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Role the U.S. Government Can Play in Restoring U.S. Innovation Leadership

before the

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Mr. Chairman, Mr. Smith, and members of the Committee, I appreciate the opportunity to appear before you to discuss the critical question of U.S. innovation leadership and what the federal government can do about it.

The United States is no longer the global innovation leader and our rank is rapidly slipping. The effects are seen in increased trade deficits, relatively lower increases in standards of living, higher unemployment and even the severity of the current economic crisis. While ultimately businesses and other organizations (e.g., universities) will have to take the lead in driving innovation, the federal government can and should take a much more proactive role. As I describe below, Congress can take a number of important steps, including: ensuring that USTR takes a more aggressive role in trade enforcement, expanding the R&D credit, promoting science, technology, engineering and math (STEM) skills and increasing support for research and most importantly research commercialization. In addition, we encourage the Committee to particularly consider two ideas discussed in more detail below: the creation of a national innovation and competitiveness strategy and the establishment of a National Innovation Foundation, akin to the National Science Foundation (NSF), but for innovation.

What is at Stake: Why is Innovation Important?

In recent years, a growing number of economists have come to see that it is not so much the accumulation of more savings or capital that is the key to improving standards of living; rather it is innovation—the creation and adoption of new products, services, processes, and business models.[1] When economists Klenow and Rodriguez-Clare decomposed the cross-country differences in income per-worker into shares that could be attributed to physical capital, human capital and total factor productivity, they found that more than 90 percent of the variation in the growth of income per worker was a result of how effectively capital is used (e.g. innovation), with differences in the actual amount of human and financial capital accounting for just 9 percent.

Innovation is also essential if we are to create a future of better jobs for all Americans. Properly conceived, innovation is not just about creating more jobs for engineers and managers in high technology industries. It is also about providing more and better training for incumbent workers in manufacturing and “low-tech” services and reorganizing work processes so that their companies can perform better. Boosting innovation leads to higher real wages for American workers, and in the moderate- to the long-term, (and often in the short-term as well) leads to more jobs. Innovation, properly conceived, also benefits not just the notable high-tech regions of the nation, but all regions.

The growth of international trade also makes it increasingly important for the United States to innovate to maintain its standard of living. Low-wage nations can now more easily perform labor-intensive, difficult-to-automate work in manufacturing and in a growing share of services. Indeed, it has become difficult for the United States to compete in such industries as textiles and commodity metals. Notwithstanding the efforts of countries like China and India to compete in advanced technology industries, for the foreseeable future their competitive advantage should remain in more labor-intensive, less complex portions of the production process.[2]

By contrast, the United States' primary source of competitive advantage should be in innovation-based activities that are less cost-sensitive. To illustrate, a software company can easily move routine programming jobs to India where wages are a fraction of U.S. levels. There is less economic incentive for moving advanced programming and computer science jobs there because innovation and quality are more important than cost in influencing the location of these jobs. Likewise, an auto company can easily move production of commodity car parts to China. But the case for moving advanced research and development or production of complex, technology-driven parts (such as drive trains) there is weaker.

Nor does this mean that the United States must inevitably cede entire industries to low-wage countries. Even in industries such as apparel and textiles, which are dominated by labor-intensive production, some firms have carved out innovation-based product niches (e.g., high-fashion articles whose designs change rapidly or textiles made of advanced materials) that make it possible for them to produce in the United States. Moreover, with sufficient productivity growth, companies can offset the cost of high U.S. wages, enabling them to produce in the United States at costs equal to or below those of low-wage countries.

The United States Led in Innovation from WWII to the End of the 20th Century

Prior to World War II, it could be argued that Europe, and in particular Germany and Great Britain, led in innovation. However, since World War II until the early part of the last decade, the United States led the world in innovation. A range of statistics consistently showed this. We were leading on patents, corporate R&D, Nobel Prize winners, high tech exports, etc. Indeed, as the Information Technology and Innovation Foundation (ITIF) documented in a report, *The Atlantic Century*, released last year, the United States was ranked first among 40 leading nations in 2000 according to an amalgam of 16 innovation-based competitiveness factors (such as funding of corporate and government R&D, venture capital as a share of GDP, new businesses created, number of scientists and engineers as a share of the workforce, etc.). And our lead was not slight; we were far ahead of our closest two rivals (Sweden and Singapore).

What Factors Helped the United States Lead in Innovation-based Competitiveness?

There are a number of policy and non-policy factors which contributed to the United States lead in innovation from the 1940s through to the 2000s.

On the non-policy side, a key factor was our large and growing market which enabled U.S. corporations to have large enough markets to invest in R&D at the scale needed to drive innovation. The large market (both in number of consumers but also in their higher incomes) also meant that U.S. firms could gain economies of scale and economies of learning that enabled costs to be driven down and new generations of products and services to become profitable faster. For example, in 1960, the number of automobiles sold in Los Angeles County alone exceeded all those sold in Asia or South America.[3]

Indeed, the U.S. led the world in the application of mass production manufacturing to virtually all sectors. Numerous production innovations, including automated assembly lines, numerically controlled machine tools, automated process control systems and mechanical handling systems drove down prices in American manufacturing and led to production of a cornucopia of inexpensively manufactured consumer goods.

The United States was also the first nation to transform its innovation system into a science-based one where innovation was derived from a more fundamental understanding of underlying processes than from one of mere tinkering and mechanical trial and error. As economist Joseph Schumpeter argued in the 1940s, reflecting on the U.S. economy, "Technological progress is increasingly becoming the business of teams of trained specialists who turn out what is required and make it work in predictable ways."[4] As a result, U.S. R&D expenditures skyrocketed by 400 percent between 1953 and 1964. For example, DuPont's R&D expenditures increased from around $1 million per year in 1921 to over $60 million by the mid-1950s.[5] The number of research and development laboratories increased from around 1,000 in 1927—with few doing basic research—to almost 5,000 in 1956, with many, like Bell Labs, conducting extensive basic research. As the innovation process became systematized and corporatized, engineers became more important. In 1900, engineers made up only 0.05 of the population, but by 1940, 2 out of 1,000 people were engineers, and by 1970, 6 out of 1,000 were.[6] As a result, the locus of innovation also switched from individual inventors like Edison and Bell tinkering in their garages to scientists working in corporate R&D laboratories.[7] One reflection of this is the fact that in 1901 there were 20,896 patents issued to individuals, with only 4,650 going to corporations. This evened out by the 1930s, but by the mid-1950s the corporate rate took off. By 1980, corporations obtained about five times more patents than individuals.

But our lead in scientific discovery alone was not enough to propel the United States to the lead. That required firms willing and able to make the investments needed to transform from invention to innovation and commercialization. And a key factor was the new science of management and the organization of firms able to handle large complex production systems. After WWII, new forms of corporate organization emerged, in which a top managerial cadre became empowered with the information necessary to centrally manage massive, sprawling enterprises. When the large, multidivisional company became commonplace after World War II, CEOs put in place elaborate paper-based managerial systems to coordinate these sprawling companies. Millions of new white-collar middle managers were needed to make these behemoths work. This rise of a new managerial class was one of the most profound changes resulting from the rise of the corporate economy. Indeed, after World War II, the formal discipline of management emerged. James Burnham's 1941 book, *The Managerial Revolution,* argued that the world was witnessing the emergence of a new ruling class, 'the managers,' who would soon replace the rule of capitalists and communists alike. Combine this with the emergence of world class business schools that educated managers who could manage innovation, and the United States had another lead over its competitors who did not embrace the 'new managerialism' until decades later.

Other factors played a role. The American inventor and entrepreneurial ethos also helped drive our innovation lead. More so than any other nation at the time, America was a place where "anyone could make it," provided they worked hard and took risks. America was able to draw on the talents of a larger share of the population to drive innovation. And related to this, in contrast to many nations, failure was not seen as a stigma from which recovery was difficult. Rather, it was a mark that someone had the fortitude to take a risk, and perhaps the second (or third, or fourth) time would be the charm. Moreover, in those days, if one wanted to remake oneself, one simply moved south or west. Indeed, the very size of our nation and the relative underdevelopment of much of the West and South until the 1970s meant that entrepreneurs could locate in places unconstrained by the dead weight of tradition and inertia. No wonder that in the 1960s Silicon Valley instead of Pittsburgh (where the largest electronics firm in the world at the time, GE, was headquartered) became the world's innovation leader. Pittsburgh was a place where if it hadn't been tried before, it was probably because it was a bad idea. Silicon Valley was a place where if it hadn't been tried before, it probably meant it was a good idea that no one had yet before come up with. In addition, in comparison to other nations that exhibited greater institutional rigidities and hierarchies, the more flexible and collaborative U.S. innovation system provided an advantage. Compared to other nations, the U.S. innovation system has long been characterized by collaboration and cooperation, with universities working more closely with industry, small firms working with large ones, etc.

Finally, our financial system provided real advantages. Compared to other nations it was easier for entrepreneurs to get financing for new and risky ventures, and for those firms to pay back initial investors, either by issuing stocks or getting large firms to finance their acquisitions as the way to maintain a pipeline of new products.[8]

It would be a mistake to argue, though, that it was only, or even largely, non-policy factors that led to America becoming the world's innovation leader. Clearly some of our policy choices to regulate less and to be more accepting of change propelled the United States to lead.

Our relatively open borders (itself a policy factor) made the United States a mecca for talent. 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. Both the U.S. economy and the standard of living of American citizens have benefited enormously from this influx of foreign talent. 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.[9] During this period, many of the leading scientists, managers and entrepreneurs came from other nations where opportunities were more limited and in some cases where the opportunities didn't even exist, as was the case in communist nations.

Likewise, our embrace of a light regulatory touch in the face of new technologies allowed innovators to be confident that their innovations would be able to enter the market. In contrast, regulatory regimes such as the European "precautionary principle," which sought to limit innovation until all possible effects were known, slowed innovation. And in fast-moving industries where competitive advantage is related to how quickly players get in the market and establish a position, the slower and more restrictive regulatory regimes in many other nations benefited the United States.

The overall business climate and rule of law that the United States has enjoyed has provided entrepreneurs and firms with the certainty that if they invested they could make a market-based rate of return. Likewise, the United States' leadership in promoting open markets and globalization helped the United States, at least through the 1980s, for it expanded the size of markets, allowing more dominant U.S. technology-based firms to gain even more scale and profits (allowing them respectively in turn to drive prices down even more and to invest more into research and new technology).

In addition, while the United States brought a number of anti-trust cases during this period, the emergence of a large number of large, profitable companies meant that innovations were a way that firms could charge premium prices or even gain market share from their competitors. With constrained competition and consequent market control, these companies could apply lower discount rates to new research opportunities; in essence, they were willing to take on the higher levels of risk required to pursue more radical but higher payoff technologies. As a result, many of these dominant firms used the steady flow of profits to invest heavily in their own research laboratories. They created factories for inventions that brought large numbers of scientists and engineers directly under the corporate umbrella. In the 1950s and 1960s, the central research laboratories of firms such as AT&T, GE, IBM, RCA and Xerox were corporate jewels that attracted highly productive researchers.

But proactive policies also played a key role. Perhaps the most important one was the role of government as a buyer of technology and funder of research and education. During the three decades immediately following World War II, the Federal government's role in supporting new technologies centered on military and space imperatives. Such familiar spin-offs as mainframe computers and jet airplanes had been largely unintended consequence of government spending for the military and the space program, both in support for research in these areas and procurement of products using these technologies. Clearly the United States' lead in many technology areas, including information technology, would not have occurred without government procurement and government support for R&D. Indeed, as late as 1992, Santa Clara County (Silicon Valley) received more defense contracts than any other county (in dollar value as a share of county economic output).

But support for research and research universities was also central in driving U.S. innovation leadership. Federal and state support meant that a large number of research universities were not only doing cutting-edge research, much of it transferred to the private sector, but also educating a regular crop of top notch scientists and engineers. Our global lead in pharmaceutical and biotech industries, for example, would not have been as strong without the significant funding provided to NIH, much of which in turn supported leading research universities.

As the United States excelled, its lead over other nations expanded, leaving the Europeans fearful of being left behind. In the 1960s, French author Jean-Jacques Servan-Schreiber wrote the best seller, *The American Challenge*, which described an all powerful American economic system widening its technological lead and utilizing superior management ability and economies of scale to take over the European economy.

But our unparallel leadership lasted only approximately 25 years. For by the mid-1970s, evidence was emerging that the United States faced new innovation competitors. But U.S. policy didn't stand still in response to the challenges of globalization 1.0 in the 1980s (the emergence of Japan and Europe as key competitors). Indeed, significant changes occurred in Federal policies in the 1980s in direct response to the heightened international competitive pressures experienced by U.S.-based corporations. In that decade, both Congress and the Executive Branch launched a series of initiatives that were intended to mobilize public resources to accelerate the development and commercial exploitation of new technologies. These programs extended well beyond the defense and space sectors that had previously been the main areas of Federal technology policy.

