Blueprint for American Prosperity

Unleashing the Potential of a Metropolitan Nation

BOOSTING PRODUCTIVITY, INNOVATION, AND GROWTH THROUGH A NATIONAL INNOVATION FOUNDATION

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EXECUTIVE SUMMARY

Innovation drives America's economic growth and ultimately determines its living standards and those of its metropolitan areas. However, the nation faces a growing innovation challenge in today's global economy. To respond, the federal government should establish a **National Innovation Foundation** (NIF)—a new, nimble, lean, and collaborative entity devoted to supporting firms and other organizations in their innovative activities. By enhancing America's world-class entrepreneurial and market environment, NIF would boost the nation's innovation leadership for the 21st century and raise productivity and incomes. Moreover, by supporting workforce development and performance improvement in firms, NIF would help create better jobs for high school graduates in manufacturing and "low tech" services as well as those with advanced degrees in high technology industries.

America's Challenge

- **Global competition is increasing.** Like manufacturing, call centers, and software production, corporate R&D is also shifting overseas. Over the last decade, the share of U.S. corporate R&D sites declined from 59 to 52 percent within the United States, while it increased from 8 to 18 percent in China and India.
- **American innovation leadership is slipping.** The U.S. ranks only seventh among OECD countries in the percentage of GDP devoted to R&D expenditures.
- **Private markets suffer innovation inefficiencies.** Private firms tend to under-invest in innovation because no single business can capture all the economic benefits arising from new technologies, products, or business models.

Limitations of Existing Federal Policy

- **There is no national innovation policy.** Rather than comprising an explicit, focused, national agenda, federal innovation efforts are scattered throughout government.
- **There is little focus on services innovation and commercialization**. Existing federal innovation activities pay little attention to the service sector and to the important roles that smaller firms and universities play in the commercialization process.
- **There is no systematic innovation partnership between the federal government and state and local governments**. Federal policies do little to support the effective, albeit underfunded, innovation efforts established by state and local governments.

A New Federal Approach

The federal government should establish a new **National Innovation Foundation (NIF)** with the sole mission of promoting innovation. The NIF's proposed budget would be $1-2 billion per year. The new entity could exist as a new agency within the Commerce Department, a government-related public corporation, or an independent federal agency like NSF. The NIF 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 implementing best-practice 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** by promoting innovation policy within the federal government and serving as an expert resource on innovation to other agencies.

I. Introduction

In the last decade, an increasing number of economists have come to conclude that innovation—the creation and adoption of new products, services and business models—is the key to improved standards of living. The United States has led the world in innovation since World War II, and it continues to have many strengths, including entrepreneurial culture and expertise, a strong science base, healthy technology companies, protection of intellectual property, robust financial markets, relatively good working relationships between business and universities, and leadership in constructing and managing complex technology-based processes and organizations. Yet, there is disturbing evidence (e.g., technology exports, etc.) that our innovation lead is shrinking. The United States' share of new U.S. patents is declining. Its share of global R&D spending is falling. Its shares of worldwide scientific publications and researchers are dropping. In the last decade, while many other nations have put in place robust innovation policies, U.S. efforts have either waned or remained static, at best. Traditionally, the federal government has focused on basic science (principally through the National Science Foundation); agency-specific mission-oriented research; supporting science, technology, engineering, and mathematics (STEM) education; and managing a patent system. However, because the process of innovation has changed, these federal activities, while necessary, are no longer sufficient to ensure a high and rising standard of living for Americans.

The argument that innovation is one of the key drivers of our nation's—and especially our metropolitan areas'—economic prosperity is a central theme in the *Blueprint for American Prosperity*, a series launched by the Metropolitan Policy Program at Brookings. This initiative sets forth an agenda of federal policy reforms around innovation, as well as human capital and infrastructure, which would enable our nation and its metropolitan areas to grow in more productive, inclusive, and sustainable ways. As a part of this initiative, this paper asserts that, if the United States is going to meet the economic challenges of the future, including the pressing need to continue to boost productivity, the federal government will need to make the promotion of innovation a larger part of its national economic policy framework. Innovation is especially important to the prosperity of our metropolitan areas because most of the nation's economic activity, and especially its innovation, occurs in metropolitan areas.

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. Improving the performance of firms that operate in the United States leads to higher real wages for U.S. workers and, if done in the way this paper proposes, will not reduce the number of American jobs. An innovation agenda for the United States should benefit workers, firms, and regions that depend on manufacturing as well as those that depend on information technology and high school and community college graduates as well as PhDs.

Congress took an important step towards promoting innovation with the passage of the 2007 America COMPETES Act. However, it needs to go beyond increasing funding for university research and boosting STEM education to support policies that will more directly help enterprises in the United States become more innovative. However, to do that effectively, federal efforts need to be nimble, lean, and conducted in sustained partnerships with other actors.

To that end, we propose that Congress build on the America COMPETES Act by creating a new National Innovation Foundation (NIF) whose core mission would be to boost innovation in nonfarm businesses. NIF's goal would not be to direct innovation or seek its own patents. Rather it would work with businesses, state governments, universities, and other partners to help spur innovation. Its activities would include funding national grants for sectoral innovation research; grants for expanding state-level technology-based economic development programs; national technology diffusion activities to help companies and industries adopt the best existing technologies, and regional grants to promote the development of industry clusters. It would also advocate for innovation, promote the measurement of innovation, and carry out policy-oriented research on innovation. Initially funded at $1 billion annually (with around $350 million coming from several programs that would be consolidated into NIF), NIF would have an eventual budget of at least $2 billion per year.

Some will argue that the role for government in the innovation process is naturally limited – that this is a task solely for the private sector. While we agree that the private sector should lead, we also believe that in an era of globalized innovation and intensely competitive markets that the federal government can and should play an important enabling role in supporting private sector and sub-national innovation efforts. Indeed, many nations have come to that realization. In recent years many nations have established generously funded, non-bureaucratic organizations whose sole mission is help businesses and other organizations be more innovative. It is time for the United States to do the same.

II. Innovation Is Key to Raising Productivity and the American Standard of Living

Many conventional economists still view "capital accumulation" as the key to growth. They advocate policies to increase saving, such as tax cuts and budget surpluses. However, 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.[1] As economist Paul Romer states, "No amount of savings and investment, no policy of macroeconomic fine-tuning, no set of tax and spending incentives can generate sustained economic growth unless it is accompanied by the countless large and small discoveries that are required to create more value from a fixed set of natural resources."[2]

Empirical studies support Romer. Economist Charles Jones finds that R&D accounts for around 1.4 percentage points of annual GDP growth.[3] Some economists estimate that R&D's rate of return to the United States as a whole (not just the return to the firms that undertake it) is as high as 30 percent.[4] But R&D alone is not enough to drive economic growth. Also need it the diffusion of new technology throughout the economy, to both technologically lagging small and mid-sized firms and entire

Box 1: What Is Innovation and How Is It Organized?

Innovation involves putting new ideas into commercial use; in this way it differs from invention, which does not necessarily involve actual use. There are several kinds of innovation: the creation of new products or services ("product innovation"), the use of new production technologies and techniques ("process innovation"), and the implementation of new ways to organize work and business processes ("organizational innovation"). Each of these may involve either an innovation new to the world (e.g., the introduction of the personal computer or the Internet) or one that is simply new to a particular firm or industry (e.g., the use of electronic communication to manage retail supply chains). (The latter is often referred to as the diffusion of innovation.) Each may be "radical" (completely different from existing products, processes, or organizational forms) or "incremental" (changing existing products, processes, or organizational forms in small ways to create new ones).[5] Some product or process innovations may result from formal research and development programs, while others may be developed as a byproduct of the production process or through feedback from the production process to formal R&D, while still others may come from interactions with users.[6] All these types of innovation are important for improving the American standard of living. Our proposed National Innovation Foundation would promote all of them while recognizing that some types of innovation are more important than others in particular firms, industries, or metropolitan areas at particular times.

Innovation in today's economy takes place in at least four distinct innovation trajectories, each with its own needs for government assistance.[7]

The *cutting-edge science-based* trajectory involves industries, such as biotechnology and parts of information technology, that depend on cutting-edge university research, which is typically patented and licensed, sometimes to new, small firms that rely on venture capital for financing. New and small firms following this innovation trajectory may need assistance with technology transfer, access to venture capital, and access to highly educated scientists and engineers. Larger firms following this path may need assistance in helping them overcome "free rider" problems where firms inadequately fund generic research that is key to their industry, but is too risky and too early-stage for them to justify individual firm investments in.

The *related diversification* trajectory involves using existing technologies to create new market opportunities, either in existing firms or in new ones. For example, the University of Akron has sought to help Akron-area firms find new applications for polymer technology, which was the core technology of the region's tire industry. In this innovation trajectory, firms' technology transfer needs are more applied and distant from cutting-edge science.

The *upgrading* trajectory is the one often followed by firms in more mature industries that do not depend much on cutting-edge science. It involves constant, usually incremental innovation in products, processes, or ways of organizing production. Firms following this trajectory, especially small- and mid-sized firms, may need assistance with such things as technological modernization, work reorganization, and worker training needed to implement them. Here, university research is not especially important. Technical assistance to firms is what is needed. Moreover, in many of these firms and industries, there are often a lack of technical standards and incentives that limit the adoption of technologies, usually IT and software.

Firms and industries on the *project-based* trajectory produce customized services that require creative solutions to problems (although these often follow a standard form). Activities as diverse as construction, sophisticated financial deals, architecture, advanced medical treatment, the arts and entertainment, and advertising follow this innovation trajectory. The project, whether it be a construction project, a financial deal, or a concert, is the basic unit of production. Firms and workers often do not have stable, long-term relationships. Yet the ability of firms to bring together creative, skilled workers for the duration of a project is paramount. They may need assistance in accessing those workers and the workers may need assistance in moving from project to project and in maintaining continuity of income and employee benefits between projects.

Innovation in all four trajectories benefits from geographic clustering. Firms engaging in similar activities or similar technologies (which are also likely to be on the same innovation trajectories) are more productive and innovative when clustered geographically.

Of course, these trajectories are not static; a given product or service can move from one trajectory to another. For example, as the production of automobiles moved from craft to mass production, the dominant innovation trajectory changed from project-based to upgrading.

industries that have not made effective use of new technologies.[8] We have seen this over the last decade as the widespread use of information technology by organizations has powered a revival of productivity growth, increases in the quality of goods and services, and the creation of new products.[9] Innovation, however, is not limited to information technology or other cutting-edge technologies, but occurs in a variety of ways throughout the economy (Box 1).

Innovation is important because it leads to the development of new products and technologies as well as because it drives economic growth. However, productivity growth is the best aggregate measure of the economic consequences of innovation. The most common measure of productivity, labor productivity, can be defined as value added per unit of labor.[10] Productivity growth is the key to higher standards of living because it lets workers produce more for the same amount of work.[11] Box 2 explains how productivity growth occurs.

Rapid productivity growth does not necessarily imply that all Americans' standards of living increase at the same rate. The distribution of the gains from productivity growth became more unequal in recent decades. Low- and middle-wage workers benefited from productivity growth between the late 1960s and the beginning of the current century but high-wage workers benefited most.[12] Reducing economic inequality should be a priority of federal policy, and other papers in this series propose policies to accomplish that goal. However, the need to reduce inequality does not obviate the need to improve productivity growth. Even though the gains from productivity growth are distributed unequally (and, in our view, unacceptably), productivity growth still benefits even those at the bottom of the earnings distribution, and slower productivity growth would make it much harder to help low and moderate income Americans increase their living standards.[13]

By the same token, U.S. productivity growth is not monolithically the same at all places in all industries or in all companies. Productivity growth rates vary widely across industries. While overall productivity growth between 2001 and 2005 averaged 2.6 percent annually, productivity in computer and electronic products grew 23 percent per year during this period, while productivity in support activities for mining fell by 8 percent per year (See table 1 in Appendix A).[14] Productivity growth rates also vary greatly among firms within the same industry.[15]

Because metropolitan areas have different industry compositions and different productivity growth rates within each industry, their productivity growth rates also vary widely.

Box 2: How Does Productivity Grow?

The productivity of an economy can grow in two different ways. First, productivity can be increased by raising the value of goods and services produced (e.g., shifting production from standardized commodities based on existing technologies to new, higher performance technologies for which consumers are willing to pay a premium and also gain greater economic benefit). Second, productivity can grow by producing a given set of goods or services in a more technically efficient manner. Although these two methods of raising productivity cannot be rigidly associated with any of the various kinds of innovation described above and are in fact complementary, product innovation is more likely to promote transitions from lower to higher value-added products while process and organizational innovation are more likely to improve technical efficiency. To often policy makers, both here in the United States and around the world, stress the first form, and give short shrift to the second, even though the latter approach is where most productivity gains come from.

Raising productivity is not a matter of working harder or working longer hours. Making production more technically efficient requires getting more out of existing work hours, not raising the number of hours worked. Although having workers work harder can yield short-term productivity gains, it is not a route to sustained, long-term growth in technical efficiency, which can be obtained only through new capital equipment and software, higher skills, or new ways of organizing work. Furthermore, shifting the mix of goods and services toward those that consumers value more highly has nothing to do with working harder or longer.

Some fear that productivity growth will lead to job losses because fewer workers will be needed to produce the same amount of goods and services. This fear is misplaced. Although productivity growth can cause job displacement in particular firms (which should be addressed through workforce adjustment and full-employment policies), historically it has lead to an expansion of output and demand that generates new jobs that more than make up for the initial losses. For almost 30 years after World War II, for example, the United States enjoyed both rapid productivity growth and rapid job growth. Economist William Nordhaus has shown that even in manufacturing, where job losses have been most severe in recent years, more rapid productivity growth was associated with more rapid job growth (or less rapid job loss).[16]

Table 2 in Appendix A shows that productivity growth in the top 100 metropolitan areas combined averaged 2.3 percent annually between 2001 and 2005, but that productivity in Baton Rouge, LA, grew at an average annual rate of about 5.1 percent during this period, while productivity in Wichita, KS, fell by 0.3 percent per year.

In large part because of the production and diffusion of information technology, overall U.S. productivity growth since the mid-1990s has been strong by historical standards and in comparison to other countries.[17] However, the large interfirm, interindustry, and interregional differences suggest that American productivity is not as high as it could be. To be sure, not all lagging firms, industries, and regions are equally able to improve their productivity growth, but the American standard of living and the competitiveness of firms in the United States would be higher if productivity growth were stronger in at least some of the lagging firms, industries and regions. More innovation in all firms, industries, and regions is one way to make this happen. More rapid diffusion of leading technologies and business practices to lagging firms, industries and regions is another.

