investment Guide to American Renewal.*
69. Economic Development Administration, "Regional Innovation Clusters Initiative Overview," 2010, http://www.eda.gov/AboutEDA/RIC/.

70. Mary Elizabeth Hughes, *Technology Transfer and Commercialization Landscape of the National Laboratories* (Washington, DC: Institute for Defense Analysis, June 2011), https://www.ida.org/upload/stpi/pdfs/p-4728nsfinal508compliantfedlabttcreport.pdf.
71. Stephanie S. Shipp et al., *Emerging Global Trends in Advanced Manufacturing* (Washington, DC: Institute for Defense Analysis, March 2012), 65, http://www.wilsoncenter.org/sites/default/files/Emerging_Global_Trends_in_Advanced_Manufacturing.pdf.
72. State Science and Technology Institute, "FY14 Federal Budget Request Overview."
73. National Science Foundation, Award Abstract #1137138, "Doctoral Dissertation Research: An Archaeological Examination of Shoshone Collective Action," http://www.nsf.gov/awardsearch/showAward?AWD_ID=1137138&HistoricalAwards=false.
74. State Science and Technology Institute, "FY14 Federal Budget Request Overview."
75. Ezell and Atkinson, *Fifty Ways to Leave Your Competitiveness Woes Behind*, 7.
76. Paul Romer, "Endogenous technical change," *Journal of Political Economy* 98 (1990): S71-S102.
77. Shipp, *Emerging Global Trends in Advanced Manufacturing*.
78. Justin Talbot Zorn and Sridhar Kota, "Engineering an Economic Recovery," *The Huffington Post* (blog), January 11, 2013, http://www.huffingtonpost.com/justin-zorn/manufacturing-economic-recovery_b_2662720.html.
79. Ibid.
80. Robert D. Atkinson and Howard Wial, *Boosting Productivity, Innovation, and Growth through a National Innovation Foundation* (Washington, DC: ITIF, 2008), http://www.itif.org/files/NIF.pdf.
81. "Government Bill: A Boost to Research and Innovation," Government Offices of Sweden, November 17, 2008, http://www.sweden.gov.se/sb/d/6949/a/115809/.
82. Jukka Haapamäki and Ulla Mäkeläinen, "Universities 2006," Finnish Ministry of Education, 2007, 23-24, http://www.minedu.fi/export/sites/default/OPM/Julkaisut/2007/liitteet/opm19.pdf.
83. Gregory C. Tassey, "Beyond the Business Cycle: The Need for a Technology-Based Growth Strategy," *Science and Public Policy*, December 19, 2012, 5, www.nist.gov/manuscript-publication-search.cfm?pub_id=910384.
84. Ibid., 10.
85. Denis O. Gray and S. George Walters, *Managing the Industry/University Cooperative Research Center* (Columbus, OH: Battelle Press, 1998), http://www.ncsu.edu/iucrc/PDFs/PurpleBook/FrontSection.pdf.
86. This is based on a report by Stuart Benjamin and Arti Rae, "Structuring U.S. Innovation Policy: Creating a White House Office of Innovation Policy" (Washington, DC: ITIF, June 2009), http://www.itif.org/files/WhiteHouse_Innovation.pdf.
87. Atkinson and Mayo, *Refueling the U.S. Innovation Economy*, 10.
88. Robert D. Atkinson et al., "Addressing the STEM Challenge by Expanding Specialty Math and Science High Schools" (Washington, DC: ITIF, April 2007), http://www.itif.org/files/STEM.pdf.
89. Many MSHS students are able to take these extra courses by taking regular education graduation requirements such as Economics, American Government, Physical Fitness, and Health online at the Florida Virtual High School.
90. Source for national figures are: U.S. Department of Education, National Center for Education Statistics, "Digest of Education Statistics," Table 181: http://nces.ed.gov/programs/digest/d05/tables/dt05_181.asp; U.S. Department of Education, National Center for Education Statistics, "2000/01 Baccalaureate and Beyond Longitudinal Study," http://nces.ed.gov/das/library/tables_listings/show_nedrc.asp?rt=p&tableID=1378.
91. Some of the expansion would come from construction and creation of new specialty MSHSs. Costs of building such a high school can range from around $11 million (for rehabilitating an existing building) to over $50 million for constructing a new MSHS in an area where land prices are more expensive. Some expansion of enrollment would come from expanding existing high schools, where the price would presumably be less. However, even at these schools the costs can be higher, particularly for more extensive laboratory equipment. Overall these funds will be used as a federal incentive to spur states and local school districts to create more specialty math and science high schools.
92. The Harrisburg University of Science and Technology, "About Us," http://www.harrisburgu.net/about/.