These initiatives can be usefully grouped into four separate areas. First, there were a series of efforts to increase the commercial impact of research already being funded by the Federal government, particularly in universities and government laboratories. Incentives were created for scientists and institutions to push their research discoveries into the commercial sphere either by creating new start-ups, licensing technologies to private firms or engaging in collaborative projects with business firms. The Bayh-Dole Act encouraged universities to see their research enterprise as a potential revenue source and concerted efforts were made over twenty years to shift resources in the Federal Laboratories away from weapons production and towards commercial applications.

Second, new programs were created to help finance pre-competitive research and development costs for individual firms, both startup and established firms.[10] Most prominent among these programs was the Small Business Innovation Research (SBIR) program through which government agencies set aside a small percentage of their R&D budgets for projects proposed by small firms, many of which are newly created spinoffs from university or federal laboratories. The Advanced Technology Program (ATP) at the National Institute of Standards and Technology (NIST) and a series of initiatives at the Department of Energy provided matching funds to support particularly promising new technologies among both new and more established firms. In addition, the United States was the first nation to create a Research and Development (R&D) Tax credit in 1981.

Third, the Federal Government expanded its “in-kind” technical support to business firms trying to surmount technological barriers. The Manufacturing Extension Partnership (MEP) has helped thousands of small firms adapt to computerization and the more demanding schedules of just-in-time production. The National Nanotechnology Initiative has made a series of federally funded, university-based laboratories available to business firms that want to avoid the costs of developing their own laboratory infrastructure. Similarly, efforts by Federal laboratories to form partnerships with firms provide them with important technical support, including through the formation of Cooperative Research and Development Agreements (CRADAs).

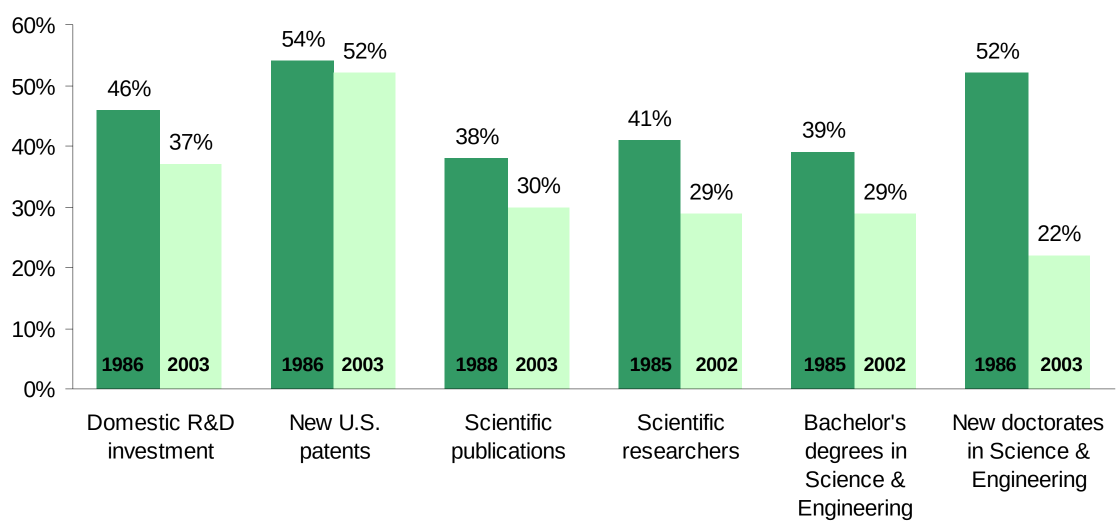
Fourth, the Federal government played an active role in facilitating and supporting research consortia that bring together multiple firms in the same industry to solve technological problems. The passage of the 1984 Cooperative Research and Development Act made it easier for companies to collaborate. Federal investment in SEMATECH in the 1980s and the Semiconductor Focus Center Program in the 1990s helped the semiconductor industry maintain a leadership position.[11] Congress created programs at NSF to spur more collaborative research, including NSF’s Engineering Research Centers, a group of 17 interdisciplinary centers located at universities and operated in close partnership with industry.

The United States Has Lost its Lead in Innovation

The combination of its policy and non-policy strengths, combined with policy and non-policy weaknesses in other nations, enabled the United States to lead in innovation for over half a century. However, changes both in the United States and abroad have meant that while the United States continues to have many strengths, there is disturbing evidence that our overall innovation lead has not only been lost, but that we are continuing to rapidly lose ground. As ITIF documented in *The Atlantic Century*, from the year 2000 to 2009, the United States slipped from number 1 to number 6 in global innovation-based competitiveness, behind nations such as Singapore, Denmark, Sweden and South Korea. The primary reason for this is that every other nation or region made faster progress than we did on a collection of 16 innovation competitiveness indicators. Overall, we ranked 40th out of 37 countries and three regions in making progress on innovation and competitiveness.

We see signs of this relative decline in innovation capacity in a wide array of indicators. The decline began at least in the 1990s with the United States' shares of worldwide total domestic R&D spending, new U.S. patents, scientific publications and researchers and bachelor's and new doctoral degrees in science and engineering all falling from the mid-1980s to the beginning of this century (figure 1), when we were still number 1. But given our strong overall lead, the declines were not enough to move us down from number 1 until this last decade.

FIGURE 1: Changes in U.S. Share of Global Totals On Various Science and Technology Indicators



Source: Council on Competitiveness

There has been a declining share of American college graduates with science and technology degrees. 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. Although Americans (citizens and permanent residents) are getting graduate degrees at an all-time high rate, the increase in graduate degrees in natural science, technology, engineering and math fields has been minimal during the last two decades. The number of non-science and engineering degrees increased by 64 percent between 1985 and 2002, while the number of science, technology, engineering and mathematics degrees grew by only 14 percent during that period.[12]

The United States ranks only 14th among countries for which the National Science Foundation tracks the number of science and engineering articles per million inhabitants. Sweden and Switzerland produce more than 60 percent as many science and engineering articles in relation to the size of their populations than does the United States.[13]

The United States ranks only seventh among OECD countries in the percentage of its GDP that is devoted to R&D expenditures (2.6 percent), behind Sweden (3.9 percent), Finland (3.5 percent), Japan (3.3 percent), South Korea (3.0 percent), Switzerland (2.9 percent), and Iceland (2.8 percent), and barely ahead of Germany and Denmark (2.5 percent each).[14] One reason explaining this is that the United States is one of the few nations where total investments in R&D as a share of GDP fell from 1992 to 2005 (largely because of a decline in public R&D support).[15] Moreover, corporate-funded R&D as a share of GDP fell in the United States by 5 percent from 1999 to 2006, while in Europe it grew by 2 percent and in Japan it grew by 12 percent.[16]

We also see the evidence of our decline in innovation-based competiveness in other areas including our trade performance. The trade deficit represents perhaps the most visible manifestation of the global challenge. At 5 percent of GDP in 2008, the current account deficit is at extremely high levels both in absolute terms and relative to the size of our economy.[17] The traditional U.S. trade surplus in agricultural products is nearing zero and in high-technology products has already turned negative. Meanwhile, our surplus in services trade is small and only holding relatively steady. Moreover, the U.S. trade surplus in services is only 17 percent of the overall trade deficit in goods.

Moreover, companies are increasingly shifting R&D overseas. For example, R&D expenditures from U.S.-based MNCs in emerging Asian markets increased from 5 percent to 14 percent between 1995 and 2006.[18] In the last decade, the share of U.S. corporate R&D sites in the United States has declined from 59 percent to 52 percent, while the share in China and India, specifically, increased from 8 to 18 percent.[19]

We also see it in the decline in U.S. manufacturing output. The United States has experienced a hollowing out of many advanced production supply chains, as more advanced manufacturing has moved offshore than has expanded in the United States. I recently spoke with the CEO of a major U.S. high technology company about a new product line they were introducing. I asked him where he was sourcing the very advanced display that was being incorporated in the device. His response was “we looked long and hard around the United States to see if we could source it here. We couldn’t find any company with the capability of producing here, so we ended up sourcing it in Taiwan.”

This hollowing out of supply chains is overlooked by many economists because the national economic accounts that track manufacturing output provide a misleading picture of the health of U.S. manufacturing by overstating output, particularly in the computer and semiconductors industry. According to the Department of Commerce’s Bureau of Economic Analysis, manufacturing output as a share of GDP has stayed somewhat constant between 1994 and 2008, at around 13.7 percent.[20] But drilling down to more detail causes a different picture to emerge. Over the last 25 years, the share of non-durable manufacturing output peaked around 1993 and has declined from around 7 percent to 4.7 percent of GDP in 2008. The share of durables, in contrast, increased to just over 9 percent in 2007, with a very slight decline in 2008, leading many to the rosy conclusion that while manufacturing employment may have declined, manufacturing output is still strong and therefore that employment declines were due only to the higher levels of productivity in manufacturing relative to the rest of the economy. But taking out computers and electronic products (NAICS code 334) shows a very different picture, with durable goods output share declining from 7 percent in 1998 to 5.3 percent in 2008. Overall manufacturing output minus computers and electronic products declined from 13 percent of GDP in 1998 to just 9.7 percent in 2008. Defenders of the status quo will respond that the proper measure is overall manufacturing, not manufacturing minus computers. But does anyone really think that the real inflation-adjusted value added of computers and electronic products really doubled between 2003 and 2007, which is what the BEA numbers suggest? The problem is that BEA counts output of computers based on improvements in Moore's law and when processing power doubles every 18 months or so it counts that in the value-added. But this clearly overstates output and provides an extremely misleading picture of the real health of the U.S. manufacturing sector. For those who want to play down the threat to the U.S. manufacturing base, these statistics provide reassuring, if false, comfort.

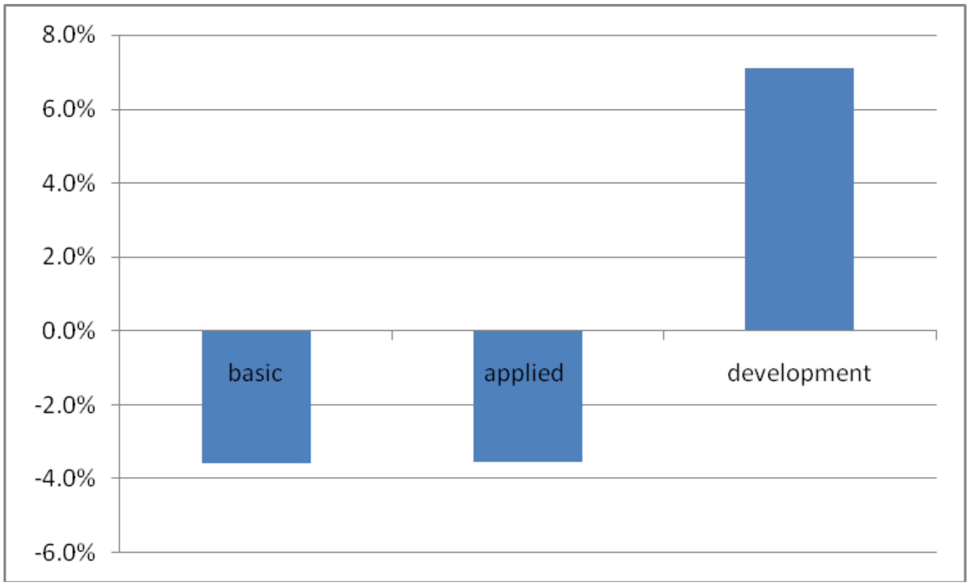
Factors Contributing to our Relative Decline in Innovation-based Competitiveness

There are a number of factors which have contributed to the United States' relative decline in innovation-based competitiveness. Many point to globalization. At one level there is no doubt that with the emergence of globalization and the relatively faster growth in income of many nations to "catch up" to the United States, one would expect to see the global share of U.S. economic output fall. And it is certainly true that as some advanced nations began to catch up to the United States (in part by emulating our policies, as described below) the U.S. share of global innovation output (e.g., R&D and patents) would also fall, although by less than overall economic output since the United States should actually be increasingly specializing in innovation-based activities as more routine-based production shifts offshore. But there was nothing preordained about the United States falling from number 1 in 2000 to number 6 in 2009. The United States can and should remain the global innovation leader.

So what happened? As in explaining our success, non-policy and policy factors have played a role. There are a number of non-policy factors that appear to be at work. First, the evolution of U.S. financial markets has placed mounting pressure on large corporations to prioritize increasing short-term returns to shareholders over growth or investments with longer-term payoffs. And related to this, the market environment has become much more competitive.

On the one hand, this has disciplined firms into being more efficient. But at the same time it has led many firms to seek short-term cost reductions (often through moving to lower cost locations) even if similar or even greater cost reductions through innovation could be achieved but over a slightly longer period of time. Likewise, these new financial pressures have forced many firms to reallocate their research portfolios more toward product development efforts and away from longer term and more speculative basic and applied research. From 1991 to 2007, basic research as a share of total corporate R&D conducted in the United States fell by 3.6 percentage points, while applied research fell by roughly the same amount, by 3.5 percentage points. In contrast, development's share of corporate R&D increased by 7.1 percentage points, as figure 2 shows.