III. Innovation Presents a Growing Challenge for the United States

Innovation is more important to the American economy now than in the past. Since the end of World War II the United States has been the world leader in innovation and high value-added production. But now a growing share of that activity is at play in international competition and other nations are posing a growing challenge to the U.S. innovation economy.

1. Increasing global competition in goods and services is making innovation more crucial for U.S. prosperity

The trade deficit represents perhaps the most visible manifestation of the global challenge. At 6.5 percent of GDP, the current account deficit is at an all-time high both in absolute terms and relative to size of our economy.[18] The traditional U.S. trade surplus in agricultural products is nearing zero and in high-technology products has turned negative. Meanwhile, our surplus in services trade is small and only holding relatively steady. Manufacturing's share of GDP has declined from 15.6 percent to 12.1 percent between 1993 and 2006, while the goods trade deficit increased by 4.3 percentage points as a share of GDP.[19] The development of more innovative products and processes would make it easier for the U.S. to reduce its trade deficit, particularly in manufacturing.

Services, meanwhile, are increasingly tradable and subject to international competition. Information-based services, from call centers to software production, can now be provided at a distance over fiber optic cables. Moreover, companies are increasingly shifting R&D overseas. Between 1998 and 2003 investment in R&D by U.S. majority-owned affiliates increased twice as fast overseas as it did at home (52 percent versus 26 percent).[20] In the last decade the share of U.S. corporate R&D sites in the United States declined from 59 percent to 52 percent, while the share in China and India increased from 8 to 18 percent.[21]

The growth of international trade and the globalization of production make 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.[22] 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 will remain in more labor-intensive, less complex portions of the production process.[23]

By contrast, the United States' primary source of competitive advantage will 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 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.[24]

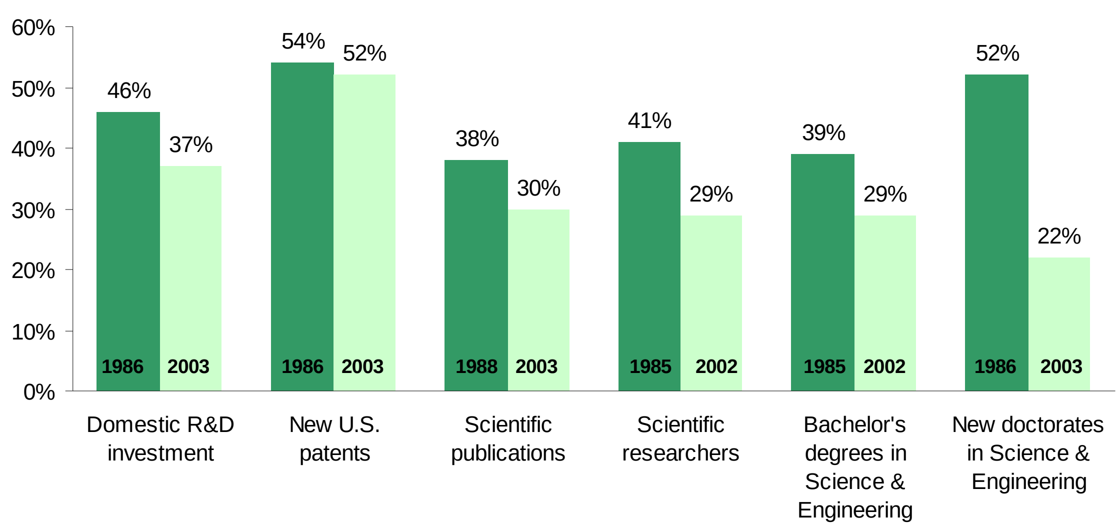
Nor does this mean that the United States must inevitably cede entire industries to low-wage countries. Even in industries such as apparel, which are dominated by labor-intensive production, some firms have carved out innovation-based product niches (e.g., high fashion articles whose designs change rapidly) that make it possible for them to produce in the United States. Moreover, with sufficient productivity growth (especially if coupled with an increase in other nations'--particularly Asian--currency values relative to the U.S. dollar), companies can more than 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. Hence the first argument for the importance of innovation for America: enhanced productivity can offset high U.S. wages and keep production in the United States., but this will require sustained process and organizational innovation, including adoption of advanced automation technologies, which cannot easily be replicated in low-wage countries.[25]

2. American leadership on key indicators of innovation is slipping compared to other high-wage nations

The American innovation challenge does not come only from low-wage nations, however. High-wage nations are catching up to or even surpassing the United States on important indicators of innovation performance. By some indicators the United States no longer leads the world:

- 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 fell between the mid-1980s and the beginning of this century (Figure 1).

FIGURE 1
The United States Is Slipping in Its Share of Global Totals on Various Science and Technology Indicators



Source: Council on Competitiveness

- A declining share of American college students graduates with science and technology degrees. The United States ranks just 33rd in the percentage of 24-year-olds with a math or science degree out of 91 countries for which data are available.[26] 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.[27]

- 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.[28]

- 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).[29] One reason 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).[30] Moreover, corporate-funded R&D as a share of GDP fell in the United States by 7 percent from 1999 to 2003, while in Europe it grew by 3 percent and in Japan by 9 percent.[31]

- The United States has also fallen behind in broadband penetration. Broadband is important because it enables companies and individuals to use more efficient processes and helps make information technology-producing companies more competitive internationally.[32] In 2001, the United States ranked fourth in broadband penetration among 30 OECD nations, but after several years of steady decline in the rankings we had dropped to 15th by the middle of 2007, behind France, Japan, Canada, South Korea, and others. Broadband penetration growth in the United States is now the second slowest in the OECD on a percentage point basis. Moreover, the United States does not fare much better in measures of broadband speed and price – important measures of the quality and viability of a nation's broadband offerings. One recent analysis ranked America 15th-in broadband speed and 18th in price among 30 OECD nations.[33]

IV. Multiple Market Failures Impede Innovation

The decline of American leadership in innovation is one reason why more concerted engagement by the federal government is warranted. Another is that markets fail to allocate sufficient resources for innovation. At least six serious market failures plague the innovation process.

1. Because individual firms cannot capture all the benefits of their own innovative activity, firms will produce less innovation activity than society needs

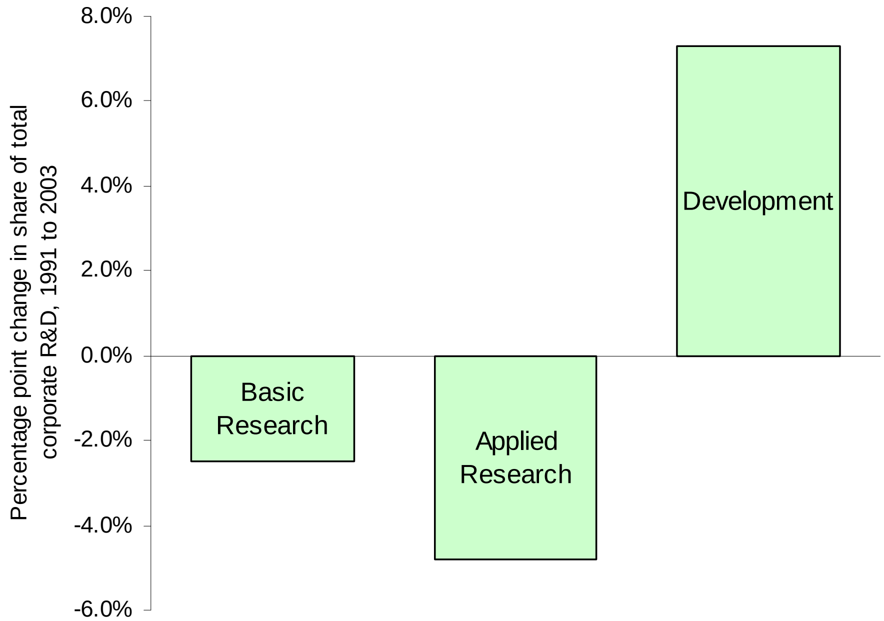
The first market failure has to do with who benefits from private companies' investments in innovation. The knowledge needed to create new products, processes, and organizational forms is not something that can be completely contained within an individual firm. It inevitably spills over to other firms, 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 are at least twice the estimated returns that the company itself receives.[34] 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. The private financing of R&D is shifting away from riskier early-stage activities

A second problem has to do with the process by which R&D is financed, and how that has changed in recent decades. In the first few decades after World War II, the financing and performance of R&D was largely internal to leading firms. Such large firms as AT&T and Xerox did a substantial amount of generic/fundamental (proof-of-concept) technology research as well as applied research and new product development. Today, venture capitalists often fund small firms to develop new products, often using university-based research. Yet this process does not always run smoothly. There were only 3,608 venture deals in the United States in 2006.[35] There is also disturbing evidence that the private sector is investing less in early- stage and riskier activities in this country. For example, even though the United States has the world's best- developed venture capital markets, less is invested in startup- and seed-stage venture deals today than a decade ago, and a smaller percentage of venture funding now goes to early-stage deals (the stage just after seed-stage).[36] As the venture capital market has matured, firms have found it more profitable to invest in larger deals and less risky later-stage deals. The result is a gap between the completion of basic research and applied R&D.

Moreover, the private sector, while investing more in R&D in this country overall, has shifted the mix of that spending toward development and away from generic technology research (produced in past decades by Bell Labs, Xerox PARC, and similar corporate research facilities). Even basic research is being shortchanged. From 1991 to 2003, basic research as a share of total corporate R&D conducted in the United States fell by 2.5 percentage points while applied fell even more, by 4.8 percentage points. In contrast, development's share of corporate R&D increased by 7.3 percentage points. (Figure 2.)

FIGURE 2
Between 1991 and 2003, 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

3. 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.[37]

4. 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.[38] The residential real estate industry has resisted moving toward more Internet-enabled sales.[39] The construction industry is plagued by inefficiencies and failures to adopt best-practice technologies and techniques.[40] A host of market failures, including chicken-or-egg issues related to standards and technology adoption, impede faster productivity growth in many industries.

In addition, regardless of industry, many small and mid-sized firms (those with fewer than 500 employees) lag in adopting technologies that leading firms have used for decades.[41] These firms may not know how their performance compares to that of other firms in their industry. Without assistance they may lack the organizational capability to discover and implement new technologies. Although there are private consultants who help firms modernize their production processes, small and mid-sized firms may not know what services they need from consultants and may not be equipped to identify and work with them. They may be unable to evaluate the quality of these services without having received them in the past. They may face capital market constraints that prevent them from financing the technological changes they need to make. U.S. firms facing intense competition from low-cost foreign producers may be uncertain about their ability to remain in business at all and may not recognize that technological modernization can help them succeed. In addition, the adoption of new technology usually requires workers to be trained in using the technology. Firms may be reluctant to invest in that training because the trained workers may leave before the investment pays off for the firm.[42] Finally, worker involvement in production decision making appears to raise productivity and can complement the productivity gains from information technology.[43] However, firms may not give workers enough say about production decisions for fear that the firm's owners will not receive enough of the resulting productivity gains.[44]

5. The innovation-producing benefits of industry clusters are under-realized

A fifth 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, a common supplier base), facilitates better labor market matching, and facilitates 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 be spur knowledge transfers. Such industries are especially likely to cluster in large metropolitan areas.[45] 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 makes it the world's most vibrant technology region. But Silicon Valley is not the only region 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.[46]

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. Cluster firms usually require external coordination (e.g., from governments, labor unions, or strong 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 more innovation and higher productivity.

6. The interests of geographically mobile firms in locating innovative activity may diverge from those of the 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.[47] 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 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.[48]

V. Government Must Act to Improve the Innovation Process

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.

First, government should subsidize both R&D and the training of workers in the use of leading-edge technologies. Second, government should help fill the financing gaps in the private R&D process, particularly for higher-risk, longer-term, and more generic research. Third, it should spur collaboration between firms and research institutions such as universities. Fourth, it should provide firms, especially small and mid-sized ones, with information about how to improve their performance and with assistance in using that information effectively. Fifth, it should help firms establish common standards for technology usage, as, for example, the Bush administration is currently doing in the use of IT in health care. Finally, there is also a growing need for government to encourage the development of industry clusters, as governments such as that of China have deliberately done as a way of reducing costs and improving productivity.[49]

Some of the needed government action should and does come in indirect forms that do not require governments to know much about the details of technology or regional economies or the needs of particular industries and firms. The R&D tax credit is an example.[50] Here the government role is to set and enforce criteria for the credit that reflect the public interest and then let individual firms make their own decisions about R&D. But to respond effectively to most of the market failures identified above, and even to identify them in a way that makes an effective response possible, governments need much more fine-grained knowledge about technology or business practice. Without such knowledge the government cannot usefully decide which R&D projects to fund, help an industry cluster overcome the barriers that inhibit its development, understand the barriers to technological or organizational modernization, or help small firms understand how to upgrade their technologies. Yet, the knowledge that is required is dispersed among private firms and other economic actors (such as educational and training institutions, regional business associations, trade associations, labor unions, and venture capitalists). It changes rapidly as business conditions change and can vary greatly between industries and across locations. It is not the kind of knowledge that a traditional bureaucratic agency, isolated from the day-to-day workings of business, can easily acquire or use. Instead, government needs a much closer and more collaborative relationship with business to gain the knowledge that will enable it to address the market failures.

The government 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, our argument implies that 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 our 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."[51] 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.[52] Such an agency needs to be more familiar with science, technology, and business practice, and have more cooperative relationships with business, than a traditional bureaucracy.[53]

VI. Current Federal Innovation Policy Has Fundamental Weaknesses

Any effort to design a federal innovation agenda must consider carefully the strengths and weaknesses of the nation's current efforts. As noted at the beginning of this paper, the U.S. innovation system possesses a number of strengths. Indeed, we have perhaps the best market environment in the world to support innovation, but arguably a weak innovation policy system. Our challenge in the face of stiff global competition is to preserve our market advantages while strengthening our innovation policies. Unfortunately, the nation contends with several weaknesses in its innovation policies.