93. The Harrisburg University of Science and Technology, "The HU Story," http://www.harrisburgu.net/about/story/.
94. Executive Office of the President, President's Council of Advisors on Science and Technology (PCAST), *Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics* (Washington, DC: PCAST, February 2012), http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-engage-to-excel-final_2-25-12.pdf.
95. David Lopatto, *Science in Solution: The Impact of Undergraduate Research on Student Learning* (Tucson, AZ: Research Corporation for Science Advancement, 2009); Sandra Laursen et al., *Undergraduate Research in the Sciences: Engaging Students in Real Science* (San Francisco: Jossey-Bass, 2010).
96. Elaine Seymour and Nancy M. Hewitt, *Talking About Leaving: Why Undergraduates Leave the Sciences* (Boulder, CO: Westview Press, 2000).
97. Ibid.
98. Richard Sabot and John Wakeman-Linn, "Grade Inflation and Course Choice," *Journal of Economic Perspectives* 5, no. 1 (1991): 159–170.
99. Jay H. Parekh, *Do Median Grades Vary Across Departments?,* CHERI Working Paper No. 30 (Ithaca, NY: Cornell University, ILR School, 2002), http://author.ilr.cornell.edu/cheri/workingPapers/upload/cheri_wp30.pdf.
100. These institutions are Amherst College, Duke University, Hamilton College, Haverford College, Pomona College, the University of Michigan, the University of North Carolina and the University of Wisconsin. Richard Sabot and John Wakeman-Linn, "Grade Inflation and Course Choice."
101. Paul M. Romer, "Should the Government Subsidize Supply or Demand in the Market for Scientists and Engineers?," *Innovation Policy and the Economy* 1 (2000): 221–252.
102. Ibid.
103. Atkinson and Mayo, *Refueling the U.S. Innovation Economy*, 127, 152.
104. Howard Hughes Medical Institute, "Science Education Alliance," http://www.hhmi.org/grants/sea/index.html.
105. Atkinson and Mayo, *Refueling the U.S. Innovation Economy*, 125, 154.
106. Robert D. Atkinson, "Student-Survey Results: Too Useful to Keep Private," *The Chronicle of Higher Education*, November 15, 2009, http://chronicle.com/article/Student-Survey-Results-Too/49128/.
107. The National Science Foundation, "FY 2013 NSF Budget Request to Congress," 14, http://www.nsf.gov/about/budget/fy2013/.
108. Abt Associates, *Training the Next Generation of Researchers: A Follow-up Study of Students Supported by NSF's Integrative Graduate Education and Research Training Program* (Washington, DC: National Science Foundation, 2010), http://www.abtassociates.com/reports/Abt_1-page_report_summary_May_2010.pdf.
109. National Science Foundation, "FY 2014 NSF Budget Request to Congress," (Arlington, VA: NSF, 2013), 38-41, www.nsf.gov/about/budget/fy2014/pdf/41_fy2014.pdf.
110. Ibid., 40.
111. Richard Freeman, "Investing in the Best and the Brightest: Increased Fellowship Support for American Scientists and Engineers" (Washington, DC: The Brookings Institute, 2006), http://www.brookings.edu/views/papers/200612freeman.pdf.
112. Established in the early years of NSF, the program provides the nation's most promising graduate students with great flexibility in selecting the university of their choice and gives them the intellectual independence to follow their research ideas unfettered by the exigencies of mode of support.
113. Donald Wulff, Ann Nquiest, and Jo Sprague, "The Development of Graduate Students as Teaching Scholars: A four-year longitudinal study," in *Paths to the professoriate: Strategies for enriching the preparation of future faculty,* eds. Donald Wulff and Ann Austin (San Francisco: University of Chicago Press, 2006); Chris Golde and Timothy Dore, "At Cross Purposes: What the experiences of today's doctoral students reveal about doctoral education," Pew Charitable Trusts, 2001, http://www.phd-survey.org/report%20final.pdf.
114. Jody Nyquist, BJ Woodford, and Dale Rogers, "Re-envisioning the PhD: A challenge for the twenty-first century," in *Paths to the professoriate: Strategies for enriching the preparation of future faculty,* eds. Donald Wulff and Ann Austin (San Francisco: University of Chicago Press, 2006).
115. Golde and Dore, "At Cross Purposes."