FIGURE 2:
BETWEEN 1991 AND 2007, THE SHARES OF TOTAL CORPORATE R&D DEVOTED TO BASIC AND APPLIED RESEARCH DECLINED WHILE THE SHARE DEVOTED TO DEVELOPMENT INCREASED



Source: Authors' analysis of National Science Foundation data

We see this focus on the shorter term in the venture capital industry. As the venture capital market has matured, firms have found it more profitable to invest in larger deals and less risky later-stage deals. Even though the overall amount of venture capital has grown since the mid-1990s, the actual amount invested in startup- and seed-stage venture deals is smaller today than a decade ago, and a smaller percentage of venture funding now goes to early-stage deals (the stage just after seed-stage).[21] The result is a gap between the completion of basic research and applied R&D.

When it comes to policy, it is important to focus both on the change in policy in the United States and externally. Externally, as we discuss below, nations put in place aggressive technology and competitiveness policies to lure internationally mobile technology investment. U.S. firms are now competing against firms in a growing number of national economies in which their governments actively help them compete.

Over the last 15 years in particular, a large number of other nations have woken up to the fact that they need to compete for internationally mobile high technology manufacturing, and they have put in place policies that reflect that determination, such as more generous research and development tax treatments and stronger government support for all stages of research. In contrast, the United States has lagged behind, believing that it needed to do little since it had long been the global innovation leader. In the early 1990s, for example, the United States had the most generous research and development tax credit among the 30 OECD nations. Now, because other nations have expanded their R&D tax incentives, the U.S. rank has fallen to 17th.

In response to increased global competition for internationally mobile economic activities, most nations have established competitiveness policies, including more competitive corporate tax codes. In the early 1980s, the average statutory tax rate amongst OECD nations was nearly 50 percent; by 2001 the rate had fallen to under 35 percent. Some formerly high tax nations have reduced their taxes dramatically. For example, the statutory corporate tax rate in Sweden in 1982 was 60 percent; by 1999 it had been reduced to 28 percent. Overall, average corporate tax rates have declined by at least 15 percentage points in leading industrialized nations over the last 30 years. Not only have corporate tax rates declined, but a growing number of nations, particularly Asian nations, use targeted tax incentives (such as tax holidays on new plants) to attract internationally mobile investment. The U.S. statutory rate has not changed since 1986, and the federal government does not provide tax incentives to attract or retain international investment.

We see the same trend in other areas. Among 36 nations, the United States ranked just 21st in the growth of government investment in R&D from 1999 to 2006, with a growth rate of just 20 percent the average of the other nations. The major reason for this slippage has been a slowdown in federal R&D investment. Since the mid-1990s total federal R&D spending grew at a sluggish 2.5 percent per year from 1994 to 2004—much lower than its long-term average of 3.5 percent growth per year from 1953 to 2004.[22] Indeed, the United States is one of only a few nations where total investment in R&D as a share of GDP actually fell from 1992–2005, largely because of that decline in public R&D support.[23] When U.S. R&D intensity is compared to other OECD countries, we find that at 2.6 percent of GDP devoted to R&D investment, the United States ranks only seventh in R&D intensity, behind a list of countries including Japan, South Korea, Finland and Sweden.[24] In more recent rankings (2006) from the OECD, the United States placed only 22nd in the fraction of GDP devoted to nondefense research.[25]

Finally, while many nations have practiced "good" innovation policy, many have also put in place "bad" innovation policy: high-tech mercantilism. Indeed, a key factor in the loss of U.S. innovation leadership has been the dramatic increase in technology-oriented trade protectionism engaged in by many U.S. competitors. While U.S. markets are generally open, the same cannot be said for many other nations. Many nations, and not just China, manipulate their currency as a way to subsidize exports and raise the price of imports. On top of that they use an array of tariff barriers to keep out U.S. exports. But these nations go further, engaging in a kind of protectionism 2.0. This involves aggressive anti-trust enforcement, particularly against U.S. high tech companies (witness foreign actions taken against U.S. tech companies like Microsoft, Intel and Qualcomm); technology standards manipulation (the Chinese alone have developed over 15 proprietary technology standards designed to keep out U.S. IT products); turning a blind eye to and even engaging in rampant intellectual property theft (over 85 percent of software in China is pirated, while many nations attempt to force U.S. pharmaceutical companies to transfer intellectual property in return for market access); and huge government subsidies to prop up high-tech exporters (without EU government subsidies, Airbus would have nowhere near the global market share it does).

But even absent what other nations have done, the U.S. relative position would have declined because of policies at home. One policy area that has been cited by many is K-12 education. While there is no doubt that improving the quality of K-12 education will have some positive benefit on our innovation-based competitive position, it would be a mistake to believe that fixing K-12 will be the silver bullet for innovation. K-12 quality has not been the major reason for the precipitous and troubling decline in U.S. innovation leadership. In fact, while the U.S. competitiveness position has declined relative to other nations, at least by one measure, our educational performance has not. For 20 nations for which there are comparable data, between 1999 and 2007 the United States ranked fourth in improvement in 8th grade math scores an sixth out of 25 nations in 8th grade science scores according to TIMMS (Trends in International Mathematics and Science Study). The United States has also made greater improvement in 8th grade science scores than several international leaders such as Japan, Sweden, Norway and Singapore between 1999 and 2007.

The United States does less well on the OECD's PISA (Programme for International Student Assessment) test, which focuses more on measures of application of learning to real world situations than does TIMMS. Still, the U.S. performance on PISA has not been so bad as to indicate our economic decline. In reading, math and science, U.S. 15-year-olds in 2000 (who would now be 25-years-old and entering the workforce) performed about as well on average as 15-year-olds in the 27 participating OECD countries and ahead of the 4 non-OECD nations. Compare the United States and Denmark. Denmark outperformed the United States in innovation-based competitiveness, ranking fifth in progress, compared to our last place rank. Yet, in 2000, U.S. 15-year-olds outperformed Danish 15-year-olds on reading, math and science. Likewise, U.S. 15-year-olds did better than 15-year-olds in Germany, Spain, Russia and Brazil, all of which made faster progress on competitiveness. Let us also remember that U.S. college education levels are at historic highs. In 2007, 46 percent of high school graduates between the ages of 18 and 24 were actively enrolled in higher education. This is hardly the stuff of catastrophic failure.

An area of more concern is the reduced investment in innovation infrastructure, including research. Total federal funding for R&D declined as a share of GDP from 1985 to 2004. To restore federal R&D support as a share of GDP to its 1993 level, we would have to increase federal R&D spending by 50 percent, or over $37 billion. Federal investment in most of the programs that focus most directly on innovation promotion have declined or grown more slowly than the economy overall. Between 1998 and 2006, the budgets for the Advanced Technology Program, the Manufacturing Extension Partnership, the Office of Science and Technology Policy, and the Industrial Technologies Program declined in nominal terms, while that of NSF's Engineering Research Center program grew at less than one-fifth the rate of GDP growth. Funding for NSF's Partnerships for Innovation also grew more slowly than GDP since the program began operating in 2000. And while our public and private research universities used to be the envy of the world, 20 years of underfunding by state governments have meant that many public research universities have fallen in capabilities relative to private research universities.

Adequately investing in and developing innovation-enhancing policies is crucial to national innovation competitiveness, as Professors Jeffrey Furman and Richard Hayes found in a study of the national innovation capacity (an economy's potential for producing a stream of commercially relevant innovations) of twenty-three countries from 1978 to 1999.[26] Starting with the year 1979, they classify countries as either world-leading innovators (the United States, Germany, Japan), middle-tier (Great

Britain, France, Australia), third-tier (Spain, Italy), or “emerging” innovators (Ireland, Taiwan) based on countries’ patenting activity per capita, a proxy for commercialized innovations.

A number of these “emerging innovators”—among them Ireland, Finland, Singapore, South Korea, Denmark and Taiwan, in particular—achieved remarkable increases in innovative output per capita from 1978 to 1999, moving to the world’s technological frontier and overtaking the innovative capacities of many mid- and third-tier countries, including Great Britain, France and Italy, whose economic conditions started off much more favorably in the early 1980s. Furman and Hayes conclude that innovation leadership among countries requires not only the development of innovation-enhancing policies and infrastructure, such as strong IP protections, openness to trade, highly competitive markets, and strong industry clusters, but also a commitment to maintaining substantial financial and human capital investments in innovation.

Additionally, federal agencies have not responded as nimbly as they should too many of the changes in the innovation environment. For example, the U.S. Patent and Trademark Office (PTO) used to be the envy of other nations around the globe for its effectiveness and efficiency. But today backlogs at the PTO mean that most patent applicants will wait years before finding out if their invention is granted a patent.

Moreover, even as services innovation has become much more important, U.S. innovation policy has not responded. U.S. innovation policy is largely focused on innovation in goods-producing industries, e.g., developing a new energy source or coming up with new materials. In the past, when goods production was a much larger share of the economy than it is today, such a focus made more sense. But in an economy where more than 80 percent of civilian jobs lie in service-providing industries, the lack of focus on services innovation makes little sense. The emerging discipline of service science brings together ongoing work in computer science, operations research, industrial engineering, business strategy, management sciences, social and cognitive sciences, and legal sciences to develop the skills required in a services-led economy.[27]

Finally, as the U.S. innovation system has spread out to all states and corners of the nation, the federal system has remained national in scope. Washington is often far removed from the firms and other institutions that drive innovation. This is particularly true for small and mid-sized firms. In contrast, state and local governments and metropolitan-level economic developers have a long track record of creating organizations that work more closely with firms. Unfortunately, most existing federal programs do not work through or in collaboration with state or local governments or regional organizations, which are often more flexible and less remote from production processes. Indeed, there is very little appreciation in Washington for the fact that virtually every state has in place technology-based economic development programs.[28] Federal program managers and policymakers all too often seem to assume that there is one uniform national economy in which regional agglomerations are at best a sideshow.

What Can We Learn From Other Nations?

Many forward-thinking countries have made innovation-led economic development a centerpiece of their national economic strategies during the past decade. These nations know that moving up the value chain to more innovation-based economic activity is a key to boosting future productivity, and that losing the competition can result in a relatively lower standard of living as economic resources shift to lower-value-added industries. These countries are implementing coordinated national innovation agendas that boost R&D funding, introduce policy changes and government initiatives that more effectively transfer technologies from universities and government laboratories to the private sector for commercialization, and ensure that immigration policies support innovation.

While many nations have taken the innovation challenge to heart and put in place a host of policies to spur innovation, the United States has done little, consequently falling behind in innovation policies and in innovation performance as well. We see this gap in at least four main areas: programs to establish civilian technology and innovation promotion agencies, services innovation initiatives, tax incentives for research and development, and policies regarding high-skill immigration.[29]

1. Civilian Technology and Innovation Promotion Agencies

A number of advanced countries are well ahead of the United States in creating national agencies that support innovation. In recent years, Finland, France, Iceland, Ireland, Australia, Japan, the Netherlands, New Zealand, Norway, South Korea, Canada, Germany, Taiwan, Switzerland and Great Britain have all either established or significantly expanded separate technology- and innovation-promotion agencies. Other nations, such as Denmark, Sweden and Spain, have longstanding agencies of this type.[30] All these countries have science- and university-support agencies similar to America's National Science Foundation, which largely fund basic research, universities and national laboratories. But these countries realized that if they were to prosper in the highly competitive, technology-driven global economy, they needed specifically to promote technological innovation, particularly in small and mid-sized companies and in partnership with universities.

Perhaps the most ambitious of these efforts is Tekes, Finland's National Agency for Technology and Innovation. In the last two decades, Finland has transformed itself from a largely natural resource-dependent economy to a world leader in technology, with Tekes a key player in the country's transformation. Affiliated with the Ministry of Employment and the Economy, Tekes funds many research projects in companies, multi-company partnerships, and business-university partnerships. With a budget of $560 million (in a country of only 5.2 million people), Tekes works in partnership with business and academia to identify key technology and application areas—including nano-sensors, ICT and broadband, health care, energy and the environment, services innovation, and manufacturing and minerals—that can drive the Finnish economy. Tekes also operates a number of overseas technology liaison offices that conduct "technology scanning," seeking out emerging technologies bearing on the competitiveness of Finnish industries, and sponsors foreign outreach efforts to help its domestic companies partner with foreign businesses and researchers.

Similarly, Japan's New Energy and Industrial Technology Development Organization (NEDO) is a quasi-public agency that receives its $2 billion budget from the Ministry of International Trade and Industry. Great Britain's new Technology Strategy Board is a non-departmental public body (similar to an independent government agency in the United States) whose mission is to drive forward the government's national technology strategy. In South Korea, the Korea Industrial Technology Foundation, established in 2001, engages in a wide range of technology activities, including providing training to develop industry technicians and cooperating with international entities to promote industrial technology development. A host of other nations have similar bodies dedicated specifically to promoting innovation and competitiveness.[31]

Most foreign innovation-promotion agencies provide grants to companies for research, either alone or in consortia, including in partnership with universities. All support university-industry partnership grant programs, whereby companies or business consortia can receive grants (usually requiring matching funds) to partner with universities on research projects. Vinnova, Sweden’s innovation-promotion agency, gives most of its grants to research consortia involving companies and universities.