1. The nation lacks an explicit national innovation policy

Since World War II, explicit national economic policy has largely been demand-side policy focused on managing the business cycle. To the extent that there has been any policy aimed at increasing the supply of goods and services, it has consisted, depending on the party in power, of indirect efforts to stimulate supply by reducing taxes, largely on individuals, or boosting public savings by reducing the federal budget deficit.[54]

When it comes to technology, the United States has a basic science policy (funding research and educating scientists and engineers) but has no specific supply-side productivity and innovation policy. Those federal innovation programs that do exist were developed and now operate in an ad hoc manner rather than as part of a general policy to promote innovation.[55] Yet, in today's economy, national economic policy must also focus on helping the supply side of the economy: organizations and entrepreneurs. This raises a whole new set of questions for economic policy. Are entrepreneurs taking risks to start new ventures? Are companies investing in technological breakthroughs and is government supporting the technology base (e.g., funding research and the training of scientists and engineers)? Are regional clusters of firms and other institutions fostering innovation? Are research institutions transferring knowledge to companies? In short, national economic policy must recognize the fundamental insight that innovation is key, that it takes place in particular institutions and places, that innovation policy ought to be a key component of national economic policy. From that perspective, simply funding more research and educating more scientists and engineers is not enough.

2. Federal innovation efforts are fragmented and diffuse, with no federally-funded organization whose sole mission is to spur innovation

Perhaps most striking of all the weaknesses in our national innovation policy system is the fact that although there are a number of programs that help companies become more innovative or productive, there is no agency or organization that has firm-level innovation as its sole mission. (Box 3 gives an overview of the principal federal programs that support nonfarm firm-level innovation, while Appendix B describes them in more detail.)

Box 3. An Overview of the Major Federal Innovation-Promotion Programs

Before the America COMPETES Act was signed into law in August 2007, the programs that focused most directly on stimulating commercial innovation were the Advanced Technology Program (ATP) and the Hollings Manufacturing Extension Partnership program (MEP), both housed at the National Institute of Standards and Technology, a part of the Commerce Department. Each program addressed a particular aspect of innovation. ATP funded firms to develop new, high-risk technologies, while MEP assists small and mid-sized manufacturers with the diffusion of best-practice technologies. Notwithstanding their strong performance, these programs were at risk of elimination for many years.[56] Under the America COMPETES Act MEP is scheduled to receive $131.8 million in fiscal year (FY) 2010, about 3 percent more (not adjusted for inflation) than it did in 1999, the year in the last decade when its budget was highest in nominal terms. The America COMPETES Act abolished ATP and created a new Technology Innovation Program (TIP) with a substantially broader scope than ATP. However, the legislation does not match the broader scope with increased funding. TIP is slated to receive $140.5 million in 2010, slightly more than ATP received in 2005 but less than ATP received in any year between 1998 and 2004.[57]

Through early 2007, the Office of Technology Policy (OTP) in the Commerce Department's Technology Administration was the only federal agency responsible for developing and advocating for federal technology policy. In 2007 the America COMPETES Act abolished the Technology Administration[58] and the Commerce Department replaced OTP with an intradepartmental technology council chaired by an advisor to the Secretary of Commerce. The new council does not have a staff comparable to OTP's and is responsible only for technology policy within the Commerce Department.

The National Science Foundation (NSF) largely focuses on basic research and the support of universities. However, it operates three grant programs that encourage industry-university collaboration: the Engineering Research Center Program, the Industry-University Cooperative Research Center program, and Partnerships for Innovation. However, these programs are almost an afterthought for NSF. In FY 2006, they accounted for only about $74 million (or 1.3 percent) of NSF's $5.58 billion budget. They also focus more on university research than on technological commercialization.

The Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs fund innovation, but they are scattered throughout various federal cabinet departments and independent agencies (11 in the case of SBIR and five in the case of STTR). They are part of the federal procurement process, with innovation as a related goal. They reserve a portion of federal R&D funding for small businesses and, in the case of STTR, universities or nonprofit research institutions that work in partnership with small businesses.

Other innovation-promotion programs are even more narrowly focused. The Energy Department's Industrial Technologies Program funds firms to develop new, high-risk technologies that promise to improve energy efficiency or environmental performance. The Labor Department's Workforce Innovations in Regional Economic Development (WIRED) program funds consortia or firms and other economic actors (such as educational and training institutions) to promote the development of regional industry clusters. However, it funds only workforce training efforts.

Innovation is an incidental part but not a primary purpose of several other federal agencies and programs. (For this reason, these programs are not included in Appendix B.) The Small Business Administration focuses on small firms, innovative or not. The Department of Commerce's Economic Development Administration focuses on helping economically distressed regions, but innovation may or may not a part of the projects it funds. Similarly, the Appalachian Regional Commission is devoted to economic development in the Appalachian region, especially in economically distressed counties. It funds various economic development projects, some of which include innovation but many of which do not. The Commerce Department's International Trade Administration operates Export Assistance Centers, whose purpose is to help U.S. firms export goods and services. The Department of Labor's Employment and Training Administration, which administers WIRED, also focuses on workforce skills related to a range of industries and activities.

The Defense Advanced Research Projects Agency (DARPA) has funded some innovation programs. The Internet grew out of a DARPA initiative. In recent years, however, DARPA has shifted toward more short-term, mission-oriented development. Indeed, it is not an exaggeration to state that if DARPA were making the kinds of investments it makes today 30 years ago, the Internet never would have been developed. Moreover, even if DARPA's funding priorities shifted back toward what they were in the past, the agency would still fund only projects that had some defense applications. Any non-defense applications of DARPA-funded R&D would be a fortuitous outgrowth of the agency's work.

With a few important exceptions, innovation is at best a byproduct of federal programs whose main purpose lies elsewhere. Even the few programs that focus explicitly on innovation deal with only limited parts of the problem, such as performance improvement in manufacturing or technology transfer from universities to firms. With the exception of the Energy Department's Industrial Technologies Program and the Labor Department's WIRED program, federal innovation programs are designed only to help individual firms, rather than whole industries, innovate. Yet although individual firms are the appropriate recipients of federal assistance, the purpose of this assistance should be much broader: to promote the creation and diffusion of innovation across as well as within firm and industry lines.

This broader goal is not part of the mission of most existing federal programs. As a result of these shortcomings, the federal government has only a very limited ability to see and promote the complementarities that may exist between innovation needs in different industries or geographic regions. Its ability to see and promote the connections between different kinds of innovation and different stages of the innovation process is likewise limited.

3. Federal innovation efforts are underfunded

Then there is the funding issue. Compared to other nations, the federal government invests little in innovation-promotion efforts. In FY 2006, the federal government spent a total of $2.7 billion, or 0.02 percent of GDP, on its principal innovation programs and agencies (ATP, MEP, the Office of Technology Policy, the three NSF innovation programs, SBIR, STTR, the Industrial Technologies Program, and WIRED) (Appendix C.) If the federal government were to invest the same share of GDP in these programs and agencies as many other nations do in comparable organizations, it would have to invest considerably more. If the United States wanted to match Finland's outlays per dollar of GDP it would have to invest $34 billion per year. Other nations invest less in their innovation-promotion agencies, but still considerably more than the United States: Sweden, 0.07 percent of GDP; Japan 0.04 percent, and South Korea 0.03 percent. 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.[59]

Moreover, U.S. investments 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 ATP, MEP, the Office of 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. The large SBIR and STTR programs grew faster than GDP between 1998 and 2006, but largely because federal agency R&D budgets (especially in the Department of Defense for development of weapons systems) grew. Total spending on the principal federal innovation promotion programs other than SBIR and STTR fell by 28 percent in nominal terms between 1998 and 2006.

The federal government's investment in innovation promotion pales in comparison with its investment in basic scientific research. For example, in FY 2005, the latest year for which state-level data are available, the value of federal grants, contracts, and cooperative agreements awarded by ATP, MEP, and the three NSF innovation-promotion programs totaled $223 million, while those awarded by the National Institutes of Health (NIH) and the balance of NSF totaled 126 times that amount, or $28.2 billion. Although this is not a comprehensive comparison of all federal expenditures on innovation promotion with all federal expenditures on basic scientific research, it illustrates the huge difference in federal commitment to these two kinds of activities.

The pattern is replicated in every state to a greater or lesser degree. Federal awards by NIH and the balance of NSF exceeded those by ATP, MEP, and the three NSF innovation-promotion programs by a factor of 18 in North Dakota and 27 in Nevada. At the other extreme, this factor was 918 in Maryland (where NIH is headquartered) and 563 in Washington state (Appendix D).

Indirect federal support for innovation is also poorly funded. In 1990, the United States had the world's most generous tax treatment for R&D. However, because the generosity of the credit has been whittled away over the years, and other nations have forged ahead, by 2006 we had dropped to 17th most generous.[60] Moreover, 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. In contrast, government support for R&D increased in most other nations, including Japan (15 percent increase), Ireland (24 percent), Canada (33 percent), South Korea (51 percent), Sweden (57 percent), China (66 percent), and Israel (101 percent).[61]

4. Federal innovation efforts are primarily focused on larger firms and a few major research universities and less on the process of commercialization, which requires public and private entities of all sizes

Another issue is that of coverage. The federal innovation system historically has focused on larger firms (typically multinational firms with large R&D units) and large, first-tier research universities. For example, the 30 universities that received the most federal science and engineering research funding in FY 2004 received 45 percent of all federal science and engineering research funding to universities. They were located in 25 metropolitan areas in 18 states.[62] These firms and universities have played key roles in driving innovation and technological development in the United States. However, the innovation needs of the U.S. economy today extend well beyond a few large firms and universities, and we cannot rely on other firms simply to copy or adapt the innovations that emerge from those firms and universities.

It is difficult for federal policy to focus explicitly on either smaller firms or smaller research universities, and especially on collaboration between the two. There are simply too many small and mid-sized firms and too many universities and colleges for the federal government to engage meaningfully with them. In contrast, it is easier for states to work with small- and mid-sized firms and second-tier colleges and universities. As a result, any federal policy that seeks to stimulate collaborative R&D among small- and mid-sized firms and non-top-ranked universities should strengthen and support state efforts.

5. Federal policy pays little attention to services innovation

A fifth problem with current federal innovation policy is the lack of attention it pays to innovation in service companies and industries. 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. As a result, there is a need to apply more scientific rigor to the practices of service firms. For example, the waste-reducing "lean production" techniques pioneered in manufacturing could be adapted to more standardized services, while improvements in workers' and managers' abilities to interpret customers' needs or solve non-routine problems could improve performance in less standardized ones.[63] 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.[64] 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.[65]

6. Efforts are insufficiently federalist

Finally, federal innovation policy does not mesh as well as it should with the efforts of other levels of government in America's federalist system. 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 workforce and economic developers have a long track record of creating organizations that work more closely with firms (See below). 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. For example, the National Science Foundation has a long history of making investments in research centers with little consideration for existing state science and technology policies. Indeed, there is very little appreciation in Washington for the fact that virtually every state has in place technology-based economic development programs.[66] Indeed, 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. Moreover, to the extent they see states and regions as having any policy role, they all too often believe it is to follow the federal government's lead.

Among the principal federal innovation programs, MEP and WIRED are set up to pay the most explicit attention to the state and regional role in supporting innovation. These are the only federal innovation programs in which the participation of state and local governments and regional business groups is central. (MEP is a joint federal-state program whose offices in every state respond to the local needs of manufacturers. WIRED funds regional partnerships of businesses, training providers, and other regional economic development actors.) TIP may fund proposals from states, but nothing in the legislation that created TIP requires state governments or state or regional-level business groups to be involved in TIP-funded research. A true federal-state partnership will require more federal innovation support to be organized in ways similar to MEP and WIRED. Federal decision makers and program managers must understand that states and regions can play an important role and that a top-down, one-size-fits-all, go-it-alone federal approach will only stifle the most important role states and regions can play: generating policy innovations and developing policies and programs suited to the unique requirements of their regional economies.

VII. States and Metropolitan Areas Are Taking the Lead in Innovation Policy but Need Federal Assistance

The design of a more robust federal innovation policy must consider, respect, and complement the plethora of energetic state and local initiatives now underway. While the federal government has taken only very limited steps to promote innovation, state governments and state- and metropolitan-level organizations have done much more. They have partially filled the gap left by federal inaction. Yet, these entities could do even more, and their current efforts could be made more effective. Federal assistance is needed to help state and regional innovation efforts reach the proper scale and achieve their full potential.

Many Washington economic policymakers, to the extent they even consider the role of states and municipalities in the nation's economic growth, think that they simply engage in zero-sum "smokestack-chasing" practices of giving incentives to firms to move or stay in one place rather than another. Although state and local governments do this, and indeed more than they should, they also do much more that is "positive-sum," including significant efforts in what has become known as "technology-based economic development" (TBED). In fact, since the 1980s, when the United States first began to face global competitiveness challenges, all states and many local governments and metropolitan business alliances have established technology-based economic development programs to grow jobs and incomes from within. Republican and Democratic governors, legislators, and local government officials support these programs because they recognize that businesses will not always create enough high-productivity jobs in their states and metropolitan areas without government support. State and local governments now invest about $1.9 billion per year in TBED activities.[67]

This is about 70 percent of the amount that the federal government spends on its principal innovation programs and agencies.

State governments and state- and metropolitan-level economic and workforce development organizations engage in a variety of different TBED activities to help spur economic growth in all four innovation trajectories. 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.

But unlike the federal government, which with the exception of a few small, underfunded agencies, is largely content to give money to universities and hope that good things will happen, states 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.[68]

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.[69]

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 to turn advanced technologies and high-tech startup companies into growing companies.[70]

Besides helping develop and commercialize new technology, states also promote upgrading and project-based innovation by helping existing firms become more competitive. Increasingly states and regional business groups are developing industry-specific initiatives to focus on particular kinds of firms. For example, the Hosiery Textile Center, located on the campuses of two community colleges in western North Carolina, helps the large number of local hosiery firms (as well as firms located in other parts of the country) compete in a global environment through training, R&D, testing, e-commerce, environmental services, and new product development.[71]

Industry- and cluster-based initiatives are particularly popular in the workforce development area. The workforce development system, largely supported by the federal government, has historically done a poor job of working closely with employers. Until recently, few state governments viewed workforce development as part of an innovation-led economic growth strategy. However, states have now begun to recognize that workforce development is central to the creation and diffusion of innovation because new products, technologies, and ways of organizing work cannot exist unless workers and managers have the skills needed to implement them. For this reason, states have increasingly turned to regional skills alliances, industry-led partnerships that address workforce needs in specific regions and industry clusters.[72] Michigan has provided competitively awarded startup grants and technical assistance to 25 industry-led regional skills alliances. Pennsylvania's $15 million Industry Partnerships program brings together multiple employers, and workers or worker representatives when appropriate, in the same industry cluster to address overlapping human capital needs. To date, the state has helped support 86 industry training partnerships in different industries.[73] The nonprofit Wisconsin Regional Training Partnership, one of the first regional skills alliances, works to bring together employers, unions, and educational institutions to help firms become more productive and competitive (Box 4).