116. Steven Campbell, Angela Fuller, and David Patrick, "Looking beyond research in doctoral education," *Frontiers in Ecology and the Environment* 3, no. 3 (2005), http://www.biology.duke.edu/jackson/ecophys/153-160_ESA_April05.pdf.
117. Moreover, research suggests that there is little difference in ethical behavior by faculty whether they are funded by industry or government; see Brian Martison, Lauren Crain, Melissa Anderson, and Raymond De Vries, "Institutions' Expectations for Researchers' Self-Funding, Federal Grant Holding, and Private Industry Involvement: Manifold Drivers of Self-Interest and Research Behavior," *Academic Medicine* 84, no. 11 (2009).
118. Annalee Saxenian, "Silicon Valley's New Immigrant High-Growth Entrepreneurs," *Economic Development Quarterly* 16 (2002): 20-31.
119. David Hart, "Global Flows of Talent: Benchmarking the United States" (Washington, DC: ITIF, November 2006), http://www.itif.org/files/Hart-GlobalFlowsofTalent.pdf.
120. Senator Orin Hatch et al., "Immigration Innovation Act of 2013," 9, http://www.coons.senate.gov/download/immigration-innovation-act.
121. Michael Stratford, "House Passes Visa Bill for Foreign Graduates, Over Democrats' Objections," *The Chronicle of Higher Education*, April 11, 2013, http://chronicle.com/article/House-Passes-Visa-Bill-for/136087/.
122. Startup Act 3.0, S. 310, 113th Cong. (2013), http://www.govtrack.us/congress/bills/113/s310/text.
123. Liz Halloran, "Gang Of 8 Champion Plan, Declare 'Year Of Immigration Reform'," *National Public Radio,* April 18, 2013, http://www.npr.org/blogs/itsallpolitics/2013/04/18/177780665/bipartisan-senate-gang-prepares-to-sell-immigration-plan.
124. Atkinson and Ezell, *Innovation Economics: The Race for Global Advantage*, 273-274.
125. Robert D. Atkinson and Scott Andes, *The Atlantic Century II: Benchmarking U.S. and EU Innovation and Competitiveness* (Washington, DC: ITIF, 2011), http://www.itif.org/files/2011-atlantic-century.pdf .
126. Atkinson et al., *Taking on the Three Deficits: An Investment Guide to American Renewal*.
127. David Leonhardt, "One Way to Trim Deficit: Cultivate Growth," *New York Times*, November 16, 2010, http://www.nytimes.com/2010/11/17/business/economy/17leonhardt.html.
128. Congressional Budget Office, "The Budget and Economic Outlook: Fiscal Years 2011-2021," January 2011, http://www.cbo.gov/doc.cfm?index=12039.

ABOUT THE AUTHORS

Stephen Ezell is a Senior Analyst at the Information Technology and Innovation Foundation, with a focus on science, technology, and innovation policy issues. Mr. Ezell holds a B.S. from the School of Foreign Service at Georgetown University, with an Honors Certificate from Georgetown's Landegger International Business Diplomacy program. He is the co-author of *Innovation Economics: The Race for Global Advantage* (Yale University Press, September 2012).

Dr. Robert Atkinson is the President of the Information Technology and Innovation Foundation. He is also the author of the books *Innovation Economics: The Race for Global Advantage* (Yale University Press, 2012) and *The Past and Future of America's Economy: Long Waves of Innovation that Power Cycles of Growth* (Edward Elgar, 2005). Dr. Atkinson received his Ph.D. in City and Regional Planning from the University of North Carolina at Chapel Hill in 1989.

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