Most agencies focus their resources on specific areas of technology. For example, by working with business and academia, Tekes has identified 22 key technology areas to fund. Many foreign programs have expanded their focus to include service sector innovation. One of Tekes’ focus areas is innovation in services, including insurance and finance, retail and wholesale trade, logistics, and knowledge-intensive business services. The United Kingdom’s Technology Strategy Board is working with knowledge-intensive industries such as creative and financial services in addition to the high-tech and engineering sectors. Most programs insulate their grant making from political pressure by using panels of outside experts to review grant application, just as our National Science Foundation and the Technology Improvement Program (TIP) do.

Most agencies also support national sector-based activities that bring together researchers in the private, non-profit and public sectors. For example, the UK’s Technology Strategy Board established its Innovation Platforms program to bring together government stakeholders and funders, engage with the business and research communities to identify appropriate action, and align regulation, government procurement and other public policies to support innovative solutions. To date, this program has identified two priority areas, intelligent transport systems and network security.[32]

One of the benefits of these programs is that they not only fund research projects but also facilitate networking and collaboration. For example, Tekes brings together in forums many of the key stakeholders in the research community. For each of its 22 technology areas there are networking groups of researchers. In addition, Tekes publishes a description of each project it funds. Through these processes, researchers learn more about research areas and gain opportunities to collaborate. Many agencies also work with industry on “roadmapping” exercises, whereby key participants (industry and academic researchers and government experts) identify technology challenges and key areas of need over the next decade. They then base their selection of research topic funding on the results of the roadmap exercise. The UK’s Technology Strategy Board is funding over 600 collaborative business-university research projects which have been launched over the past two to three years. Like Tekes, it is also responsible for more than 20 industry- and technology-based knowledge transfer networks, with more being established.

Foreign innovation-promotion agencies do not limit their activities to R&D support. The Danish Technological Institute and Iceland Technology Institute, for example, help small and mid-sized firms upgrade their technologies and business processes. Enterprise Ireland offers workforce training grants to small and mid-sized businesses.

Many innovation-promotion agencies also have foreign outreach efforts to help domestic companies partner with foreign companies or researchers. For example, Tekes has a number of overseas offices that act as technology liaisons including in Washington, DC, Singapore and South Korea. Indeed, 40 percent of Tekes-funded projects involve international collaboration. Spain's innovation-promotion agency, CDTI, also helps Spanish businesses find partners in other nations and provides up to 60 percent funding to the participating Spanish firm.

Most of these organizations are affiliated with, but separate from, national cabinet-level agencies similar to our Commerce Department. However, some are independent government agencies or government-sponsored corporations. The Danish Technological Institute is a private, nonprofit organization. In virtually all cases, though, these nations have made an explicit decision not to place their innovation-promotion initiatives under the direct control of large government departments. Although most innovation-promotion agencies are affiliated with those departments, they usually have a substantial degree of independence. It is common for these agencies to have their own executive director and a governing board of representatives from industry, government, university, or other constituency groups. For example, Japan's government recently made a conscious choice to establish NEDO as an autonomous agency because it realized that MITI, as a large government bureaucracy, did not have the flexibility needed to manage such a program. NEDO is governed by a board of directors, with the Chair appointed by MITI and members from industry, universities and other government agencies. Similarly, Tekes is affiliated with the Ministry of Trade and Industry but has its own governing board that includes national and regional government, businesses and union representatives.[33] The Technology Strategy Board, begun in 2004 as a unit of the Department of Trade and Industry, was established in 2007 as an executive non-departmental public body. While it is now affiliated with the Department for Innovation, Universities and Skills, it is governed by a board made up mostly of technical experts from industry.[34]

One reason for structuring innovation-promotion agencies this way is that they have more flexibility, including the ability to pay salaries high enough to attract staff from the business world and the ability to employ some staffers who are on leave from positions in private business. For example, about one-third of the NEDO staff is from industry and one-third is from universities, while the remaining third is full time NEDO staff. Rotating in outside staff helps keep the agency in touch with current business practices and cutting-edge technology. (For similar reasons, NSF employs some people who are on leave from academic and research positions outside the federal government.) The Technology Strategy Board has been able to source a fairly large share of its staff from industry, enabling it to have the kind of expertise that would be difficult without this ability. In addition, independent government bodies can adapt more quickly than those that are subject to the tight control of larger agencies. It is easier for them to start new initiatives and abolish less effective ones. Likewise, many national technology agency programs are able to pay employees more than the standard government salaries, enabling them to attract higher quality individuals, often with industry experience. Nevertheless, most of these agencies are fairly lean. For example, Tekes, with a budget equivalent to $560 million, has a staff of just 300.

To be effective, these agencies need to be flexible and able to work closely with industry. For this reason they are less bureaucratic than traditional ministries or departments. As the UK government notes, "As separate legal entities, non-departmental public bodies can operate more flexibly than executive agencies, entering into partnerships and taking commercial and entrepreneurial decisions." Moreover, "their distance from government means that the day-to-day decisions they make are independent as they are removed from ministers and civil servants."[35] Foreign innovation-promotion agencies today are a far cry from the strongly directive Japanese MITI of the 1980s. They do not try to decide the path of business innovation and then induce firms to follow that path. Instead, they exemplify the cooperative, facilitative government role that is needed to address the market failures that hamper the innovation process.

If the United States wanted to match Finland's outlays per dollar of GDP in innovation-promotion efforts, it would have to invest $34 billion per year. While other nations invest less in their innovation-promotion agencies than Finland, they still invest considerably more than the United States. As a percent of their countries' GDPs, Sweden spends 0.07 percent, Japan 0.04 percent and South Korea 0.03 percent on their innovation promotion agencies. To match these nations on a per-capita basis, the United Sates would have to invest $9 billion to match Sweden, $5.4 billion to match Japan, and $3.6 billion to match South Korea.[36] It is astounding that economies a fraction the size of the United States spend more on innovation-promotion in *actual dollars*, let alone as a percentage of their economy.

But compared with other industrialized democracies, the U.S. government invests relatively little in innovation-promotion efforts. In fiscal year 2006, the federal government spent a total of $2.7 billion, or 0.02 percent of gross domestic product, on its principal innovation programs and agencies: the National Institute of Standards and Technology's Advanced Technology Program and Manufacturing Extension Partnership, the White House's Office of Science and Technology Policy, three NSF-administered innovation programs (Small Business Innovation Research, Small Business Technology Transfer and Industrial Technologies Program), and the Department of Labor's Workforce Innovation Regional Economic Development (WIRED) program.

This places U.S. industries and corporations operating alone at a disadvantage against foreign corporations that benefit from coordinated and enlightened national strategies among universities, governments and industry collaborations to foster competitiveness. For example, the Japanese government has recognized advanced battery technology as a key driving force behind its competitiveness, and views battery technology as an issue of "national survival."[37] It is funding Lithium-ion battery research over the five-year period from October 2007 to October 2012 at $275 million (¥25 billion), and longer term has committed to a 20-year Li-ion battery research program. Germany's government will provide a total of €1.1 billion ($1.4 billion) over 10 years to applied research on automotive electronics, lithium ion batteries, lightweight construction, and other automotive applications.[38]

2. Services Innovation Initiatives

As services increasingly drive employment, productivity, and economic growth, a number of countries have developed explicit national services innovation policies focused on spurring innovation in the services sectors of their economies. Policymakers in these countries have recognized that knowledge of services innovation has largely been informed by studies of the manufacturing sector, and acknowledged the need to tailor unique measures to the needs of services firms and industries.[39]

The focus on service innovation began in the mid-2000s with a coterie of small Northern European countries—Finland, Denmark, Norway, The Netherlands and Sweden—and has since grown to include additional small countries in Europe and Asia (Taiwan, Ireland and Singapore) and large nations (Great Britain, Canada and Germany). Finland was the first to implement a national services innovation policy, with a five-year, €100 million[40] program launched in 2006 called "SERVE—Innovative Services Technology Programme."[41] Finland's neighbors soon followed suit, recognizing the increasing importance of services as their domestic manufacturing industries departed for cheaper production centers abroad, particularly in the form of "near-shoring" to Baltic and Eastern European countries. The same phenomenon affected developed Pacific Rim countries, as manufacturing moved first from Japan and Taiwan to cheaper production centers in China, and now out of China and on to the poorer nations of Southeast Asia. This process has forced almost all industrialized countries to seek to migrate their economies up the value chain towards knowledge-based, high-value-added services activities such as R&D, design, finance, consulting/training, and post-installation service and support.

Policy approaches quickly evolved into two main strands. First, these countries strove to develop framework conditions that support competitive services industries. As they began to scrutinize their services industries, these countries found they first needed considerable work in setting favorable framework conditions, such as removing barriers to labor market mobility in services industries, further opening and integrating cross-border services markets, developing better accounting practices for intangible assets, updating intellectual property and trade laws to accommodate the unique characteristics of services, developing core information technology infrastructure, and providing structures and incentives to encourage services exports.

Second, with this supportive policy framework in place, these countries implemented specific programs to support innovation in services businesses. Specific efforts (and at least one sample country implementing them) include:[42]

- Boosting academic research in the area of services innovation and services business, especially research on creating innovative services-based business models, quantifying improvements in services productivity, and enhancing the quality of services delivery. (Finland, The Netherlands, Denmark)
- Funding Services Science research; that is, cross-disciplinary research that draws on fields such as computer science, management, operations, marketing and organizational behavior. (Singapore, Taiwan)
- Extending research and experimentation tax credits to services industries; especially, defining where the "innovative step" occurs for services firms. (Norway and The Netherlands)
- Developing innovation metrics that measure innovation in services, not just advanced manufacturing, and looking for "hidden innovation" in services industries. (Great Britain, the United States, Ireland)
- Supporting the development of creative industries through establishing regional design centers. (South Korea, the Netherlands, Great Britain)
- Providing online self-assessment tools that allow companies to benchmark their innovation infrastructures (R&D budgets, number of employees, intellectual property strategies) against in-nation and in-industry peer companies. (Great Britain and European Union)
- Benchmarking services innovation policies across European countries. (European Union)

3. Tax Incentives for Research and Development

The tax incentives the U.S. government provides corporations for R&D activities have fallen from the most generous in the world in the late 1980s to 17th among 30 OECD countries in 2004.[43] Many nations now provide significantly more generous tax incentives for research than does the United States. From leading the world in the late 1980s,[44] the United States by 1996 fell to seventh most generous among OECD nations, behind Spain, Australia, Canada, Denmark, the Netherlands and France.[45] By 2004, we had fallen to 17th in generosity for general R&D; 16th for machinery and equipment used for research; and 22nd for buildings used for research.[46]

Among nations with a tax incentive for R&D, the United States now provides one of the weakest incentives, below our neighbors Canada and Mexico, and behind many Asian and European nations. Japan's credit is almost three times as generous as the United States', and for small companies it's four times as generous. In 2004, France adopted a credit essentially equivalent to a 40 percent incremental R&D tax credit. In an explicit effort to attract U.S. corporate R&D, our neighbor to the north is even more generous. In Canada, large companies are eligible for a flat 20 percent credit while small companies can receive a 35 percent credit; in many provinces, equally generous credits can be taken on top of the federal credit. Indeed, over the past decade, all other nations with R&D tax incentives have boosted the generosity of their R&D tax incentives, particularly since 2000.[47]

At a time of increased concern about America's growing competitiveness challenge, our tax credit has been getting weaker, both in absolute terms and relative to other nations, in part because of changes made by Congress over the years that have diminished its generosity.[48] In fact, until the passage in 2006 of the Alternative Simplified Credit, the credit was about half as generous as it was in the early 1980s.[49] Even with the recent increases in R&D tax incentives (the passage of the Alternative Simplified Credit in 2006 and its expansion in the Emergency Economic Stabilization Act of 2008), the United States moved up only to 14th place. Out of the 21 OECD nations that offered R&D tax credits in 2008, the United States ranked 17th. The United States would need to increase the ACS to 20 percent to move up to 10th place, 31 percent to move to 5th place, and 47 percent to become the most generous of the OECD nations.[50] However, this doesn't include non-OECD nations such as India, China and Brazil, all of which have significantly more generous tax incentives to attract multinational R&D. India's R&D tax credit is now four times that of the United States. On top of salaries for R&D personnel that are as low as one-sixth of the costs in the United States, China provides a 150 percent deduction on R&D expenses (provided that R&D spending increased 10 percent over the prior year). Some countries, including Denmark and the Netherlands, have begun to extend R&D tax credits to cover process R&D activities, effectively extending the R&D tax credit from their goods to services industries as well.