Box 4. The Wisconsin Regional Training Partnership[74]

Founded in 1992, the Wisconsin Regional Training Partnership (WRTP) is a nonprofit organization that helps its member firms create and train workers for family-sustaining jobs in the Milwaukee metropolitan area. WRTP originally focused on training and job upgrading in manufacturing as part of a strategy to retain manufacturing jobs in the metropolitan area. Today the members of WRTP include firms in the construction, health care, and service industries as well as manufacturers.

WRTP provides or funds training and referral services for both incumbent and entry-level workers. It also provides member firms with technical assistance in implementing new technologies and new ways of organizing work. Its activities to date have mainly supported the upgrading (e.g., manufacturing and health care) and project-based (e.g., construction) innovation trajectories. WRTP develops its programs in response to member firms' needs; it does not simply train workers and hope that appropriate jobs will materialize. WRTP also helps its member firms develop skill standards in basic, problem-solving, and technical skills. All basic and problem-solving skills are common to all member firms. Most technical skills are common to more than one firm. By focusing on the common skill needs of firms in industry clusters in the Milwaukee area, WRTP helps its members solve problems that they would be unable to solve, or unable to solve as well, by acting individually.

WRTP's governing board includes representatives of firms and industry associations in the Milwaukee-area manufacturing, construction, telecommunications, and energy industries, as well as representatives of labor unions The Partnership receives funding from its member firms and from the Milwaukee area workforce investment board, educational institutions, Milwaukee-area and national foundations, and a number of federal, state, and local government agencies.

For more information visit www.wrtp.org

States are also focused on helping new firms become established and thrive. A number of states have established entrepreneurial support programs. For example, the Kentucky Entrepreneurial Coaches Institute identifies and training community citizens from 19 rural counties who are willing to work with current and potential entrepreneurs to help develop new business ideas and ventures.[75] Many states and regions have also established seed and early-stage venture funds to help spur the creation and development of new fast growing firms. For example, the Oklahoma Capital Investment Board borrows money from banks and invests them in VC firms that have indicated a willingness to invest in

Oklahoma businesses. Since the program's inception the number of venture funds actively investing in the state has increased from 1 to 14.

Existing state and regional TBED efforts are impressive, but state and local governments and metropolitan-level organizations could do even more. One reason they do not do so is, that like firms, it is difficult for them to capture all the benefits of TBED activities. Some of the benefits flow to universities, firms, and customers in other states or localities. Moreover, the benefits can take a relatively long time to come to fruition, often during the terms of subsequent governors, legislators, mayors, and county executives. For these reasons, states invest less in TBED than the needs of the nation require. Federal incentives are needed to help them do more. In addition, states do not systematically coordinate their TBED efforts with those of neighboring states, even when there are important industry clusters that cross state lines. Nor do states systematically learn from the TBED successes and failures of other states. By giving states incentives to coordinate their TBED activities where appropriate, serving as a source of information about successful and unsuccessful TBED practices, and tying support to the development and implementation of smart innovation strategies, the federal government can help states do better (as well as more) TBED.

VIII. Other Countries Have Created National Innovation Organizations

Other advanced countries, meanwhile, are well ahead of the United States in creating well-funded, sophisticated agencies to support innovation. Although foreign policies and programs are not always fully transferable to other nations, including the United States, they can provide a sense of what kinds of new policy approaches are possible and appropriate. The present proposal for a National Innovation Foundation builds on the best features of other nations' innovation programs.

In recent years many nations, including Finland, France, Iceland, Ireland, Japan, the Netherlands, New Zealand, Norway, South Korea, Sweden, Switzerland, and the United Kingdom, have either established or significantly expanded separate technology- and innovation-promotion agencies. Other nations, such as Denmark and Spain, have longstanding agencies of this type.[76] All these nations have science- and university-support agencies similar to our NSF, which largely fund basic research, universities, and national laboratories. But they 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 firms and in firms in partnership with universities.

Perhaps the most ambitious of these efforts is Finland's Tekes. In the last two decades Finland has transformed itself from a largely natural resource-dependent economy to a world leader in technology. Although the emergence and growth of Nokia, the world's leading mobile phone manufacturer, is a large part of the Finnish success story, one of the contributing factors is the work of Tekes. Affiliated with the Ministry of Trade and Industry, Tekes funds many research projects in companies, multi-firm partnerships, and business-university partnerships. Indeed, with a budget of $560 million (in a country of only 5.2 million people), Tekes plays a major role in the Finish innovation system. Box 5 describes how Tekes decides which innovation areas to fund.

Box 5. How Tekes Sets Its Innovation Funding Priorities

Tekes finances and activates highly challenging R&D projects in companies, universities, and research institutes, allocating half its funding to the best and most challenging projects according to demand, and the other half through technology programs in selected focus areas. Tekes has identified both technology focus areas (e.g., nano-sensors, mobile communications, broadband, managing a networked business) and application focus areas (e.g., service innovation, sustainable energy, modernizing production technologies in strong industry clusters, information security). Tekes chooses focus areas that will spur Finish productivity, raise value-added and growth in output (including through new business development), improve knowledge-intensive business, and boost Finland's attractiveness as a business location. To guide its decision-making, Tekes consults widely with companies, business organizations, universities, research institutes, public agencies and other stakeholders, including many outside of Finland.

Other nations have been active as well. For example, 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 (MITI). The United Kingdom'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. South Korea's Korea Industrial Technology Foundation, established in 2001, engages in a wide range of technology activities, including provide 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.[77]

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 retail trade and logistics. The UK'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 applications (as our National Science Foundation and 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 Technology Strategy Board established its Innovation Platforms program to bring together government stakeholders and funders, engage with business and the research community 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.[78]

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 the projects 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 Technology Strategy Board is funding over 600 collaborative business-university research projects which have been launched over the past two to three years. It is also responsible for 22 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 industry, government, university, and sometimes other constituency group representatives. 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.[79] 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.[80]

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 practice 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 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."[81] 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. The United States should follow their lead.

IX. The Federal Government Should Create a National Innovation Foundation to Address America's Innovation Needs

To help spur innovation the federal government should establish a National Innovation Foundation (NIF)—a new, nimble, lean, and collaborative entity devoted to supporting firms and other organizations in their innovative activities. The goal of NIF would be straightforward: to help firms in the nonfarm American economy become more innovative and competitive.[82] 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. NIF 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. Box 6 shows how NIF would respond to each flaw. (The following sections of this paper detail the responses outlined in Box 6.)

Box 6. NIF Would Address the Major Flaws in Federal Innovation Policy

Current federal innovation policy:	NIF would:
Lacks an explicit national innovation policy.	Be responsible for and capable of developing an explicit national innovation policy, which it would implement through its activities in support of R&D, technology diffusion, regional industry clusters, measurement and research, and advocacy.
Is fragmented and diffuse, with no federal organization whose sole mission is to spur innovation.	Be the only federal organization dedicated solely to innovation and bring together in one place the core federal innovation-promotion activities that are now scattered among several agencies.
Underfunds federal innovation-promotion efforts.	Increase funding of core efforts from less than $400 million to $2 billion.
Is focused on larger firms and a few major research universities.	Provide more support for small and mid-sized firms and for educational institutions other than elite universities.
Pays little attention to service innovation.	Make service innovation a part of its technology diffusion activities.
Is insufficiently federalist.	Fund new innovation-based economic development grants in partnership with states and expand the scope of the existing federal-state MEP and federal-regional WIRED partnerships.

Because flexibility should be one of NIF's key characteristics, we do not wish to over-specify NIF's operational details. NIF would determine how best to organize its activities; it would not be locked into a particular programmatic structure For example, if there are more complementarities within, rather than across activities, then it may make sense to organize each activity as a separate program within NIF. If the knowledge needed to carry out these activities is strongly specific to particular industries, technologies, or innovation trajectories, then it may make sense for NIF to have separate programs divided along these lines with all activities carried out within each program. (Finland's Tekes, for example, is organized by technology.) Likewise, innovation measurement and research functions could be centralized in a single unit of NIF or divided into multiple units, and it could make sense to combine some measurement and research activities with grantmaking functions if there were a strong enough relationship between the two. NIF's flexibility to determine its own internal organizational structure, and to change it when economic or technological conditions warrant, is an important advantage of NIF over existing federal programs.

1. Catalyze industry-university research partnerships through national sector research grants

To start with, NIF would offer competitive grants to national industry consortia to conduct research at universities—something the government does too little of now. These grants would enable federal R&D policy to break free of the dominant but unproductive debate over science and technology policy, which has tended to pit those who argue that the federal government should fund industry to conduct generic pre-competitive R&D against 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 by both potential use and fundamental understanding).[83] 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.

Currently, the federal government supports a few sector-based research programs, but they are the exception rather than the rule (Box 7). Moreover, the existing initiatives are largely underfunded. As a result, a key activity of NIF would be to fund sector-based research initiatives. NIF would offer competitive Industry Research Alliance Challenge Grants to match funding from consortia of businesses, businesses and universities, or businesses and national labs. These grants would resemble those that the current TIP and the NSF innovation programs (Partnerships for Innovation, Industry-University Cooperative Research Centers, and Engineering Research Centers) offer. However, NIF grants 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. Moreover, like TIP and the NSF innovation programs, NIF's work in this area would be industry-led, with industry coming to NIF with

Box 7. Sector-Based Innovation Promotion Efforts
There are numerous examples of successful sector-based partnerships. For example, 12 wireless communications companies have formed a research consortium with the University of California-San Diego Engineering School to work on advanced research related to their industry.[84] The Semiconductor Research Corporation (SRC) – a nonprofit research consortium of 36 companies and federal government agencies – plans, invests in, and manages a low-overhead, industry-driven, pre-competitive Global Research Center program that addresses the short-term needs identified in the Semiconductor Industry Association's International Technology Roadmap for Semiconductors. The Microelectronics Advanced Research Corporation, a subsidiary of SRC, operates a Focus Center Research Program that funds multi-university research centers to address broad, long-range technological challenges identified in the Roadmap. Semiconductor and related firms and the Department of Defense jointly fund the Focus Centers.[85] The National Center for the Manufacturing Sciences (NCMS), located in Ann Arbor, Michigan and funded jointly by manufacturers and the Department of Defense, is a collaborative research network that includes approximately 50 large corporations and hundreds of medium and small firms. NCMS uses the collaborative model to develop a variety of distinct manufacturing processes. Partnerships developed under the umbrella of the center have been responsible not only for new technological applications but also for process improvements such as rapid prototyping using computer simulation.[86]

proposals. Like those programs, NIF's grantmaking would be a vehicle for funding research that does not necessarily have either a strong regional component or applications that are likely to be specific to particular metropolitan areas.

To be eligible for NIF 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-10 year) technology roadmap that charts out generic science and technology needs that the firms share
- provide at least a dollar-for-dollar match of federal funds

Rotating technology-specific panels staffed with experts in fields such as biotechnology, photonics, chemistry, manufacturing, information technology, and materials would evaluate grant proposals. (This review process would be similar to those that TIP and NSF now use.)

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.

NIF R&D grants (including the state grants described below as well as national sector grants) should support the growth of employment and income in the United States. Foreign companies would be allowed to participate if they have research or production facilities in the United States and if their home nation allows foreign facilities of U.S. multinationals to participate in its research programs. Moreover, all firms receiving support from NIF must commit to performing NIF-supported R&D in the United States and promoting the production of any resulting goods or services in the United States. These rules are based on but slightly stronger than similar rules that govern TIP and its predecessor, ATP.[87] In addition, because it is often difficult to attribute the production of a particular product to a specific act of research or development, NIF would take into account, as one factor in funding grant proposals, the likelihood that the proposed R&D will ultimately lead to production that takes place in the United States.[88] NIF and/or Congress should develop additional criteria for NIF R&D awards. These could be modeled on existing TIP award criteria, which include potential to address critical national needs, generate substantial benefits to the nation as a whole, and contribute to the nation's science and technology knowledge base.[89]

NIF could also support a productivity enhancement research fund to support research into automation, technology-enabled remote service delivery, quality improvement, and other methods of improving productivity. Automation (e.g., robotics, machine vision, expert systems, voice recognition) is a key to boosting productivity in both manufacturing and services. Technology-enabled remote service delivery (e.g., home health monitoring, remote diagnosis, perhaps even remote surgery) have considerable potential to improve productivity in health care and other personal service industries. A key function of NIF would be to fund research at universities or joint business-university projects focused on increasing the efficiency of automated manufacturing or service processes. NIF would support early-stage research into processes with broad applications to a range of industries, not late-stage research focused on particular companies. NIF would also fund a service-sector science initiative to conduct research into productivity and innovation in the nearly 80 percent of the economy that is made up of service industries.

2. Expand regional innovation-promotion through state-level grants to fund activities like technology commercialization and entrepreneurial support

NIF would also offer state Innovation-Based Economic Development (IBED) Partnership Grants to help states expand their innovation-promotion activities. Any effective national innovation initiative will need to find a way to assist the tens of thousands of innovation-focused small and mid-sized firms as well as larger firms that have specific regionally based innovation needs that they cannot meet on their own. Unlike small nations, the United States is too big for the federal government to play an effective direct role in helping these firms. State and local governments and regional economic development organizations are best positioned do this. Indeed, as we have shown, they are already doing so. But without assistance from the federal government states will invest less in TBED activities than is in the national interest. NIF would compensate for this political failure by offering competitive grants to increase state investments in these activities. In recognition that innovation encompasses more than just new technology, NIF grants would go beyond funding state investments in TBED to include innovation-based economic development (IBED) more generally. The state IBED grants would replace part of the grant making that TIP and the NSF innovation programs currently perform but would operate exclusively through the states and would not be restricted to small and mid-sized firms.

States would submit proposals to NIF laying out their IBED strategy and explaining how NIF support would enable them to do more and better. Qualifying activities would include a host of IBED activities, such as technology commercialization centers, industry-university research centers; regional cluster development programs, regional skills alliances, and entrepreneurial support programs. States would have to explain how their proposed activities would serve the national interest as well as the state interest; the national interest should be the primary criterion for the award of federal IBED assistance to states. 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 IBED 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 IBED activities in neighboring states or that included plans for interstate collaboration in IBED would receive extra points in the review process. Proposals could address the needs of industry clusters but would not be restricted to cluster-based innovation activities. To be eligible for NIF funding, states would need to provide at least two dollars in actual funding for every NIF dollar they receive.