4. High-Skill Immigration

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. In a study benchmarking high-skill immigration policies in eight nations (the United States, Canada, New Zealand, Australia, Japan, Great Britain, Germany and France), "Global Flows of Talent: Benchmarking the United States," ITIF found that the United States trails other peer countries in developing a proactive approach to attract high-skill foreign workers.[51]

Using data from 2001 to 2006, the United States received an average of about 67,000 highly skilled permanent immigrants per year, with Canada receiving 56,000 per year, Australia 20,000 and New Zealand about 10,000.[52] As a share of their populations, these rates are all several times larger than those in the United States—more than 11 times larger in the case of New Zealand.

ITIF's study of the immigration policies of those eight countries found three broad approaches. The first group—Australia, Canada and New Zealand—conceive of immigrants as a source of economic growth and consider highly skilled immigrants especially valuable contributors. The second group—the United States and Great Britain—are more amenable towards immigration but do not place high priority on tilting the mix of immigrants toward the talented. The third group—France, Germany and Japan—tend to view highly skilled immigrants (and immigrants in general) more as threats to native workers than as positive additions to national well-being.

While the United States may not be as reflexively anti-immigration as some other industrialized countries, in recent years it has severely limited the flow of foreign talent entering the country at a time when the science and engineering workforce in the United States has become increasingly reliant on foreign talent. In 1995, non-U.S. citizens accounted for only 6 percent of the U.S. science and engineering workforce; by 2006, that percentage had doubled to 12 percent, and for the youngest cohort of scientists and engineers (ages 21 to 35), the percentage rose to 20 percent.

With the United States restricting the number of H-1B visas issued annually to 85,000 from 2006 to 2008 (and 65,000 as of today),[53] almost 50 percent of highly talented foreign professionals who applied for temporary work in the United States in the years 2006 to 2008 were turned away. Limiting the influx of talented foreign-born science and engineering professionals not only hurts U.S. competitiveness, it may also contribute to the decision of companies to source R&D operations abroad to be closer to local pools of S&E talent.

Why Does the United States Need a Robust Innovation Policy?

The global competitive landscape continues to stiffen as a number of countries get serious about creating favorable climates that attract foreign direct investment and R&D activities and that support the innovation efforts of their domestic corporations and workforce. It is time for the United States to articulate and implement an innovation-led economic growth strategy to respond to global economic competitiveness challenges.

But before detailing some of the key elements of such a strategy, it is first worth briefly discussing why there is a need to develop such a strategy. Unfortunately in the United States too many conventional "neoclassicalist" economists hold on to the antiquated view that economic welfare is maximized by individual firms acting as independent utility maximizers, doing what is best for them individually. In fact, according to this view, many policy efforts to help firms become more innovative will only make things worse. Indeed, the worst possible sin in the eyes of neoclassical economists is to "pick winners and losers" (an absurd characterization since nations only pick winners, not losers). Substituting for the wisdom of the market can only lead to a worse, not better, allocation of resources, they opine.

Because of that, many conventional neoclassical economists argue that policy makers should be indifferent to the occupational and industrial mix of the U.S. economy. For most neoclassical economists, the right industrial structure is the one that "the market" provides, because by definition market exchanges engaged in by two parties are what is known as "Pareto optimal." Why else would the parties engage in them? Any attempt by policy makers to try to alter this invisible hand by increasing innovation output can only reduce, not increase, economic welfare. This view, it should be noted, is almost unique in the world. In no other nation, perhaps with the exception of British Commonwealth nations, does the economics profession consist of such a large cohort of neoclassicalists counseling such blind faith in market processes.

This helps explain a key reason why so many neoclassical economists advising Washington have been so blasé about the decline in U.S. high-tech manufacturing. To the extent that they are even willing to admit that high-tech manufacturing has declined, they simply assert as a matter of faith that domestic resources left idle by offshoring will automatically shift to new higher-productivity industries. The magic of the market will optimally reallocate resources. But only if one believes that economies are largely made up of "Coasian" factors of production that assemble and reassemble on the basis of prices could one take this view seriously. As innovation economist Greg Tassey argues, "The central failure of current economic growth models is the assumption that shifts in relative prices will automatically elicit a Schumpeterian-type efficient reaction from domestic private markets—namely an adjustment involving development/ assimilations of new technologies to replace offshored ones."[54]

According to this view, if a high-wage, high-tech firm like Boeing, for example, were to go out of business because of unfair European Commission subsidies to Airbus, as long as America maintains flexible labor and capital markets, these resources will flow into other industries, including into expanding or new firms and sectors. In such a market environment, policies are needed only to facilitate the transition of resources from losing to winning companies, including making sure that losing companies are not protected from this tough but necessary discipline, and helping workers get reemployed quickly. As a result, proponents of this view believe that as long as we have a good education system and don't restrain creative destruction, then all should be well.

This conventional view may have accurately described a country's economy before the emergence of the globalization era over the last two decades. During the old economy era, if firms could not compete and went out of business, the only issue was making sure that their assets, including employees, were quickly redeployed to other companies that could compete successfully. If Boeing failed, Northrop Grumman or Lockheed Martin would add capacity.

But in the new global economy, in which knowledge is increasingly the major factor of production, this framework no longer sufficiently explains industrial and economic change. As such, in the 21st century global economy, nations can no longer be indifferent to the industrial and value-added mix of their economy. In contrast to the neoclassical view, knowledge is not a free-flowing commodity held solely by individuals. It is embedded in organizations and if organizations die so too does a significant amount of knowledge. Moreover, there are significant spillover effects from firm activities and significant first-mover advantages, including learning effects that enable firms' early leads to translate into dominant positions. There are also significant network effects that mean that advancement in one industry (e.g., broadband telecommunications) can lead to advancement in a host of others (e.g., Internet video). As a result, for many parts of the U.S. economy exposed to international competition, if you lose it, you can't easily reuse it. In these cases, foreign high-value imports may end up substituting for the defunct U.S. product.

To bring this back to a company like Boeing, if America were to lose Boeing, in all likelihood it could not rely on market forces, even a dramatic drop in the dollar, to later recreate a domestic civilian aviation industry. For to do so would require recreating not just the firm, but it's complex web of suppliers, professional associations, university programs in aviation engineering and other knowledge-sharing organizations.

Clearly if Boeing were to go out of business, the economy would quickly regain "equilibrium" as factors of production were reabsorbed. But neoclassical economics assume that there is only one equilibrium and it is the role of government to make sure that that the market attains it. But new research suggests that there may be multiple equilibria in an economy, some better than others. Indeed, while economies can attain equilibrium, absent a robust innovation policy that equilibrium may not be a high-wage, high-skill equilibrium. Research by economist Elvio Accinelli has shown that there is strategic complementarity between the percentage of high-skill workers and high-value added, innovative firms in an economy. He finds that economies can be in perfect neoclassical equilibrium at either a high level of innovation or in a "poverty trap" of low skills and underinvestment in innovation. Since the poverty trap can be avoided if the number of innovative firms in an economy exceeds a threshold level leading to an increased number of skilled workers, there is a role for public policy to move economies to a high-level equilibrium on innovation.[55]

But there is a second reason for an innovation policy and that is because economies are subject to a host of "market failures" with the implication that markets acting alone will not always lead to optimal performance. Following are five market failures that cause markets to perform suboptimally:

1. Because individual firms cannot capture all the benefits of their own innovative activity, firms will produce less innovation activity than society needs. The first market failure has to do with who benefits from private companies' investments in innovation. The knowledge needed to create new products, processes and organizational forms is not something that can be completely contained within an individual firm. It inevitably spills over to other firms, which can use it without paying the costs of creating it. For example, an entrepreneur develops a new business model that others copy. A university transfers discoveries from the lab to the marketplace. A company makes a breakthrough that forms the basis of innovations that other companies can use. This is why studies have found that the rates of return to society from corporate R&D and investments in IT are at least twice the estimated returns that the company itself receives.[56] Firms' inability to capture all the benefits of their own innovative activity means that firms, left on their own, will produce less innovation than society needs.

2. R&D increasingly depends on collaboration between firms and universities but the interests of the collaborators are not well-aligned. Problems with the important interactions of firms and universities represent another area of possible market failure. As short-term competitive pressures make it difficult for even the largest firms to support basic research and even much applied research, firms are relying more on university-based research and industry-university collaborations. Yet, the divergent needs of firms and universities can hinder the coordination of R&D between these two types of institutions. University researchers are not necessarily motivated to work on problems that are relevant to commercial needs. University technology transfer offices do not always promote the licensing of university intellectual property to firms. Conversely, individual businesses sometimes want to "rent" universities' research capabilities and appropriate the resulting research discoveries for themselves. This can impede the free flow of knowledge that can contribute to innovation elsewhere in the economy.[57]

3. Many industries and firms lag in adopting proven technologies. Market failures also plague the diffusion of innovation. Outside of relatively new, science-based industries such as information technology and biotechnology, many industries lag in adopting more productive technologies. For example, the health care industry has lagged in adoption of available technologies that could boost productivity and health care quality.[58] The residential real estate industry has resisted moving toward more Internet-enabled sales.[59] The construction industry is plagued by inefficiencies and failure to adopt best-practice technologies and techniques.[60] A host of market failures, including chicken-or-egg issues related to standards and technology adoption and principal-agent problems where innovation may hurt the implementers of it (e.g., real estate agents embracing e-realty systems) impede faster productivity growth in these sectors of the economy.

4. The innovation-producing benefits of industry clusters are under-realized. A fourth market failure involves the under-recognition of industry clusters' role in innovation. Both the creation and the diffusion of innovation often occur in geographic clusters. Geographic industry clustering enables firms to take advantage of common resources (e.g., a workforce trained in particular skills, technical institutes or a common supplier base), to facilitate better labor market matching and to facilitate the sharing of knowledge. This process may be particularly relevant in industries that rely more on the creation or use of new knowledge, as clustering appears to spur knowledge transfers. Such industries are especially likely to cluster in large metropolitan areas.[61] Perhaps the best known cluster is Northern California's Silicon Valley, where a large agglomeration of high-tech firms, research universities such as Stanford, technical colleges to train high-tech workers, venture capitalists, and other supporting institutions make it the world's most vibrant technology region. But Silicon Valley is not the only region in the United States with industry clusters: From the furniture cluster in Tupelo, Mississippi; to the jewelry cluster in Rhode Island and southern Massachusetts; to the recreational vehicle cluster in Elkhart, Indiana; to the biotechnology clusters in the Boston, Washington, DC, and San Diego metropolitan areas, regional industry clusters abound. And as these examples show, clusters are not only made up of "high-tech" firms. Moreover, clusters are not confined to manufacturing, but also exist in a host of service industries, including financial services in New York, movies and music in Hollywood, software in Seattle and gaming in Las Vegas. Evidence suggests that industry clustering may have become more important for productivity growth during the last three decades; the extent to which an industry was geographically concentrated (at the metropolitan or county level) was increasingly associated with subsequent productivity growth during the last three business cycles.[62]

Yet 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, but no individual firm takes these "external" benefits it produces into account when making its own location decisions. In addition, the firms in a cluster have common needs (e.g., for worker training or infrastructure) that they cannot meet on their own. Clustered firms usually require external coordination (e.g., from governments or industry associations) to meet these needs because no one firm can capture all the benefits. Failure to meet these common needs makes clusters smaller and less productive than they would otherwise be. If the benefits of clustering to all firms in the United States were considered and the common needs of all firms in each cluster met, there would be more clustering, and thus more innovation and higher productivity.

5. The interests of geographically mobile firms in locating innovative activity may diverge from those of U.S. residents. There is one other failure that has emerged in the last decade or so and that, while not a market failure per se, results in too little innovation in the United States. That failure is the potential divergence between the interests of geographically mobile firms and those of the residents of the United States.[63] Firms' decisions about where to locate innovative activity are based on their own interests, which may or may not coincide with the interests of a place's residents. Since World War II and the emergence of a truly national market, most U.S. states have put in place policies to tilt the choice of corporations to invest in their states. To be sure, even the most liberal governors recognize and respect the power and primacy of markets as the key driver of prosperity. But even the most conservative governors recognize that this market-produced bounty does not always automatically end up in their own jurisdiction. For this reason, both Republican and Democratic governors "intervene" in their economies with robust economic development policies. They are not content to let the "market" determine what kind and how many jobs are created: they work to ensure that they gain more high-paying, high-productivity jobs. With the rise of the globally integrated enterprise, the United States faces the same reality states faced after World War II: without robust economic and innovation policies, it risks losing out in global competition.

These failures in the process of innovation and its diffusion suggest that, left to itself, the market will produce less innovation and lower productivity in the United States than our society needs. In a globally competitive world, this is a limitation that we can no longer afford. What is more, these market failures in turn suggest that there are several ways in which government can improve the process.

What Steps Should Congress Take to Boost U.S. Innovation and Competitiveness?

The government's role in addressing these market failures is not to regulate business or to direct the path of technological or economic development. We do not advocate a heavy-handed, government-driven industrial policy. Indeed, such a policy cannot be nimble enough to respond to the kinds of market failures that afflict the innovation process. At the same time, though, we do not advocate giving away public funds to companies without any public benefit. Government should be a facilitator that spurs firms to innovate in ways that serve the public interest. Economist Dani Rodrik captures this view of the appropriate relationship between government and business with respect to innovation policy when he describes "an interactive process of strategic cooperation between the public and private sectors which, on the one hand, serves to elicit information on business opportunities and constraints and, on the other hand, generates policy initiatives in response."[64] Political scientist Dan Breznitz similarly writes that a government innovation-promotion agency should not pick strategic products or technologies but should motivate firms, individually and in cooperation with other firms and government, to make the investments needed to innovate.[65] In short, while we believe that the private sector should lead in innovation, we also

believe that in an era of globalized innovation and intensely competitive markets the federal government can and should play an important enabling role in supporting private sector innovation efforts.
Indeed, many nations have already come to this realization. In recent years, they have come to understand that markets relying on price signals alone will not always be as effective as smart public-private partnerships in spurring higher productivity and greater innovation. It is time for the United States to do the same. There are two major areas where the United States needs to act, one domestic and one international.

More Robust Trade Enforcement

It will be difficult for the United States to regain global innovation leadership if we continue to largely turn a blind eye to rampant foreign policies that distort the spirit, if not often the letter, of the WTO, with the goal of limiting U.S. imports of high tech products and services and promoting their exports. These countries want it both ways. They desperately want access to the U.S. market (and as reflected by the fact that the United States has run massive annual trade deficits, for instance, of almost $800 billion in 2006 alone,[66] they are getting it) but they don't want to buy U.S.-produced goods and services. They want U.S. foreign direct investment, particularly high-tech investment, through outsourcing, joint ventures and other types of investment, but they also want to systematically weaken the competitive advantage of U.S. technology companies in favor of their domestic technology companies. They want our wonderful technology and intellectual property, but they don't want to pay for it. "Take" is not "trade."

These aggressive technology mercantilist policies have resulted in fewer high paying technology jobs in the United States and have eroded the United States' global innovation leadership position. As such if we want to stop the continued erosion of America's technology leadership, the federal government will have to be much more vigilant and make fighting these unfair trade practices a top priority. Both Congress and the Obama Administration need to let countries know that they can't expect to get the WTO's benefits when they aren't meeting its obligations. Countries are willfully violating these agreements and we need to make them live up to their commitments.

While many of the tools for more aggressive enforcement of global trade policies are in the hands of the administration, Congress can play an important supporting role. To start with, we urge Congress to pass S.1466: The Trade Enforcement Act of 2009, which strengthens USTR's trade enforcement powers and restructures the agency to more greatly focus on eliminating foreign barriers to exports.[67] In short, Congress should hold USTR's feet to the fire and expect them to wake up every morning figuring out how they are going to enforce trade agreements, and defend American technology jobs from the assault of unfair trade practices.

Develop and Implement a More Robust National Innovation Policy

Even with the orientation of many neoclassical economists there is a somewhat broad consensus that the role of the federal government should include support for basic research, education, and provision of a good regulatory climate. But while these are necessary ingredients, they are woefully inadequate in enabling the United States to increase its global rank in innovation-based competitiveness. Indeed the neoclassical model which not only posits an overly simplistic innovation process (the linear model) but also assumes that it is only basic research which requires a government role is a poor guide to policy. Generic platform technologies, infra-technologies and risk reduction all also require a public-private approach. What are essentially ideological statements put forth by neoclassical economists, such as that the role of government is not to support applied research, are supported by little logic and even less data and only serve to stop, not advance, needed reasoned analysis and discussion. With this in mind, I list a number of specific proposals that if enacted would help the U.S. regain its innovation lead.

1. Spur Science, Technology, Engineering and Math (STEM) Education and Skills
Ensuring an adequate supply of talented scientists and engineers is one key step in the U.S. innovation agenda. Following are three proposals to address the STEM challenge:

1a) Fund Specialty Math and Science High Schools
A wide array of proposals before Congress seek to intervene upstream in the STEM pipeline at the K-12 level. These include expanding professional development programs for science teachers; enhancing science enrichment programs; using No Child Left Behind to judge scientific educational outcomes; 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).

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.[68] By creating an environment focused more intensely on science and technology, these schools have been able to successfully enable students to study science and math, often at levels far beyond what students in conventional high schools are at; they 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.[69]

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 partnership 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 in 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 they 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).[70] 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. 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 will under-invest 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 around 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 $100 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.**[71] 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.

1b) Fund Joint Government-Industry STEM Ph.D. Fellowships

One key factor in producing more Ph.D. degrees in STEM, especially by U.S. residents, is the ability to support doctoral fellowships. But as 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.[72] But rather than simply expand funding for the NSF Graduate Research Fellowship program (funded at $102 million) to do this, Congress should instead create a new NSF-industry Ph.D. 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.[73] 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 Ph.D. 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 that the companies are interested in. Students would of course 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, they 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.[74] Most doctoral programs still train students as if they were going to be going into academic teaching and research careers. But increasingly this is not the case.[75] For example, one survey of doctoral chemistry students found that only 36 percent intended to go into academia (compared to 76 percent of English students).[76] 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.”[77] 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.[78]

1c) Allow Foreign Students Receiving STEM Ph.D.s from U.S. Universities to Automatically Qualify for Green Cards

While ideally the supply of American STEM workers will expand to fill the 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. 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.[79]

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. In a study benchmarking high-skill immigration policies in eight nations (the United States, Canada, New Zealand, Australia, Japan, Great Britain, Germany and France), ITIF found that the United States trails other peer countries in developing a proactive approach to attracting high-skilled foreign workers.[80]

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.

2. Create a National Innovation and Competitiveness Strategy Modeled on the National Broadband Strategy

The United States needs to create millions of new good-paying jobs over the next decade. If the United States wants to do this and be successful in the global economy, it is critical that the federal government develop a serious, in-depth, and analytically-based national competitiveness strategy. We are in fact one of the few nations without one. Denmark, the United Kingdom, South Korea, The Netherlands and Ireland are just a few of the nations that in recent years spent the time and effort to craft a national competitiveness strategy. The last time the United States did anything similar was President Carter's Domestic Policy Review on Industrial Innovation in 1978. This review was in fact extremely important in setting the stage for a number of important Congressional initiatives in the following decade, including the R&D tax credit, the Bayh-Dole Act, the National Cooperative R&D Act, and the Stevenson-Wydler Technology Innovation Act.

It should be noted that ITIF is not advocating industrial policy or top-down direction of innovation. Thus we have deliberately chosen the term "agenda" to describe the outcome of a process that we believe must engage private and civil society constituencies and reflect the bottom up as well as top down nature of innovation. This would allow the development of a robust national innovation agenda. Its value would be apparent in allowing our country to more effectively address complex challenges with "whole of government" solutions, galvanize the public by advancing a useful narrative around innovation, enable us to engage more effectively with global innovation constituencies, and most importantly allow us to reinvent the traditional sources of our economic and societal success.

The American Recovery and Reinvestment Act charged the FCC with the development of a national broadband plan. The next America COMPETES Act should charge the White House Office of Science and Technology Policy with the development of a national competitiveness strategy. Adequate funding should be provided to bring in an outside director with deep technical and policy knowledge and hire individuals with technical and business experience.

A national innovation strategy would provide an opportunity to engage in a comprehensive analysis of the key factors contributing to future U.S. competiveness. Legislation to create this could require that the strategy focus on a number of broad issues, going more in depth on each. These should include assessing: 1) current U.S. competitiveness, including at the major industry level; 2) current business climate for competiveness (including tax and regulatory); 3) trade and trade policy issues; 4) education and training; 5) science and technology policy; 6) regional issues in competitiveness (including the role of state and local government and impacts on rural, urban and other regions); 7) measurement and data issues; and 8) proper organization of government to support a comprehensive innovation and competitiveness agenda.

3. Spur Technology Commercialization

While the United States remains a leader at nurturing innovation and commercializing new inventions, the process can and should be improved. The United States will 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 include:

3a) 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 the commercialization of technology, and is still based on the linear model of research that assumes that basic research gets easily translated into commercial activity. In fact, the process is ripe 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.

However, in an era of fiscal constraint adequate new funding may be difficult to obtain. As a result, one idea would be to establish an automatic set-aside program taking a modest percentage of federal research budgets and allocating them to a technology commercialization fund. Currently the SBIR program allocates 2.5 percent of agency research budgets to small business research projects; the STTR program allocates 0.3 percent to universities or nonprofit research institutions that work in partnership with small businesses.

3b) Thus, Congress should allocate 0.15 percent of agency research budgets (around $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.[81] Half the funds would go to universities, and federal laboratories 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 of funds 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 $1.9 billion per year in TBED activities.[82] This is about 70 percent of the amount that the federal government spends on its principal innovation programs and agencies.

States and regions engage in a variety of different TBED activities. They 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 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.[83] Finally, states have established initiatives to help firms commercialize research into new business opportunities. For example, Oklahoma’s non-profit 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 startups into growing companies.[84] But without assistance from the federal government, states will invest less in TBED activities than is in the national interest. A formula-based allocation to help fund state TBED efforts would help correct this limitation.

We propose that NIST be responsible for administering this program. Universities and federal labs would submit proposals explaining their proposed activities. States would submit proposals to NIST laying out their TBED strategy and explaining how NIST support would enable them to do more and better. Qualifying activities would include a host of TBED activities, such as technology commercialization centers, industry-university research centers, regional cluster development programs, regional skills alliances, and entrepreneurial support programs. In addition, where relevant, states would need to spell out in detail how they intended to create innovation alliances among local governments, businesses, educational institutions, and other institutions (such as economic development organizations or labor unions) in metropolitan areas. States would have to explain how their activities would meet the needs of firms following innovation trajectories that currently exist or that can reasonably be developed within the state. The precise mix of TBED activities would be left up to each state because the mix of innovation trajectories and the specific needs of firms in each trajectory vary among and within states. However, proposals would have to be economically realistic. For example, a state proposal to develop a new biotechnology cluster in a metropolitan area that had no existing institutions to support such a cluster and no realistic strategy to develop those institutions would be unlikely to be funded. Proposals that built appropriately on TBED activities in neighboring states or that included plans for interstate collaboration in TBED would receive extra points in the review process. To be eligible for NIST funding, states would need to provide at least two dollars in actual funding for every NIST dollar they receive.

Rotating panels of TBED experts would review proposals. In most cases these would be experts in the field (e.g., consultants, academics, venture capitalists and economic development professionals). For states there would be a two-stage proposal review process. States would submit initial proposals describing activities and use of funds. Based on review from the TBED panel and NIST staff, the program would provide feedback to states on how to modify and improve their proposals. States would then submit final proposals that would be reviewed and scored by the outside panel of experts. Proposals that were judged acceptable would be funded to the extent that funds were available, with priority going to those with the highest scores. States with proposals judged not fundable would be eligible to receive modest planning grants and technical assistance from NIST staff to develop a proposal for the subsequent year’s competition.[85]

4. Expand the R&D Tax Credit

As ITIF has demonstrated, the U.S. R&D tax credit is no longer generous when compared to other nations. It is not enough to make the credit permanent, it also needs to be expanded. There are several reforms that are needed. One is to provide greater incentives for collaborative R&D. Increasingly, firms are collaborating with other firms or institutions in order to lower the cost of research and increase its 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.[86] Moreover, participation in research consortia has a positive impact on firms’ own R&D expenditures and research productivity.[87]

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. Moreover, 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 under-invest in such research relative to societally optimal levels.[88] This risk of underinvestment is particularly true as the economy has become more competitive, and a reflection of this is the fact that for the first time since the data were collected in 1953, the percentage of U.S. academic R&D supported by industry has declined in each of the last five years.[89] This may stem from the fact that university contracts are often undertaken as discretionary activities and are the first to be cut when revenues are down.[90]

Other countries, including France, Norway, Spain and the United Kingdom, provide firms more generous tax incentives for collaborative R&D. Denmark and Hungary provide more generous tax deductions for collaborative R&D with public research institutions.[91] Japan's R&D incentive is almost twice as generous for research expenditures companies make with universities and other research institutes.[92] 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.[93] 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 and provide a more generous incentive for collaborative research. 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.[94] **Congress should go further and allow firms to take a flat credit of 30 percent for collaborative research conducted at universities, federal laboratories, and research consortia.**

In addition, Congress needs to expand the Alternative Simplified Credit. Currently the ASC provides a credit of 14 percent of qualified R&D expenditures in excess of 50 percent of base period expenditures. **Congress should increase the Alternative Simplified Credit rate from 14 percent to between 20 and 40 percent**, depending on the level of increase in research investment. **Congress should also broaden the definition of qualified R&D from beyond that involved in inventing a new product, to that involved in developing a new production process.** Under current law only product R&D is eligible for the credit. But a key source of U.S. manufacturing renewal will come from more advanced production processes. Allowing companies to take a credit against process R&D investments would spur more of this kind of research. Taking these steps would put the U.S. R&D tax credit back among the top 5 most generous in the world.