Rotating panels of IBED experts would review proposals. In most cases these would be experts in the field (e.g., consultants, academics, venture capitalists, and economic development professionals). 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 IBED panel and NIF staff, NIF 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. All state proposals that met the basic procedural and state funding requirements would receive NIF funds. However, the amount of NIF funding to states would depend on the overall availability of NIF funding and on the states' relative scores. States with low-scoring proposals would be eligible to receive modest planning grants and technical assistance from NIF staff to develop a better proposal for the subsequent year's competition.[90] NIF staff would also work in close partnership with states to help ensure that their efforts were effective and in the national as well as state interest.

3. Encourage technology adoption by assisting small and mid-sized firms in implementing best-practice processes and organizational forms that they do not currently use

A third activity of NIF would be to conduct a technology diffusion effort aimed primarily at assisting small and mid-sized firms. While NIF's national sector grants and state IBED grants would largely support new-to-the-world, sometimes radical product and process innovation, its technology diffusion work would focus more on the diffusion of existing processes and organizational forms to firms that do not currently use them. This effort would incorporate and build on the existing MEP, the only federal program whose primary purpose is to promote technology diffusion among such firms. NIF effort would follow the MEP model of a federal-state partnership. One or more technology diffusion centers would be located in each state. Like existing MEP centers, the centers could be operated by state or private organizations. States would submit proposals to NIF for the operation of these centers and NIF would evaluate the centers periodically. Some specific changes to the current MEP program would enable NIF to serve as a more comprehensive and more effective promoter of technology diffusion for both manufacturing and service industries.

NIF technology diffusion effort would lift the price barrier that inhibits some firms from using MEP services. Although the practice of charging fees to client firms is useful as a test of the market value of the services, the current limit on federal funding of MEP centers results in fees that are higher than those that some potential clients are able to pay. Expanding federal funding, while maintaining the requirements of state matching funding and some fees from businesses for services, would make it possible to reduce fees.

MEP centers currently are required to serve all firms that are willing to pay for their services. NIF technology diffusion effort would, instead, develop criteria for prioritizing the firms it served. These criteria would reflect NIF's mission to promote higher standards of living through productivity and innovation. NIF would give priority to those firms that are most likely to contribute to this mission. For example, firms whose productivity or related performance measures (such as employee computer usage or employee turnover) meet certain standards, or that commit to meeting these standards within a specified time period as part of their contractual agreement with NIF, might be given priority to receive NIF services. NIF's focus would be on firms that want to boost productivity and innovation rather than on those that wish to compete primarily through low wages.

NIF would expand the scope of the current MEP beyond its current emphasis on applying waste-reducing, quality-improving lean production techniques to the direct production of manufactured goods. (Appendix B's description of MEP provides more information about lean production.) It would do so in the following three ways.

- *Help improve productivity in service activities that are part of the manufacturing value chain as well as in direct production activities.* NIF would help manufacturing firms improve their pre- and post-production service activities as well as their direct production processes. Pre-production activities (managing orders from customers and the flow of goods and raw materials from suppliers) and post-production activities (shipping finished products and managing order fulfillment) contribute directly to manufacturing firms' productivity. Lean production techniques similar to those used on the shop floor can be applied to them.

  Likewise, NIF's technology diffusion activities would include firms that provide services ancillary to manufacturing (such as freight transportation and warehousing), as a few MEP centers have begun to do. The disaggregation of the manufacturing value chain in recent decades has meant that non-manufacturing firms now provide many of these services, which manufacturing firms once performed for themselves. Yet productivity growth in these services contributes to manufacturing productivity growth regardless of which firms provide them. Moreover, lean production techniques can be applied to these services.

Manufacturing firms in mature industries may need to develop new products or find new markets for existing products if they are to remain competitive. NIF technology diffusion effort would also be able to help here, both by applying lean production techniques to product development and marketing and by providing more general assistance with business strategy.

- *Assist firms in industries unrelated to manufacturing if lean production techniques can improve productivity in those industries.* Lean production methods can also help improve productivity in some services that are unrelated to manufacturing. For example, waste-reduction techniques that reduce inventories can be used to reduce patient waiting time in hospitals. Leading retailers use the same kinds of supply-chain management methods as leading manufacturers; productivity in retail trade would grow faster if smaller, less sophisticated retailers received assistance in implementing these methods.

- *Help service firms improve productivity in less standardized service processes to which lean production ma not be applicable.* Most of the work processes in professional and business services; education, health care, and social assistance; arts, entertainment, recreation, accommodation and food services; other services; and government are not standardized enough to permit the application of lean production techniques. Yet because these industries account for almost 40 percent of GDP and have had productivity growth well below the national average, raising their rate of productivity growth could have a large impact on the American standard of living. Drawing on NIF-funded research in the emerging field of service science, NIF's technology diffusion effort would develop practical methods for raising service productivity and disseminate those methods widely.

In addition to supporting efforts that assist firms directly, NIF would analyze opportunities and challenges regarding technological, service delivery, and organizational innovation in service industries, such as health care, construction, residential real estate, financial services, and transportation services. It would recommend steps, if any, (e.g., revising procurement practices, modifying regulations, helping spur standards development) that federal and state governments could take to help spur innovation, including through widespread use of information technology and e-commerce.[91]

4. Support regional industry clusters with grants for cluster development

As illustrated earlier in this paper, state and regional industry cluster consortia have been effective in solving productivity-related problems that individual firms cannot solve alone. The Department of Labor WIRED program builds on this insight in the area of workforce development, offering competitive grants to self-designated regional clusters of firms and related economic actors. NIF would incorporate WIRED-type grants but these grants would be expanded to include other cluster activities, such as technological modernization, shifting to higher value-added products or services, or export marketing cooperation. A companion paper in the *Blueprint* Policy Paper series, "Clusters for Competitiveness: A New Federal Role for Stimulating Regional Economies," explains the rationale for and operational details of this proposal.

NIF would determine the relationship between its cluster grants and its state IBED grants. For example, cluster grants could be a subset of the IBED grants; states could include the development of specific industry clusters within their IBED proposals. Alternatively, some NIF funding of clusters could occur within the IBED grants while certain well-defined kinds of cluster grants, such as those for multi-state clusters or demonstration projects, could remain outside the IBED system.

5. Emphasize performance and accountability by measuring and researching innovation, productivity, and the value-added to firms from NIF assistance

To guide its own work and provide firms and government agencies with the information they need to promote innovation, NIF would create methods of measuring innovative activity and carry out research on innovation. To do so, it would engage in several distinct but related efforts.

NIF would conceptualize and advocate for the measurement of innovation. NIF would be the primary entity for conceptualizing how innovation should be measured and the primary advocate within the federal government for measuring innovation. It would help the major federal statistical agencies (the Census Bureau, Bureau of Economic Analysis, and Bureau of Labor Statistics) and the National Science Foundation develop operational measures of innovation that can be included in new or existing economic data sources. With the exception of some small-scale pilot surveys, NIF would not conduct innovation surveys or be the primary source of data on innovation. Other agencies already have established abilities to conduct surveys and generate economic data, and firms' reporting burden is smaller if new data are collected in those agencies' existing surveys than if NIF creates entirely new surveys. Instead, NIF would provide financial support for surveys that the other agencies can conduct. It would also use the results of these surveys as part of its own research.

NIF would work with other agencies to improve the measurement of productivity and innovation. NIF would also work with BEA, BLS, and the Census Bureau to improve the measurement of productivity. Here there are three priorities. First, we need better measures of output in the service sector, especially in service industries such as health care and education whose output is not standardized.[92] Second, we need measures of total factor productivity (the most comprehensive measure of productivity, which accounts for capital, materials, energy, and purchased services, in addition to labor, as productive inputs) for all industries. Currently, BLS estimates total factor productivity at the industry level for manufacturing and a few service industries, but not for the bulk of the service sector. NIF would help support BEA in its current plan to expand and improve the measurement of non-labor inputs. Finally, to understand productivity at the regional level we need bottom-up estimates of gross product and productivity for counties and metropolitan areas. BEA recently released top-down estimates of gross metropolitan product and is planning to develop bottom-up estimates. NIF would support this effort and, in addition, would sponsor a joint effort by BEA, BLS, and Census to develop county and metropolitan estimates of labor productivity and total factor productivity.

Although productivity measures the economic consequences of innovation, indicators of specific types of innovative activity are also essential. Currently only two such indicators are available: patents and research and development. The latest year for which patent data are available at the metropolitan level is 1999; NIF would work with the Patent and Trademark office to update these data. NSF sponsors an annual survey of research and development that the Census Bureau conducts. This survey provides information about pubic and private R&D expenditures nationwide and by state; NIF would advocate for and, if necessary, fund the collection and reporting of these data by metropolitan area.

Patents and R&D expenditures, though, are only indirect measures of a small portion of firm-level innovative activity. Most new products and production processes are not patented and many do not result from formal R&D. Recognizing this, the European Commission sponsors a firm-level Community Innovation Survey of product and process innovation in European Union member countries. This survey asks firms about the number of product and process innovations that they have implemented during the past three years, the sources and funding of those innovations, the firm-level results of those innovations, methods to protect innovation, and barriers to innovation.[93] The most promising way to obtain similar information for the United States would be to add questions on these subjects to the existing NSF-sponsored R&D survey.[94] NSF is currently in the process of redesigning the R&D survey to include some of this information. NIF would work with NSF and the Census Bureau to ensure that the redesigned survey captured as much of the relevant information as possible and provided valid information for states and metropolitan areas as well as for the nation as a whole.

NIF would develop new measures of the value of R&D. In addition to working to improve the measurement of productivity and innovation, NIF would develop new approaches to the measurement of private and social rates of return from R&D. In this way it would help firms improve their assessment of the private benefits of R&D and help the federal and state governments better understand the benefits of R&D to society as a whole.

NIF would evaluate its own activities. NIF would also sponsor data-collection efforts to help evaluate its own activities and deepen its understanding (and the understanding of other government agencies and the general public) of the determinants of firm- and establishment-level productivity. For the purpose of evaluation, MEP centers are currently required to report on their use of MEP assistance and the firm-level results of that assistance. However, the required data do not accurately measure the results of the assistance. NIF would require all firms that benefited directly from its assistance to report on what actions, if any, they took as a result of the assistance. It would also require these firms to provide information needed to measure their productivity before and after they received assistance. NIF would collect only the minimum amount of data needed to enable it to evaluate its activities and would design its survey to minimize the reporting burden on firms.

This information can be used to evaluate NIF activities only if the same firm-level information is available for a nationally representative sample of firms. Currently such information is available on a very limited basis. One MEP center conducts a survey that provides the necessary data but it covers only about 400 manufacturing firms annually, most of them in the Midwest. The Census Bureau's Longitudinal Research Database and its annual surveys of manufacturing, services, and wholesale and retail trade are larger and nationally representative but they do not provide enough detail on the components of firms' revenues and costs. To obtain the needed data, NIF would sponsor expanded versions of the Census Bureau's annual surveys of manufacturing, services, and wholesale and retail trade and new surveys of industries not currently covered by existing Census Bureau annual surveys. As with other NIF-sponsored data, regional detail at the state and metropolitan levels would be desirable.

NIF would keep track of innovation in the U.S. economy. NIF would use its innovation data not only to evaluate its own activities but also to track innovation at the national, state, metropolitan, and industry levels. NIF would make its innovation data available to the public as a resource for understanding the status of innovation by industry and geography, and employ it for that purpose in its own work.

NIF would conduct research on innovation. In this connection, NIF would supplement its assessments of major industries with a limited number of in-depth, policy-oriented reports on trends in more narrowly defined industries, technologies, business organization, and the organization of work. These reports would resemble those that Congress' former Office of Technology Assessment produced through its Industry, Technology, and Employment division. They would address issues that are important for improving productivity and promoting innovation and that could be influenced by public policy. Those issues could be ones that are currently of interest to executive branch agencies or Congress, or they could be ones that policymakers will need to understand as they address emerging policy issues. NIF's reports would develop and evaluate public policy options in a balanced, nonpartisan manner.

6. Champion innovation by promoting innovation policy within the federal government and serving as an expert resource on innovation to other agencies

Finally, NIF would be the federal government's major advocate for innovation and innovation policy. One key component of this would be to produce an annual Innovation Report, akin to the annual *Economic Report of the President*. More generally, the foundation's advocacy role in support of innovation would resemble the Small Business Administration's role as a champion for small business. NIF would seek input into other agencies' decisions on programs that are likely to affect innovation. Its expertise in innovation would also make it a key source of assistance to federal innovation programs in other parts of the federal government (e.g., in the Agriculture and Energy Departments, whose innovation programs would not be part of NIF) and to auxiliary federal innovation-supporting activities (patenting, basic scientific research, and education in science, technology, engineering, and mathematics, which would likewise not be included in NIF). However, unlike the Small Business Administration, NIF would not have any authority to intervene in other agencies' decisions. Nor would other agencies be required to consult NIF before taking action.

X. Options for Financing and Organizing NIF

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 other 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, 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 spent at least one dollar on innovation for every dollar NIF spent.

Several options exist for financing and organizing NIF:

1. Funding for NIF could come from several sources

Congress could choose to fund NIF from some or all of the following sources.

Existing federal innovation-promotion programs that NIF would incorporate or replace. NIF's national sector and state IBED grantmaking would incorporate TIP and NSF's Partnerships for Innovation, Industry-University Cooperative Research Center, and Engineering Research Center programs, but would fund much more R&D and other innovation-related activities than those programs currently support. NIF's technology diffusion work would incorporate and expand on MEP, while its cluster grants would be an expanded version of WIRED. NIF's innovation measurement, research, and advocacy activities would incorporate the innovation advocacy work that the Commerce Department's Office of Technology Policy used to perform, while supplementing that work with needed measurement and research. Federal expenditures on all the programs that NIF would replace or incorporate total $344 million.[95] (See Appendix C for details.) In addition, the America COMPETES Act provides a total of about $88 million more in 2010 for MEP and the new TIP than MEP and ATP received in 2006.[96] Therefore, current and already planned expenditures on the programs whose work would be included in NIF total $432 million.