5. Fund Industry-University-Government Manufacturing Research and Deployment Centers

The debate over science and technology policy has tended to oscillate between those who argue that the federal government should fund industry to conduct generic pre-competitive R&D and those who maintain that money should be spent on curiosity-directed basic research at universities. This is a false dichotomy. There is no reason why some share of university basic research cannot be oriented toward problems and technical areas that are more likely to have economic or social payoffs to the nation. Science analyst Donald Stokes has described three kinds of research: purely basic research (work inspired by the quest for understanding, not by potential use), purely applied (work motivated only by potential use), and strategic research (research that is inspired both by potential use and fundamental understanding).[95] Moreover, there is widespread recognition in the research community that drawing a bright line between basic and applied research no longer makes sense. One way to improve the link between economic goals and scientific research is to encourage the formation of industry research alliances that fund collaborative research, often at universities.

While the government supports a few sector-based research programs, they are the exception rather than the rule.[96] Moreover, existing ones are largely underfunded. As a result, **Congress should fund a competitive Industry Research Alliance Challenge Grant program to match funding from consortia of businesses, businesses and universities, or businesses and national labs.** This program would resemble the current Technology Improvement Program (TIP) operated by NIST but would have an even greater focus on broad sectoral consortia and would allow large firms as well as small and mid-sized ones to participate. It could be housed in either NSF or NIST.

To be eligible for matching funding, firms would have to: form an industry-led research consortium of at least five firms, agree to develop a mid-term (three-to-ten year) technology roadmap that charts out generic science and technology needs that the firms share, and provide at least a dollar-for-dollar match of federal funds. This initiative would increase the share of federally funded university and laboratory research that is commercially relevant. In so doing it would better adjust the balance between curiosity-directed research and research more directly related to societal needs.

6. Establish a National Innovation Foundation

If Congress wanted to go further, it could establish a National Innovation Foundation (NIF)—a new, nimble, lean, and collaborative entity devoted to supporting firms and other organizations in their innovative activities.[97] The goal of NIF would be straightforward: to help firms in the nonfarm American economy become more innovative and competitive. It would achieve this goal by assisting firms with such activities as joint industry-university research partnerships, technology transfer from laboratories to businesses, technology-based entrepreneurship, industrial modernization through adoption of best practice technologies and business practices, and incumbent worker training. By making innovation its mission, funding it adequately, and focusing on the full range of firms' innovation needs, NIF would be a natural next step in advancing the innovation agenda that Congress put in place when it passed the America COMPETES Act. A National Innovation Foundation would:

- Catalyze industry-university research partnerships through national sector research grants.
- Expand regional innovation-promotion through state-level grants to fund activities like technology commercialization and entrepreneurial support.
- Encourage technology adoption by assisting small and mid-sized firms in taking on existing processes and organizational forms that they do not currently use.
- Support regional industry clusters with grants for cluster development.

- Emphasize performance and accountability by measuring and researching innovation, productivity, and the value-added to firms from NIF assistance.
- Champion innovation to promote innovation policy within the federal government and serve as an expert resource on innovation to other agencies.

By doing these things, NIF would address quite robustly each of the major flaws that weaken current federal U.S. innovation policy. We recognize that in the current fiscal climate it will be difficult for the federal government to launch major new investment initiatives, especially since strong political forces on either side of the aisle oppose raising taxes or cutting spending. Nevertheless, the compelling need to boost innovation and productivity merits a substantial investment in NIF. We propose that the federal government fund NIF at an initial level of $1 billion per year (with around $350 million coming from several programs that would be consolidated into NIF), ramping up to $2 billion after several years. At $2 billion, NIF's budget would be approximately one-third the size of NSF's. In addition, because of its strong leveraging requirements from the private sector and state governments, NIF would indirectly be responsible for ensuring that states and firms spend at least one dollar on innovation for every dollar NIF spent.

7. 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 more limited than it needs to be. To remedy that we propose two recommendations:

7a) Form an Office of Innovation Policy in OMB (i.e., an Office of Information and Regulatory Affairs for Innovation)[98]

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.

7b) To remedy these problems, Congress should create a White House Office of Innovation Policy that would have the specific mission of being the "innovation champion" within these processes. OIP 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. OIP 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 OIP would not be designed to thwart federal regulation; as a matter of fact, in some cases, the existence of OIP 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 an OIP a fairly small change to the system? Certainly adding OIP 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 will 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, OIP 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 OIP 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.

Conclusion

For over half a century, the United States led the world in innovation on a per-GDP and per-capita basis. This leadership role not only enabled America to be the leading military power, it enabled us to be the leading economic power, with the resultant economic and social benefits that came with that. But now more than ever, the American standard of living depends on innovation. To be sure, companies are the engines of innovation and the United States has an outstanding market environment to fuel those engines. Yet firms and markets do not operate in a vacuum. By themselves they do not produce the level of innovation and productivity that a perfectly functioning market would. Even indirect public support of innovation in the form of basic research funding, R&D tax credits, and a strong patenting system, important as they are, are not enough to remedy the market failures from which the American innovation process suffers.

At a time when America's historic lead in innovation has evaporated and its relative innovation competitiveness continues to shrink, when more and more high-productivity industries are in play globally, and when other nations are using explicit public policies to foster innovation, the United States cannot afford to remain complacent. Relying solely on firms acting on their own will increasingly cause the United States to lose out in the global competition for high-value added technology and knowledge-intensive production. Congress has an opportunity to take steps now to stop and reverse this slide, but only if it adopts the kinds of policies and makes the kinds of investments needed to help firms in the United States do a better job of driving innovation here at home.

Endnotes:

[1] Elhanan Helpman, *The Mystery of Economic Growth* (Cambridge, Massachusetts: Belknap Press, 2004).

[2] This is not to say that these nations have not developed some technology-based jobs. It is to say that relative to the rest of their economies, technology jobs will be a much smaller share than is the case in the United States. For an analysis of how, because of very low wages, China is specializing in manual assembly production, see Thomas Hout and Jean Lebreton, "The Real Contest Between America and China," *Asian Wall Street Journal*, September 16, 2003.

[3] Ronald J. Oakley, *God's Country: America in the Fifties*, (New York: Red Dembner Enterprises, 1986), 239.

[4] Joseph Schumpeter, *Capitalism, Socialism and Democracy* (New York: George Allen & Unwin Ltd.,1975), 132.

[5] Total private industrial research and development expenditures as a share of GDP grew 28 times from 1920 to 1960 (0.07 percent to 2.0 percent). By the mid-1950s, over 3,000 companies had R&D facilities. Public and private R&D expenditures grew from $3.6 billion in 1940 to $23 billion in 1967 (in constant dollars). See http://www.nsf.gov/sbe/srs/seind00/c1/tt01-03.htm.

[6] The process was the same with scientists. The 1900 census had only two scientific occupations: chemical assayers and metallurgists.

[7] Under the census categories, 'inventor' was a separate occupation since 1900, but was downgraded to a title within professional workers not elsewhere classified in 1940.

[8] Robert D. Atkinson, "The Globalization of R&D and Innovation: How Do Companies Choose Where to Build R&D Facilities?" October 4, 2007, Testimony to the House Science Committee, http://www.itif.org/index.php?id=102; Richard Rosenbloom and William J. Spencer. Eds. *Engines of Innovation: U.S. Industrial Research at the End of an Era* (Boston, Massachusetts: Harvard Business School Press, 1996).

[9] Richard Florida, "The World is Spiky," *Atlantic Monthly*, October 2005, 48-51, http://www.isites.harvard.edu/fs/docs/icb.topic30774.files/2-2_Florida.pdf.

[10] Pre-competitive research is defined as everything before the development of a saleable prototype.

[11] Raymond E. Corey, *Technology Fountainheads: The Management Challenge of R&D Consortia* (Boston: Harvard Business School Press, 1997); Andrew P. Cortell, *Mediating Globalization: Domestic Institutions and Industrial Policies in the United States and Britain* (Albany, New York: SUNY Press, 1997).

[12] Robert D. Atkinson *et. al*, "Addressing the STEM Challenge by Expanding Specialty Math and Science High Schools," Information Technology and Innovation Foundation, March 2007, http://www.itif.org/publications/addressing-stem-challenge-expanding-specialty-math-and-science-high-schools.

[13] Authors' analysis of data on scientific articles from National Science Foundation, "Science and Engineering Indicators 2008," National Science Foundation, 2008, Appendix Table 5-34; population data from the World Bank World Development Indicators database.

[14] Organization for Economic Co-operation and Development, *OECD Science, Technology and Industry Scoreboard 2007*, http://ocde.p4.siteinternet.com/publications/doifiles/922007081P1G2.xls.

[15] Organization for Economic Co-operation and Development *, OCED S&T and Industry Outlook*, 2004.

[16] Organization for Economic Co-operation and Development, OECD *Science, Technology and Industry Scoreboard 2005*, 2005.

[17] U.S. Bureau of Economic Analysis, "U.S. Current-Account Deficit Increases in 2006," News Release, March 14, 2007, www.bea.gov/newsreleases/international/transactions/2007/pdf/transannual06_fax.pdf.

[18] "Science and Engineering Indicators: 2010," National Science Foundation, 2010, http://www.nsf.gov/statistics/seind10/c0/c0s3.htm.

[19] Booz Allen Hamilton and INSEAD, "Innovation: Is Global the Way Forward?" (n.p.: Booz Allen Hamilton, 2006), 3.

[20] U.S. Bureau of Economic Analysis, "Real Value-Added by Industry."

[21] While venture capital in the United States more than doubled from $11.3 billion in 1996 to $26.4 billion in 2006, the amount invested in startup- and seed- stage deals fell from $1.3 billion to $1.1 billion. The amount invested in early-stage deals rose from $2.8 billion to $4.0 billion between 1996 and 2006, but the early-stage share of total venture funding fell from about 25 percent to about 15 percent. Similarly the number of startup- and seed-stage deals fell from 504 to 342; the number of early-stage deals rose from 762 to 918, but this represented a relative decline from about 30 percent to about 25 percent of all deals. Authors' analysis of 2006 data from PricewaterhouseCoopers/National Venture Capital Association MoneyTree Report, available at https://www.pwcmoneytree.com/MTPublic/ns/nav.jsp?page=historical.

[22] Titus Galama and James Hosek, *U.S. Competitiveness in Science and Technology* (Santa Monica, California: RAND Corporation, 2008), 67.

[23] Organization for Economic Co-operation and Development, *OECD Science Technology and Industry Scoreboard 2005*.

[24] Organization for Economic Co-operation and Development, *OECD Science, Technology, and Industry Scoreboard 2007*, 2007, http://oecd.p4.siteinternet.com/publications/doifiles/922007081PIG2.xls.

[25] Norman Augustine, *Is America Falling Off the Flat Earth?* (Washington: National Academies Press, 2006), 53.

[26] Jeffrey L. Furman and Richard Hayes, "Catching up or standing still? National innovative productivity among 'follower' countries, 1978–1999," *Research Policy* 33 (2004): 1329–1354.

[27] See Abe Tadahiko, "What is Service Science?" Research Report 246, Fujitsu Research Center, Tokyo, Japan, December 2005. The America COMPETES Act calls for a National Academy of Sciences study of service science (a useful first step) but does not create any means for the federal government to advance this discipline or diffuse its findings to foster innovation in services. See America COMPETES Act, section 1005, P.L. 110-69, 121 Stat. 593 (2007).

[28] Issues of the State Science and Technology Institute's *Weekly Digest* provides examples (www.ssti.org).

[29] In this context, "civilian" means non-defense-focused technology and innovation promotion agencies focusing on private sector and non-defense public sector technology and innovation funding and support.

[30] Information about foreign technology and innovation-promotion agencies is from the following sources: Denmark—Danish Technological Institute Web site, www.danishtechnology.dk; Finland—Tekes Web site, www.tekes.fi/eng, and personal communication with Peter Westerstråhle of Tekes; France—*OECD Reviews of Innovation Policy: France* (Paris: Organization for Economic Cooperation and Development, 2006); Iceland—Technological Institute of Iceland Web site, www.iti.is/english; Ireland—Enterprise Ireland Web site, www.enterprise-ireland.com; Japan—NEDO Web site, www.nedo.go.jp/english, and personal communication with Hideo Shindo of NEDO; Netherlands—TNO Web site, www.tno.nl/index.cfm?Taal=2; New Zealand—New Zealand Trade and Enterprise Web site, www.nzte.govt.nz; Norway—Innovation Norway Web site, www.innovasjonnorge.no; South Korea—Korea Industrial Technology Foundation Web site, http://english.kotef.or.kr; Spain—CDTI Web site www.cdti.es/index.asp?idioma=es&r-1024*768; Sweden—Vinnova Web site, www.vinnova.se/misc/menyer-och-funktioner/Global-meny/In-English; Switzerland—CTI Web site, www.bbt.admin.ch/kti/index.html?lang=en; United Kingdom–Technology Strategy Board Web site, www.dti.gov.uk/innovation/technologystrategyboard.

[31] It is difficult to obtain information on actual results. However, discussions with government officials suggest that overall, the programs have been successful. Moreover, agencies work to improve performance. For instance, Tekes conducts regular evaluations of specific programs. An example of such an evaluation may be found at http://www.tekes.fi/julkaisut/FENIX_arviointi.pdf (in Finnish, with English summary).

[32] Technology Strategy Board Web site, www.dti.gov.uk/innovation/technologystrategyboard/page40223.html.

[33] Tekes Web site, http://tekes.fi/eng/contact/personnel/hallitus.htm.

[34] Technology Strategy Board Web site, www.dti.gov.uk/innovation/technologystrategyboard/page40218.html.

[35] United Kingdom Cabinet Office, "Public Bodies: A Guide for Departments," (June 2006).

[36] Expenditures for Finland, Sweden, Japan and South Korea are based on personal correspondence between the authors and representatives of the respective nations' innovation-promotion agencies. Inference for the United States is from the authors' analysis.

[37] Testimony of Don Hillebrand, Ph.D., Director, Center of National Transportation Research at Argonne National Laboratory, to House Appropriations Subcommittee on Energy and Water Development, February 14, 2008.

[38] Auto Industry UK, "Germany invests €420M in lithium-ion battery development," May 13, 2008, http://www.autoindustry.co.uk/news/13-05-08_2.

[39] Forfas, *Service Innovation in Ireland – Options for Innovation Policy*, (Dublin, Ireland: Forfas, September 2006), 10, http://www.forfas.ie/media/forfas060928_services_innovation_full_report.pdf.

[40] €100 million converted into $120 million according to exchange rates at the time. (€100 million converts to $135 million in today's dollars.)

[41] Tekes, the Finnish Funding Agency for Technology and Innovation, *Service innovations – innovative business* (Helsinki, Finland: Tekes, 2006).

[42] While this is a small sampling, a comprehensive inventory of European services innovation policies is available via the European Innovation Policy Project in Services available at http://www.europe-innova.org/servlet/Doc?cid=9268&lg=EN.

[43] Robert D. Atkinson, "Expanding the R&D Tax Credit to Drive Innovation, Competitiveness and Prosperity," Information Technology and Innovation Foundation, April 2007, http://www.itif.org/node/1280.

[44] Bronwyn Hall and John van Reenen, "How Effective Are Fiscal Incentives for R&D? A Review of the Evidence," *Research Policy* 29 (2000): 449–469.

[45] Dominique Guellec and Bruno van Pottelsberghe de la Potterie, "Does Government Support Stimulate Private R&D?" *OECD Economic Studies* 29 (1997).

[46] In fact, government support declined significantly over this period and as a result, the United States was one of the few nations where the share of R&D-to-GDP ratio fell between 1991 and 2002.

[47] Martin Falk, "What Drives Business R&D Intensity Across OECD Countries?" Paper Presented at the DRUID 10th Anniversary Summer Conference, Copenhagen, Denmark (June 27–29, 2005).

[48] In 1985, the rate was reduced from 25 to 20 percent, and other restrictions (such as the 50 percent rule and the recapture of benefits through reductions in expensing) were put in place in the late 1980s.

[49] K.C. Whang, *A Guide to the Research Tax Credit: Why We Have It, How It Works, and How It Can Be Improved* (Washington, DC: U.S. Congress, Working Paper Series, Offered to the Joint Economic Committee Minority, Dec. 1998).

[50] Robert Atkinson and Scott Andes, "U.S. Continues to Tread Water in Global R&D Tax Incentives," Information Technology and Innovation Foundation, 2009, http://www.itif.org/files/WM-2009-03-rd.pdf.

[51] David M. Hart, "Global Flows of Talent: Benchmarking the United States," Information Technology and Innovation Foundation, November 2006, 12, http://www.itif.org/files/Hart-GlobalFlowsofTalent.pdf.

[52] Australian data are drawn from the Australian Department of Immigration and Multicultural Affairs (DIMA) annual *Immigration Update*, http://www.immi.gov.au/media/publications/statistics/. New Zealand data are drawn from OECD, SOPEMI 2006, 303-304. Canadian data are drawn from Citizenship and Immigration Canada annual *Facts and Figures*, accessible at http://www.cic.gc.ca/english/research/menu-fact.html. All figures are for principal applicants only.

[53] However, the 65,000 cap doesn't apply to all countries. For example the United States-South Korea Free Trade Agreement allows for a higher number of H-1B visa applicants from South Korea.

[54] Gregory Tassey, "Rationales and Mechanisms for Revitalizing U.S. Manufacturing R&D Strategies," December 2009, forthcoming in *Journal of Technology Transfer*, June 2010.

[55] Elvio Accinelli, Silvia London, and Edgar J. Sanchez Carrera, "Complimentarity and Imitative Behavior in the Populations of Firms and Workers," 2008, http://www.ssrn.com/abstract=1136323, (accessed on February 28, 2008).

[56] See Charles I. Jones and John Williams, "Measuring the Social Return to R&D," *Quarterly Journal of Economics* 113 (1998): 1119-1135; Edwin Mansfield, "Social Returns from R&D: Findings, Methods, and Limitations," *Research Technology Management* 34 (1991): 24-27; Eric Brynjolfsson, Lauren Hitt, and Shinkyu Yang, "Intangible Assets: How the Interaction of Information Technology and Organizational Structure Affects Stock Market Valuations," Brookings Papers on Economic Activity 1, (2000): 137-199.

[57] On the conflict between firms' desires to appropriate university research capacity and universities' broader social and economic role in promoting the free flow of knowledge, see Richard K. Lester and Michael J. Piore, *Innovation: The Missing Dimension* (Cambridge: Harvard University Press, 2004).

[58] Daniel Castro, "Improving Health Care: Why a Dose of IT May Be Just What the Doctor Ordered," Information Technology and Innovation Foundation, 2007, http://www.itif.org/node/1238.

[59] Shane Ham and Robert Atkinson, "Modernizing Home Buying: How IT Can Empower Individuals, Slash Costs, and Transform the Real Estate Industry," Progressive Policy Institute, 2003.

[60] Barry LePatner, *Broken Buildings, Busted Budgets: How to Fix America's Trillion-Dollar Construction Industry* (Chicago: University of Chicago Press, 2007).

[61] For a comprehensive overview of the causes and consequences of geographic industry clustering, see Joseph Cortright, *Making Sense of Clusters: Regional Competitiveness and Economic Development* (Washington: Brookings Institution, 2006). On the geographic clustering of innovation and the special importance of large metropolitan areas for innovation, see Andrew Reamer with Larry Icerman and Jan Youtie, *Technology Transfer and Commercialization: Their Role in Economic Development* (Washington: U.S. Department of Commerce, Economic Development Administration, 2003), 57-110.

[62] The authors' analysis of Bureau of Economic Analysis data on value added and employment at the national level and Economy.com data on the geographic distribution of industry employment shows that, for the 17 nongovernmental industry supersectors other than real estate (accommodation and food services; administrative and waste management services; arts, entertainment, and recreation; construction; educational services; finance and

insurance; health care and social assistance; information; management of companies and enterprises; manufacturing; mining; other services; professional, scientific, and technical services; retail trade; transportation and warehousing; utilities; and wholesale trade), the cross-industry correlation between an industry's Herfindahl index of employment concentration at the county or metropolitan level (a measure of the extent to which an industry is geographically concentrated rather than spread out evenly across the nation) at the beginning of the business cycle and the growth of inflation-adjusted value added per job in the industry over the course of the business cycle increased over the course of the 1979–89, 1989–2000, and 2000–05 periods. (Business cycles here are approximated by periods that begin and end in the last pre-recession year. The most recent period ends in 2005 because of data limitations.) At the county level, the correlation coefficient rose from -0.18 in 1979–89 to -0.07 on 1989–2000 to 0.36 in 2000–05. At the metropolitan level, it rose from -0.12 in 1979-89 to 0.00 in 1989–2000 to 0.15 in 2000–05.

[63] For a detailed treatment of this issue in the context of international trade, see Ralph Gomory and William J. Baumol, *Global Trade and Conflicting National Interests* (Cambridge, Massachusetts: MIT Press, 2000).

[64] Dani Rodrik, "Industrial Policy for the Twenty-First Century," Kennedy School of Government Working Paper, Harvard University, 2004, 38.

[65] Dan Breznitz, *Innovation and the State* (New Haven, Connecticut: Yale University Press, 2007), 29.

[66] Annual U.S. trade deficits have subsequently shrunk somewhat, to $731.2 billion in 2007 and to $673.3 billion in 2008; however, these annual trade deficits are still extremely high.

[67] "S.1466: Trade Enforcement Act of 2009," Govtrack.us, 13, http://www.govtrack.us/congress/bill.xpd?bill=s111-1466. See also Robert Atkinson, "Combating Unfair Trade Practices in the Innovation Economy," Testimony before the Committee on Finance, United States Senate, May 22, 2008, http://www.itif.org/files/atkinsonfinancecommitteetestimony.pdf.

[68] Robert D. Atkinson *et. al*, "Addressing the STEM Challenge by Expanding Specialty Math and Science High Schools."

[69] 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.

[70] Source for national figures are: U.S. Department of Education, National Center for Education Statistics, "Digest of Education Statistics," Table 18, http://nces.ed.gov/programs/digest/d05/tables/dt05_181.asp, and 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.

[71] Some of the expansion would come from construction and creation of new MSHSs. Costs for 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 an incentive to spur states and local school districts to create more specialty math and science high schools.

[72] Richard Freeman, "Investing in the Best and the Brightest: Increased Fellowship Support for American Scientists and Engineers," The Brookings Institute, 2006, http://www.brookings.edu/views/papers/200612freeman.pdf.

[73] 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.

[74] 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*, ed. 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.

[75] 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*, ed. Donald Wulff and Ann Austin (San Francisco: University of Chicago Press, 2006).

[76] Chris Golde and Timothy Dore, “At Cross Purposes: What the experiences of today’s doctoral students reveal about doctoral education.”

[77] 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.

[78] 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).

[79] Government Accountability Office, “Streamlined Visas Mantis Program Has Lowered Burden,” GAO 05-198, February 2005, http://www.gao.gov/new.items/d05198.pdf.

[80] David Hart, “Global Flows of Talent: Benchmarking the United States.”

[81] 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.

[82] Dan Berglund, State Science and Technology Institute, in-person interview with Rob Atkinson, January, 2010.

[83] 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.

[84] 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. 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.

[85]This kind of assistance to states with unsuccessful proposals is based on similar assistance that JumpStart, a nonprofit pre-venture capital fund in the Cleveland area, and Adena Ventures, an Athens, OH-based venture capital firm, provide to applicants whose proposals are not yet fundable. See www.jumpstartinc.org/Process/Assist.aspx and www.adenaventures.com/serviceprograms/opsassist.aspx.

[86] Jane E. Fountain and Robert D. Atkinson, *Innovation, Social Capital, and the New Economy: New Federal Policies to Support Collaborative Research*, Progressive Policy Institute, July 1998, http://www.ppionline.org/ppi_ci.cfm?knlgAreaID=140&subsecID=293&contentID=1371.

[87] L. Branstetter and M. Sakakibara, “Japanese Research Consortia: A Microeconometric Analysis of Industrial Policy,” *Journal of Industrial Economics*, 46 (1998): 207–233.

[88] 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 (Dec. 1981): 1111-1112.

[89]According to NSF, industrial R&D support to U.S. universities and colleges in current dollars reached its peak in 2001 and has declined every year since then (to 2004). The share of academic R&D provided by industry peaked in 1999 and has declined every year since. See Alan I. Rapoport, “Where Has the Money Gone? Declining Industrial

Support of Academic R&D," National Science Foundation, Division of Science Resources Statistics, September 2006, http://www.nsf.gov/statistics/infbrief/nsf06328/.

[90] Barry Bozeman and Albert N. Link, "Tax Incentives for R&D: A Critical Evaluation," *Research Policy* 13, no. 1 (1984): 21-31.

[91] Denmark looks to promote public and private co-operation in R&D by having a 150 percent deduction of investments co-financed by a public university or research institute and the industry.

[92] Jacek Warda, "Tax Treatment of Investment in Intellectual Assets: An International Comparison," *OECD Science, Technology and Industry Working* Papers, 4, 2006, Appendix 1.1.

[93] 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 non-profit 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.

[94] 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.

[95] Donald Stokes, "Pasteur's Quadrant*,*" Brookings Institution, 1997.

[96] See the Focus Center Program, http://fcrp.src.org/member/about/about_centers.asp.

[97] Robert Atkinson and Howard Wial, "Boosting Productivity, Innovation, and Growth Through a National Innovation Foundation," Information Technology and Innovation Foundation and The Brookings Institution, April 2008, http://www.itif.org/publications/boosting-productivity-innovation-and-growth-through-national-innovation-foundation .

[98] 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," Information Technology and Innovation Foundation, June 2009, http://www.itif.org/files/WhiteHouse_Innovation.pdf.