Wasteful oil and gas subsidies. If Congress does not appropriate all the additional funding that the America COMPETES Act authorizes and does not wish to fund NIF out of general revenue, then it could fund NIF by reducing or eliminating wasteful subsidies to oil and natural gas producers. The staff of Congress' Joint Committee on Taxation estimated that the two largest federal tax expenditures for oil and gas production totaled $2.2 billion in FY 2007 and will total $1.7 billion in FY 2010.[97]

General revenue. If Congress does not appropriate all the additional funding that the America COMPETES Act authorizes (as it did not in FY 2008), then the funding sources suggested above will not be fully available, In that event, Congress could fund NIF out of general revenue, even increasing the budget deficit if necessary. Deficit financing is warranted for NIF because it is an investment whose benefit to the U.S. economy will occur in the future (rather than an item of consumption whose benefit will be exhausted in the year in which the spending occurs) and because the total amount needed to fund NIF is minuscule in relation to the overall federal budget. Even if the entire $1 billion needed to bring NIF from its initial funding level to its final funding level were obtained from general revenues, this would amount to less than one twenty-fifth of one percent of total federal outlays in 2006.

2. NIF could be organized as part of the Commerce Department, as a government-related nonprofit organization or as an independent federal agency

NIF will need to have a number of key characteristics that innovation-promotion agencies in other countries already have. It will need to be flexible and able to change course over time; able to understand and act on innovation needs at the firm level; able to hire high-quality staff, including people with experience in business; have close links to key stakeholders, including business, and state and local governments; and be accountable for results. Careful, objective evaluation of what works and does not must be built into it from the beginning. It will also need a sense of mission and esprit de corps. There are at least three possible ways in which NIF could be structured so that it is likely to have these characteristics:

Commerce Department option. NIF could be housed within the Commerce Department's National Institute of Standards and Technology (NIST), where TIP and MEP are currently located. This has the advantage of building on considerable expertise at NIST. Moreover, TIP and MEP are relatively flexible programs that have a good understanding of business needs (within their narrowly defined areas of expertise) and are committed to evaluating their programs, so NIST has experience operating programs with some of the key characteristics that NIF would need. It would be possible to give NIF somewhat more autonomy (along the lines of foreign innovation agencies that are housed within larger government agencies) by giving NIF a separate advisory board (similar to the National Technical Information Service Advisory Board in the Commerce Department or the National Cancer Advisory Board in the Department of Health and Human Services) or even a separate governing board (similar to the National Assessment Governing Board, which is responsible for the Education Department's National Assessment of Educational Progress). Either the Secretary of Commerce or the President could be given the authority to appoint such a board. However, because NIST's main mission is standards and testing work, the risk exists that an expanded innovation role would not get the attention it deserves. Indeed, a NIF within NIST could suffer from the same underfunding and neglect that plagued ATP and that continue to plague MEP and the new TIP.

Public sponsored corporation option. At the opposite extreme, NIF could be set up as a new publicly-sponsored corporation along the lines of the Corporation for Public Broadcasting (CPB) or the public-private hybrid universities that exist in some states (e.g., Cornell University and the Pennsylvania State University). This is the way in which the Danish Technological Institute is organized. The advantage of this option is that it would give NIF the maximum amount of flexibility and agility, which it will need if it is to interact effectively with business and the states. It would also be possible for Congress to advance-fund NIF for one year beyond the fiscal year for which it funds government agencies. This funding structure, which CPB enjoys, would give NIF added financial stability and make it easier to develop long-range plans. NIF's governing board could be appointed by the President with Senate approval (as CPB's is) but it would also be possible to have constituency groups (such as business groups) or Congressional leaders appoint some board members directly. Some board seats could be self-perpetuating, as in other non-profit organizations. However, the risk is that such an organization may not as easily reflect the public interest goals inherent in establishing and funding NIF.

Independent federal agency option. A middle-ground option would be to follow the example of Britain's Technology Strategy board and establish NIF as an independent government agency, akin to the Export-Import Bank or the Overseas Private Investment Corporation. Both are modest-sized agencies that work extensively with the private sector. Both are governed by a board of directors from the private sector. Both are able to hire more quickly and pay higher salaries than most traditional government agencies. The National Science Foundation and the Federal Reserve Board are other examples of independent government agencies that share some of the same features. Indeed, the similarity between NIF's staffing, evaluation and measurement, and grantmaking needs and those of NSF may make the independent agency model especially suitable for NIF. If NIF were established along these lines it should have a governing board of approximately seven to 12 members. There would be designated board seats for representatives of business and other constituency groups, which could include universities and colleges, state and local government officials, nonprofit technology and economic development organizations, labor unions and professional associations, and leading innovation experts. The President would appoint board members subject to Senate confirmation. To ensure continuity and independence from the Administration, board members would have staggered terms of at least four years. The length of board members' terms would reflect the extent to which Congress wished to make NIF politically accountable or politically insulated. Similarly, Congress could choose to have the President or the Secretary of Commerce appoint NIF's executive director if it wanted NIF to be more politically accountable or have NIF's board make this appointment if it wanted to make the agency more insulated from day-to-day politics. If Congress wanted an independent NIF to have a relationship with the Department of Commerce (similar to the relationships between many foreign innovation agencies and their nations' commerce ministries) then it could make the Secretary of Commerce an ex officio member of NIF board.

NIF would have a staff of approximately 250 individuals. NIF should recruit the best practitioners and researchers whose expertise overlaps the areas of productivity, technology, business organization and strategy, regional economic development, and (to a lesser extent) trade. It should be the federal (or federally sponsored) destination of choice for such professionals. Like NSF, NIF would be set up to allow some staff members to be rotated into the agency for limited terms from outside of government and to allow some permanent NIF staff members to go on leave for limited terms to work for private employers. This would help keep NIF in touch with the latest developments in business and technology.

In summary, regardless of how NIF is organized, it would play a key role in promoting innovation that does not currently exist in the federal government. NIF would help businesses of all sizes; its mission, unlike that of the Small Business Administration, would not primarily be to help small business. It would help disadvantaged regions (and thriving ones), but its mission, unlike those of the Economic Development Administration and the Appalachian Regional Commission, would not be to foster development primarily in disadvantaged or distressed regions. It would help fund research (as well as support technology development, commercialization and diffusion) but its mission, unlike that of the National Science Foundation and NIH, would not be to support research universities and basic science. It would help fund the training that incumbent workers need to work with new technologies or new forms of work organization but, unlike the Department of Labor's Employment and Training Administration, it would not fund workforce development programs for disadvantaged workers or new entrants to the labor force. Unlike DARPA and the Energy Department's Industrial Technologies program, NIF would not be restricted to funding innovation in just one industry or application.

XI. CONCLUSION

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 it is, is not enough to remedy the market failures from which the American innovation process suffers. At a time when America's historic lead in innovation is shrinking, 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.

The proposed National Innovation Foundation would build on the few federal programs that already succeed in promoting innovation and borrow the best public policy ideas from other nations to spur innovation in the United States. It would do so through a combination of grants, technical assistance, information provision, and advocacy. It would address the major flaws that currently plague federal innovation policy and provide the United States a state-of-the-art initiative for extending its increasingly critical innovation prowess.

Yet NIF would neither run a centrally directed industrial policy nor give out "corporate welfare." Rather, it would work cooperatively with individual firms, business and business-university consortia, and state governments to foster innovation that would benefit the nation but would not otherwise occur. In a world of growing geographic competition for innovative activities these economic and political actors are already making choices among industries and technologies to serve their own interests. NIF would give them the resources they need to make those choices for the benefit of the nation as a whole.

Without the direct federal spur to innovation that NIF would offer, productivity growth will be slower. Wages will not rise as rapidly. U.S. companies will introduce fewer new products and services. Other nations have realized this and established highly effective national innovation-promotion agencies. It is time for the United States to do the same. By combining America's world-class market environment with a world-class public policy environment, America can remain the world's innovation leader in the 21st Century.

APPENDIX A
Productivity Growth in Major Industries and in the 100 Largest Metropolitan Areas

TABLE 1
Productivity Growth by Industry, 2001-2005

Industry	**Average annual productivity growth rate* (percent)**
Computer and electronic products	22.8%
Information and data processing services	17.3
Air transportation	13.0
Pipeline transportation	12.2
Publishing industries (includes software)	11.7
Textile mills and textile product mills	11.5
Broadcasting and telecommunications	11.0
Paper products	9.1
Miscellaneous manufacturing	8.5
Primary metals	8.1
Petroleum and coal products	7.9
Furniture and related products	7.9
Funds, trusts, and other financial vehicles	7.7
Motor vehicles, bodies and trailers, and parts	7.0
Chemical products	6.6
Machinery	6.3
Computer systems design and related services	6.2
Utilities	6.0
Apparel and leather and allied products	5.9
Electrical equipment, appliances, and components	5.8
Plastics and rubber products	5.0
Printing and related support activities	4.7
Miscellaneous professional, scientific, and technical services	4.6
Fabricated metal products	4.4
Motion picture and sound recording industries	3.7
Nonmetallic mineral products	3.7
Securities, commodity contracts, and investments	3.6
Retail trade	3.3
Truck transportation	3.1
Social assistance	3.0
Warehousing and storage	3.0
Nonagricultural private industries excluding real estate	**2.6**
Administrative and support services	2.2
Waste management and remediation services	2.1
Performing arts, spectator sports, museums, and related activities	1.8

Wood products	1.8
Accommodation	1.7
Rail transportation	1.6
Other transportation and support activities	1.5
Ambulatory health care services	1.5
Management of companies and enterprises	1.2
Wholesale trade	1.1
Food and beverage and tobacco products	0.9
Federal Reserve banks, credit intermediation, and related activities	0.8
Food services and drinking places	0.8
Insurance carriers and related activities	0.7
Hospitals and nursing and residential care facilities	0.5
Amusements, gambling, and recreation industries	-0.5
Educational services	-0.5
Other services, except government	-0.6
Other transportation equipment	-0.8
Legal services	-0.9
Transit and ground passenger transportation	-1.1
Construction	-1.3
Rental and leasing services and lessors of intangible assets	-1.5
Oil and gas extraction	-1.9
Mining, except oil and gas	-2.2
Water transportation	-3.6
Support activities for mining	-8.0

*Average annual compound growth rate of real value added per full-time equivalent employee, calculated using chained 2005 dollars.

Source: Authors' analysis of Bureau of Economic Analysis data.

TABLE 2
Productivity Growth by Metropolitan Area, 100 Largest Metropolitan Areas,* 2001-2005

Metropolitan Area	**Average annual productivity growth rate** (percent)**
Baton Rouge, LA (MSA)	5.1
San Jose-Sunnyvale-Santa Clara, CA (MSA)	5.0
Sarasota-Bradenton-Venice, FL (MSA)	3.9
Des Moines-West Des Moines, IA (MSA)	3.9
Charlotte-Gastonia-Concord, NC-SC (MSA)	3.7
Sacramento-Arden-Arcade-Roseville, CA (MSA)	3.7
Boise City-Nampa, ID (MSA)	3.7
Portland-Vancouver-Beaverton, OR-WA (MSA)	3.6
Palm Bay-Melbourne-Titusville, FL (MSA)	3.5
Poughkeepsie-Newburgh-Middletown, NY (MSA)	3.4
Durham, NC (MSA)	3.3
Oxnard-Thousand Oaks-Ventura, CA (MSA)	3.3
Tampa-St. Petersburg-Clearwater, FL (MSA)	3.3
San Francisco-Oakland-Fremont, CA (MSA)	3.2
Los Angeles-Long Beach-Santa Ana, CA (MSA)	3.2
Fresno, CA (MSA)	3.1
Stockton, CA (MSA)	3.0
Washington-Arlington-Alexandria, DC-VA-MD-WV (MSA)	2.9
San Diego-Carlsbad-San Marcos, CA (MSA)	2.9
Knoxville, TN (MSA)	2.9
Rochester, NY (MSA)	2.9
Orlando-Kissimmee, FL (MSA)	2.9
Omaha-Council Bluffs, NE-IA (MSA)	2.8
Albuquerque, NM (MSA)	2.8
Austin-Round Rock, TX (MSA)	2.8
Cleveland-Elyria-Mentor, OH (MSA)	2.8
Dallas-Fort Worth-Arlington, TX (MSA)	2.8
Bakersfield, CA (MSA)	2.7
Nashville-Davidson-Murfreesboro-Franklin, TN (MSA)	2.7
Miami-Fort Lauderdale-Pompano Beach, FL (MSA)	2.7
Lexington-Fayette, KY (MSA)	2.6
Jacksonville, FL (MSA)	2.5
Trenton-Ewing, NJ (MSA)	2.5
Memphis, TN-MS-AR (MSA)	2.4
Boston-Cambridge-Quincy, MA-NH (MSA)	2.4
Toledo, OH (MSA)	2.4
Tulsa, OK (MSA)	2.4
Akron, OH (MSA)	2.3
Dayton, OH (MSA)	2.3

Kansas City, MO-KS (MSA)	2.3
Providence-New Bedford-Fall River, RI-MA (MSA)	2.3
Philadelphia-Camden-Wilmington, PA-NJ-DE-MD (MSA)	2.3
Lansing-East Lansing, MI (MSA)	2.3
Las Vegas-Paradise, NV (MSA)	2.3
All Top 100 Metropolitan Areas	**2.3**
Youngstown-Warren-Boardman, OH-PA (MSA)	2.2
San Antonio, TX (MSA)	2.2
New York-Northern New Jersey-Long Island, NY-NJ-PA (MSA)	2.2
Minneapolis-St. Paul-Bloomington, MN-WI (MSA)	2.2
Atlanta-Sandy Springs-Marietta, GA (MSA)	2.1
Chattanooga, TN-GA (MSA)	2.1
Indianapolis-Carmel, IN (MSA)	2.1
Buffalo-Niagara Falls, NY (MSA)	2.1
Syracuse, NY (MSA)	2.1
St. Louis, MO-IL (MSA)	2.1
Madison, WI (MSA)	2.1
Denver-Aurora, CO (MSA)	2.0
Pittsburgh, PA (MSA)	2.0
Grand Rapids-Wyoming, MI (MSA)	2.0
Columbus, OH (MSA)	2.0
Hartford-West Hartford-East Hartford, CT (MSA)	2.0
Virginia Beach-Norfolk-Newport News, VA-NC (MSA)	2.0
Little Rock-North Little Rock-Conway, AR (MSA)	2.0
Baltimore-Towson, MD (MSA)	2.0
Charleston-North Charleston, SC (MSA)	1.9
Colorado Springs, CO (MSA)	1.9
Bridgeport-Stamford-Norwalk, CT (MSA)	1.9
Chicago-Naperville-Joliet, IL-IN-WI (MSA)	1.9
Portland-South Portland-Biddeford, ME (MSA)	1.9
Cincinnati-Middletown, OH-KY-IN (MSA)	1.9
Oklahoma City, OK (MSA)	1.9
Houston-Sugar Land-Baytown, TX (MSA)	1.9
Albany-Schenectady-Troy, NY (MSA)	1.8
New Haven-Milford, CT (MSA)	1.8
Milwaukee-Waukesha-West Allis, WI (MSA)	1.8
Detroit-Warren-Livonia, MI (MSA)	1.8
Birmingham-Hoover, AL (MSA)	1.8
Springfield, MA (MSA)	1.7
Honolulu, HI (MSA)	1.7
Seattle-Tacoma-Bellevue, WA (MSA)	1.7
El Paso, TX (MSA)	1.6
New Orleans-Metairie-Kenner, LA (MSA)	1.6
Louisville-Jefferson County, KY-IN (MSA)	1.6
Worcester, MA (MSA)	1.5
Phoenix-Mesa-Scottsdale, AZ (MSA)	1.5
Scranton-Wilkes-Barre, PA (MSA)	1.4

Salt Lake City, UT (MSA)	1.4
Lancaster, PA (MSA)	1.3
Columbia, SC (MSA)	1.3
Richmond, VA (MSA)	1.2
Cape Coral-Fort Myers, FL (MSA)	1.1
Harrisburg-Carlisle, PA (MSA)	1.1
Augusta-Richmond County, GA-SC (MSA)	1.0
Tucson, AZ (MSA)	1.0
Jackson, MS (MSA)	0.9
Riverside-San Bernardino-Ontario, CA (MSA)	0.9
Raleigh-Cary, NC (MSA)	0.8
Greensboro-High Point, NC (MSA)	0.7
Greenville-Mauldin-Easley, SC (MSA)	0.6
Allentown-Bethlehem-Easton, PA-NJ (MSA)	0.6
Wichita, KS (MSA)	-0.3

*100 largest metropolitan areas by number of jobs.

**Average annual compound growth rate of real value added per job, deflated using GDP deflator. Measures of work hours or full-time equivalent employees are not available for metropolitan areas.

Source: Authors' analysis of Bureau of Economic Analysis data.

Appendix B
Principal Federal Programs that Support Firm-Level Innovation

National Science Foundation

Engineering Research Centers are a group of 17 interdisciplinary centers located at universities and operated in close partnership with industry. Each is composed of a lead university and up to four other colleges or universities. They target four technology areas: bioengineering; design and manufacturing; earthquake engineering; and micro/optoelectronics and information systems Each center enables universities and firms to collaborate in pursuing strategic advances in complex engineered systems and systems-level technologies that have the potential to spawn whole new industries or radically to transform the product lines, production technologies, or service delivery methods of current industries. Proposals require a ten-year strategic research plan and must indicate how technological components will be integrated into larger natural or social systems. The program provides five-year awards of $3-$4 million per year. Lead universities must provide 20 percent cost sharing.

In 2007, NSF announced the Generation Three (Gen-3) Engineering Research Centers (ERC) Program, which focuses more explicitly on innovation. Partnerships will include state, local government, or academic programs designed to stimulate entrepreneurship. Foreign universities may participate (previously only foreign firms were allowed as affiliates) and cost sharing is no longer required.

Industry-University Cooperative Research Centers. The Industry-University Cooperative Research Centers are designed to be long-term collaborations among industry, government, and universities. IUCRCs engage in industrially relevant fundamental research resulting in direct technology transfer from academia to industry, while furthering the education of undergraduate and graduate level students who perform research at the Centers. A university acts as the lead on the project in partnership with membership organizations. The vast majority of partners (90 percent) are business firms; other partners include non-NSF federal agencies, national laboratories, state governments, and other academic institutions. NSF mainly serves to provide seed money in the form of a planning grant of $10,000 (for 18 months) and an initial five-year award of up to $70,000 annually, renewable for a second five-year period for $35,000 annually. However, the NSF award constitutes a small part of the IUCRCs' financing. Each center must have a minimum of six business partners that provide at least $300,000 in membership dues. Centers are expected to be financially independent of NSF after ten years.

Partnerships for Innovation. Created in 2000, the Partnerships for Innovation program fosters connection between public and private organizations to spur innovation in a technology area, industry, or geographic region. Partnerships encompass three areas of activity: research, technology transfer, or commercialization; workforce education and training; and creating the infrastructure for facilitating and disseminating innovation. Academic institutions must be the lead organization with a private firm or non-profit organization serving as partner; state and local governments and international partners are also encouraged to participate. Ten to fifteen awards are given per year for up to $600,000 each, with an award duration of 2-3 years.

Department of Commerce

Technology Innovation Program and the former Advanced Technology Program , TIP and its predecessor, ATP, were designed to share the cost of early stage, high risk R&D with industry to encourage the development of commercially promising technologies that might otherwise go unfunded. ATP evaluated proposals from single firms and joint ventures based on scientific and technological merit and their potential for broad-based economic development. TIP will focus mostly on scientific and technological merit and will not assess the potential for broad-based economic benefits in its proposal evaluation criteria.

Under ATP, single firms could receive up to $2 million for as many as three years. Joint ventures could include multiple private companies, universities, government laboratories (excluding NIST laboratories), independent research organizations, and nonprofit organizations. ATP encouraged university participation in joint ventures with industry but universities were not allowed to lead a research project or retain the intellectual property. Joint ventures could receive ATP funding for up to five years but were required to fund the majority of total project costs. ATP did not fund product development or commercialization or give special consideration to small businesses, although roughly two-thirds of the ATP awards went to small companies or to joint ventures led by a small company. Funding for new awards was suspended in 2005 but ATP continued to fund pre-existing projects.

The America COMPETES Act of 2007 abolished ATP and replaced it with TIP. TIP differs from ATP in several respects. TIP specifically calls for assistance to institutions of higher education, national laboratories, nonprofit research institutions, and other organizations. It may fund state-sponsored proposals. TIP must fund areas of research that have "strong potential to address critical national needs through transforming the Nation's capacity to deal with major societal challenges that are not currently being addressed, and generate substantial benefits to the Nation that extend significantly beyond the direct return to the applicant."[98] While any U.S. company was eligible to receive funds under ATP, TIP funding may only go to small and medium-sized businesses and to other eligible organizations such as universities. TIP permits a university to lead a research joint venture and retain the intellectual property from the project. Funding levels under TIP are a maximum of $3 million for single company proposals and $9 million for joint ventures. TIP limits the federal share to a maximum of 50 percent for all projects, not only joint ventures.

Experimental Program to Stimulate Competitive Technology. EPSCoT was a competitive matching grant program administered by the Technology Administration's Office of Technology Policy in 1998 and 1999. The program was meant to benefit states that have historically received a smaller share of federal research funding. It supported state and regional efforts at technology-based economic development by building institutional capacity for commercialization. The program awarded 18 grants; funding ranged from $70,000 to $300,000.

Hollings Manufacturing Extension Partnership Program. The federal government began supporting technology diffusion among small and mid-sized manufacturing firms during the late 1980s and expanded its effort substantially in the mid-1990s. In recent years the federal government has spent approximately $106 million annually on the Hollings Manufacturing Partnership Program (MEP). The National Institute of Standards and Technology, in the Department of Commerce, administers MEP in partnership with the states through a network of 59 non-profit centers in all 50 states and Puerto Rico. MEP centers are either separate organizations or parts of other state-run or private organizations. They receive funding from state governments and fees from client firms in addition to federal funding. No more than one-third of their funding may come from the federal government; states and client firms must provide at least double the federal contribution.

MEP centers provide both information and direct services to client firms. Evaluations of MEP services have shown that they raise productivity in client firms.[99] MEP services have mainly involved helping firms adopt modern “lean production” methods in their direct production activities. Pioneered by Japanese auto manufacturers and now standard practice among leading firms in the U.S. and abroad, lean production reorganizes plant layout, work flow, and production tasks to cut costs by reducing wasted time and materials. Machine downtime and inventories are minimized. Workers work in teams to solve production problems as they arise. Implementing lean production requires training production workers and managers and reorganizing business processes more than it requires changing “hard” technology.

Office of Technology Policy. Until it was abolished in a Commerce Department reorganization in 2007, this was the only federal agency responsible for developing and advocating for federal technology policy. Its recent agenda included organizing workshops on various aspects of innovation in the United States, promoting international technology partnerships to strengthen the U.S. competitive position internationally, and encouraging entrepreneurship and technology-based economic development.

Department of Energy

Industrial Technologies Program. The Industrial Technologies Program invests in high-risk R&D focused on improving industrial energy efficiency and environmental performance while stimulating productivity and growth. It seeks to reduce energy intensity (energy demand per unit of industrial output) through the development and commercialization of innovative technologies. The program also provides best practices information to industry through training sessions, software tools, and university-based Industrial Assessment Centers. Program investments are determined by peer review.

Department of Labor

Workforce Innovation in Regional Economic Development (WIRED). Administered by the Employment and Training Administration (ETA). the WIRED Initiative (also known as H-1B High Growth Job Training Grants) facilitates an integrated regional approach to workforce development by supporting labor market areas that cross municipal, county and state lines. Designed for regions that have been affected by global trade, are dependent on a single industry, or are recovering from natural disasters, the initiative offers funding and technical assistance encourage innovative approaches to economic development. ETA assists the regions in areas such as entrepreneurship, career academies and identifying, mapping and leveraging assets. The initiative also facilitates peer to peer contact to share best practices with other WIRED regions and federal partners.

Since its inception in 2005, WIRED has offered three "generations" of regional grants in 13 geographic areas to proposals. State Governors apply on behalf of a team of multi-county public and private partners. First generation WIRED regions (2006) were awarded $15 million over 3 years and second generation WIRED regions received a $500,000 immediate investment and an additional $4.5 million over 3 years, contingent on approval of an implementation plan. The solicitation for third generation WIRED regions was announced in February 2007; awards of up to $5 million each will be given to 13 regions.

Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs

The SBIR and STTR programs target innovation in small firms, businesses which may not be able to compete effectively against larger firms for government assistance. The programs are intended to help meet the research needs of federal agencies and encourage technological innovation and commercialization in small business via set asides in departmental R&D budgets.

SBIR operates in eleven federal cabinet departments and independent agencies: the Departments of Agriculture, Commerce, Defense, Education, Energy, Health and Human Services, Homeland Security and Transportation; the Environmental Protection Agency, NASA, and NSF. The agencies participating in SBIR set aside 2.5 percent of their extramural R&D budgets for the program. Agencies make SBIR awards based on small business qualification, degree of innovation, technical merit, and future market potential.

STTR reserves 0.3 percent of the extramural budget in five departments and agencies: the Departments of Defense, Energy, and Health and Human Services; NASA, and NSF. Unlike SBIR projects, STTR awards are given to partnerships between small business and nonprofit research institutions. These collaborations not only assist small business in receiving federal funding but also encourage practical applications of the often theoretical research that goes in nonprofit research labs.

The SBIR and STTR programs are undertaken in three phases. Phase I awards are given for 9 months and up to $100,000 to explore the feasibility of a project. Applicants then compete for Phase II awards, given for up to $750,000 over two years, to fund the R&D efforts identified in Phase I. In Phase III, businesses are expected to pursue commercial applications with outside funding sources or non-SBIR/STTR federal grants or contracts. The Small Business Administration coordinates and evaluates the SBIR and STTR programs.

APPENDIX C
Federal Expenditures on Principal Programs that Support Firm-Level Innovation, FY 1998-2006

Program	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
NSF- Partnerships for Innovation*	$0	$0	$8,500,000	$10,000,000	$10,540,000	$4,970,000	$9,940,000	$9,920,000	$9,350,000
NSF- Industry-University Cooperative Research Center Program (IUCRC)*	$4,340,000	$5,370,000	$5,190,000	$5,230,000	$5,380,000	$5,790,000	$6,000,000	$6,980,000	$7,340,000
NSF- Engineering Research Center Program*	$52,800,000	$56,260,000	$50,220,000	$58,500,000	$56,200,000	$56,200,000	$62,900,000	$56,200,000	$57,390,000
Commerce Advanced Technology Program (ATP)*	$179,092,300	$190,342,800	$198,279,000	$175,425,800	$197,756,000	$199,404,000	$186,975,000	$138,059,000	$72,583,000
Commerce Manufacturing Extension Partnership Program (MEP)*	$114,100,000	$127,900,000	$103,300,000	$105,900,000	$108,200,000	$111,100,000	$46,500,000	$101,900,000	$111,300,000
Commerce Undersecretary for Technology (includes Office of Technology Policy)*	$11,000,000	$15,000,000	$12,000,000	$13,242,000	$13,436,000	$14,993,000	$11,770,000	$11,852,000	$5,923,000
Commerce Experimental Program to Stimulate Competitive Technology (EPSCoT)	$0	$1,997,217	$0	$0	$0	$0	$0	$0	$0
Energy- Industrial Technologies Program	$133,900,000	$162,800,000	$137,416,000	$145,986,000	$100,900,000	$96,824,000	$90,450,000	$73,371,000	$56,855,000
Labor- Workforce Innovation in Regional Economic Development* (WIRED)	$0	$0	$0	$0	$0	$0	$0	$47,000,000	$80,000,000
Small Business Innovation Research (SBIR)	$1,067,000,000	$1,097,000,000	$1,190,000,000	$1,294,000,000	$1,435,000,000	$1,670,000,000	NA	$2,028,923,000	$2,028,923,000
Small Business Technology Transfer (STTR)	$65,000,000	$65,000,000	$70,000,000	$71,000,000	$92,000,000	$92,000,000	NA	$233,314,422	$233,314,422
TOTAL	**$1,627,232,300**	**$1,719,672,800**	**$1,774,905,000**	**$1,879,283,800**	**$2,019,412,000**	**$2,251,281,000**	**NA**	**$2,707,519,422**	**$2,662,978,422**
Total as Percentage of GDP	0.0186	0.0186	0.0181	0.0186	0.0193	0.0205	NA	0.0217	0.0201

NA=not available.

*indicates program that would be incorporated into or replaced by the proposed National Innovation Foundation. ATP was abolished in 2007 and replaced by the Technology Innovation Program, whose activities would be incorporated into or replaced by NIF. The Office of Technology Policy was abolished in 2007; NIF would incorporate its former activities.

Sources: NSF programs—personal communication from NSF staff; ATP and MEP—actual obligations supplied by National Institute of Standards and Technology Budget Office; Office of Technology Policy—President's Budget; EPSCoT—Consolidated Federal Funds Report; Industrial Technologies Program—Department of Energy, Energy Efficiency and Renewable Energy Web site eere.energy.gov; WIRED—Catalog of Federal Domestic Assistance; SBIR and STTR—National Science Foundation, Science and Engineering Indicators (1998-2003), SBIR and STTR Annual Reports (2005-2006); authors' analysis of Bureau of Economic Analysis GDP data.

APPENDIX D

Federal Expenditures on Selected Programs that Support Firm-Level Innovation Compared with Federal Expenditures on Major Basic Scientific Research Programs, FY 2005

	Selected Firm-Level Innovation Program Expenditures*	Major Basic Scientific Research Program Expenditures**	Major Basic Scientific Research Programs as Multiple of Selected Firm-Level Innovation Program Expenditures
Alabama	$1,718,036	$328,679,360	191.3
Alaska	$595,096	$47,298,156	79.5
Arizona	$1,936,716	$314,551,998	162.4
Arkansas	$1,693,889	$70,859,355	41.8
California	$37,651,478	$4,093,344,659	108.7
Colorado	$3,712,219	$574,056,075	154.6
Connecticut	$4,638,091	$502,550,852	108.4
Delaware	$909,198	$45,888,178	50.5
District of Columbia	$0	$422,065,619	--
Florida	$6,973,593	$505,750,026	72.5
Georgia	$2,887,019	$474,230,920	164.3
Hawaii	$2,098,290	$116,919,498	55.7
Idaho	$640,980	$22,695,956	35.4
Illinois	$7,311,845	$955,331,590	130.7
Indiana	$858,866	$316,100,340	368.0
Iowa	$1,870,262	$233,757,956	125.0
Kansas	$1,765,741	$112,773,535	63.9
Kentucky	$565,122	$187,706,426	332.2
Louisiana	$1,604,672	$220,621,273	137.5
Maine	$928,517	$84,353,082	90.8
Maryland	$2,057,143	$1,888,797,982	918.2
Massachusetts	$8,669,722	$2,630,984,609	303.5
Michigan	$14,972,451	$725,139,102	48.4
Minnesota	$5,605,507	$506,944,878	90.4
Mississippi	$1,438,344	$56,579,522	39.3
Missouri	$2,943,400	$562,338,948	191.1
Montana	$550,536	$70,987,231	128.9
Nebraska	$718,543	$96,170,282	133.8
Nevada	$1,536,933	$41,111,338	26.7
New Hampshire	$453,013	$123,406,857	272.4
New Jersey	$10,291,684	$398,235,184	38.7
New Mexico	$5,207,573	$154,665,870	29.7
New York	$14,535,999	$2,393,174,387	164.6
North Carolina	$8,908,462	$1,201,010,691	134.8
North Dakota	$1,658,069	$29,754,397	17.9

Ohio	$9,611,326	$802,501,682	83.5
Oklahoma	$1,807,666	$107,986,568	59.7
Oregon	$1,282,089	$334,180,818	260.7
Pennsylvania	$9,880,794	$1,665,241,239	168.5
Rhode Island	$2,402,139	$163,110,587	67.9
South Carolina	$2,438,710	$180,337,220	73.9
South Dakota	$250,442	$27,392,074	109.4
Tennessee	$1,994,479	$480,496,817	240.9
Texas	$18,780,245	$1,303,126,027	69.4
Utah	$1,690,748	$188,946,263	111.8
Vermont	$996,084	$76,839,006	77.1
Virginia	$5,617,303	$828,104,128	147.4
Washington	$1,644,039	$926,436,664	563.5
West Virginia	$359,165	$26,352,732	73.4
Wisconsin	$4,110,999	$539,874,026	131.3
Wyoming	$352,257	$16,602,329	47.1
Total, All States	**$223,125,494**	**$28,176,364,312**	**126.3**

*Selected firm-level innovation programs are Commerce's Advanced Technology Program and Manufacturing Extension Partnership Program and the National Science Foundation's Partnerships for Innovation, Engineering Research Center Program, and Industry-University Cooperative Research Center Program.

**Major basic scientific research programs are National Institutes of Health and the balance of the National Science Foundation (excluding the three NSF innovation-promotion programs).

Note: Expenditures shown here include only those for grants, contracts, and cooperative agreements. For this reason, and because of accounting differences, these data may not be comparable with those shown in Appendix C.

Source: Authors' analysis of data from National Institute of Standards and Technology, Consolidated Federal Funds Report, National Institutes of Health, and National Science Foundation.

NOTES

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

[2] Paul M. Romer, "Implementing a National Technology Strategy with Self-Organizing Industry Boards," in Martin Neil Baily, Peter C. Reiss, and Clifford Winston (eds.), *Brookings Papers on Economic Activity, Microeconomics 1993: 2* (Washington: Brookings Institution, 1993), p. 345.

[3] Charles I. Jones, "Sources of U.S. Economic Growth in a World of Ideas," *American Economic Review* 92 (2002): 220-239.

[4] Ibid. It might be thought that a high rate of return would pull adequate private capital into innovation efforts, obviating the need for a government role. However, there are at least two reasons for government action. First, the social rate of return exceeds private rates of return, so the private sector will invest less in innovation than society needs. Second, a persistently high private rate of return relative to the opportunity cost of capital suggests that there are market barriers to private investment.

[5] For a discussion of the difference between incremental and radical innovation, see Richard G. Lipsey, Kenneth I. Carlaw, and Clifford T. Bekar, *Economic Transformations: General Purpose Technologies and Long Term Economic Growth* (New York: Oxford University Press, 2005).

[6] On user-driven innovation, see Eric Von Hippel, *Democratizing Innovation* (Cambridge: MIT Press, 2005).

[7] The descriptions of the innovation trajectories are based on Sean Safford, *InnovateNow! Report*, University of Chicago, 2007; and on personal communication with Sean Safford.

[8] Bronwyn H. Hall, "Innovation and Diffusion," National Bureau of Economic Research Working Paper 10212 (Cambridge, MA; National Bureau of Economic Research, 2004).

[9] Robert D. Atkinson and Andrew S. McKay, *Digital Prosperity* (Washington: Information Technology and Innovation Foundation, 2007).

[10] The Bureau of Labor Statistics uses this value-added definition of productivity for the U.S. economy as a whole and for service industries, but uses physical output rather than value added as the basis of its manufacturing productivity measures. Because the economic well-being of the nation or of a particular metropolitan area can increase because of a movement from lower to high value-added products, we measure productivity for all industries and metropolitan areas using the Bureau of Economic Analysis' measures of value added. Where possible we measure labor input by hours of work or numbers of full-time equivalent workers. However, these hours-sensitive measures are not available below the national level, so our metropolitan productivity statistics use wage and salary employment in a metropolitan area as the measure of labor input. An even more comprehensive productivity measure, total factor productivity, takes account of machines and other inputs to production in addition to labor. However, it is currently available only for some industries and only at the national level. Therefore, we do not make use of it, although NIF would promote improvements in the measurement of total factor productivity at both the national and regional levels.

[11] Per capita income can grow because of increases in work hours, reductions in the unemployment rate, or increases in labor force participation as well as because of productivity growth. Of these sources of income growth, however, only productivity growth can be sustained over long periods of time because, unlike the others, it is not subject to any long-term physical or social limit. Our analysis of Bureau of Labor Statistics productivity data and Census income data shows that both productivity and real per capita income grew at an average annual rate of 1.9 percent between 1967 and 2005.

[12] See Ian Dew-Becker and Robert J. Gordon, "Where Did the Productivity Growth Go? Inflation Dynamics and the Distribution of Income," in William C. Brainard and George L. Perry (eds.), *Brookings Papers on Economic Activity 2005: 2* (Washington: Brookings Institution, 2005).

[13] For an analysis of how low and middle-wage workers still benefit from productivity growth see Stephen Rose, "Does Productivity Growth Still Benefit Working Americans? Unraveling the Income Growth Mystery to Determine How Much Median Incomes Trail Productivity Growth" (Washington: Information Technology and Innovation Foundation, 2007).

[14] The estimates presented in table 1 may overstate productivity growth in manufacturing industries because U.S. manufacturers' use of temporary help services and offshored services may be understated in the data from which the productivity estimates are derived. See Susan Houseman, "Outsourcing, Offshoring, and Productivity Measurement in U.S. Manufacturing," Upjohn Institute Staff Working Paper 06-130 (Kalamazoo, MI: Upjohn Institute for Employment Research 2006). Moreover the estimates may misstate productivity growth in many service industries because the outputs of those industries may not be accurately measured. See Stephen A. Herzenberg, John A. Alic, and Howard Wial, *New Rules for a New Economy* (Ithaca, NY: Cornell University/ILR Press, 1998). Nevertheless, it is likely that productivity growth was relatively low in many service industries and relatively high in many manufacturing industries, even if the estimates derived from BEA data are inaccurate. Moreover, substantial interindustry variation in productivity levels and growth rates would still exist.

[15] For example, a survey of 100 small metalworking shops showed that value added per full-time equivalent worker fell or remained unchanged between 1992 and 1994 in half the shops surveyed but rose by 10 percent per year in 15-20 percent of the shops. Daniel Luria, "Toward Lean or Rich? What Performance Benchmarking Data Tell Us About SME Performance, and Some Implications for Extension Center Services and Mission," MMTC White Paper (Plymouth, MI: Michigan Manufacturing Technology Center, n.d.).

[16] William Nordhaus, "The Sources of the Productivity Rebound and the Manufacturing Employment Puzzle," NBER Working Paper 11354 (Cambridge, MA: National Bureau of Economic Research, 2005).

[17] See generally Robert D. Atkinson and Andrew S. McKay, *Digital Prosperity* (Washington: Information Technology and Innovation Foundation, 2007). For historical comparisons and the role of information technology, see William Nordhaus, "The Sources of the Productivity Rebound and the Manufacturing Employment Puzzle," NBER Working Paper 11354 (Cambridge, MA: National Bureau of Economic Research, 2005); Dale W. Jorgenson, Mun S. Ho, and Kevin J. Stiroh, *Information Technology and the American Growth Resurgence* (Cambridge: MIT Press, 2005). For international comparisons of productivity growth see Lawrence Mishel, Jared Bernstein, and Sylvia Allegretto, *The State of Working America 2006/2007* (Ithaca, NY: Cornell University Press, 2007). For an analysis of U.S. and European productivity trends see Robert Atkinson, "Boosting European Prosperity Through the Widespread Use of ICT" (Washington: Information Technology and Innovation Foundation, 2007).

[18] 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.

[19] Authors' analysis of Bureau of Economic Analysis data.

[20] Authors' calculations based on annual statistics published in the Bureau of Economic Analysis' *Survey of Current Business*, such as Raymond Mataloni, Jr., "U.S. Multinational Companies: Operations in 2003," *Survey of Current Business* 85 (2005): 9-29, and National Science Foundation, Division of Science Resources Statistics, *Research and Development in Industry: 2003*, NSF 07-314 (Arlington, VA: National Science Foundation, 2007), table 1, pp. 13-14. U.S. majority-owned foreign affiliates are foreign business enterprises that are owned at least 50 percent by U.S. parent(s). See also Robert Atkinson, "The Globalization of R&D and Innovation: How Do Companies Choose Where to Build R&D Facilities?" testimony before the House Science Committee, October 4, 2007.

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

[22] For a more complete discussion of the offshoring of routine service work, see Robert Atkinson and Howard Wial, *The Implications of Service Offshoring for Metropolitan Economies* (Washington: Brookings Institution, 2007).

[23] 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.

[24] A discussion of the reasons why some types of work are less susceptible to offshoring than others may be found in Atkinson and Wial, op. cit.

[25] See Kristin Dziczek, Jay Baron, and Dan Luria, *The World Class Tool Shop and Its Prospects in Michigan* (Ann Arbor, MI: Center for Automotive Research, 2005); Dan Luria, Matt Vidal, and Howard Wial, "'Full-Utilization Learning Lean' in Component Manufacturing: A New Industrial Model for Mature Regions and Labor's Stake in Its Success," report to Alfred P. Sloan Foundation, 2005.

[26] Authors' analysis of data in National Science Foundation Statistics, *Global Higher Education in S&E* (Arlington, VA: National Science Foundation, 2006), appendix table 2-37.

[27] Robert D. Atkinson and others, "Addressing the STEM Challenge by Expanding Specialty Math and Science High Schools," (Washington,: Information Technology and Innovation Foundation, 2007).

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

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

[30] Organization for Economic Co-operation and Development, *OCED S&T and Industry Outlook* (Paris: OECD 2004).

[31] Organization for Economic Co-operation and Development, OECD *Science, Technology and Industry Scoreboard 2005* (Paris: OECD 2005).

[32] See Robert D. Atkinson, "The Case for a National Broadband Strategy" (Washington: Information Technology and Innovation Foundation, 2007).

[33] Julie Hedlund, "Assessing Broadband Leaders" (Washington: Information Technology and Innovation Foundation, 2008).

[34] 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.

[35] 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.

[36] 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.

[37] University technology transfer offices are often more concerned with the amount of revenue they obtain from the licensing of intellectual property than with the extent to which ideas developed in their universities are commercialized. See Robert E. Litan, Lesa Mitchell, and E.J. Reedy, "Commercializing University Innovations: Alternative Approaches," in Adam B. Jaffe, Joshua Lerner, and Scott Stern (eds.), *Innovation Policy and the Economy*, vol. 8 (Cambridge: MIT Press, forthcoming). 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).

[38] See Daniel Castro, "Improving Health Care: Why a Dose of IT May Be Just What the Doctor Ordered" (Washington: Information Technology and Innovation Foundation, 2007).

[39] Shane Ham and Robert Atkinson, "Modernizing Home Buying: How IT Can Empower Individuals, Slash Costs, and Transform the Real Estate Industry" (Washington: Progressive Policy Institute, 2003).
[40] Barry LePatner, *Broken Buildings, Busted Budgets: How to Fix America's Trillion-Dollar Construction Industry* (Chicago: University of Chicago Press, 2007).

[41] Large firms are more likely to adopt new technologies than smaller firms. Edwin Mansfield and others, *The Production and Application of New Industrial Technology* (New York: Norton, 1977).

[42] For discussions of these market failures see, e.g., Bronwyn H. Hall, "Innovation and Diffusion," National Bureau of Economic Research Working Paper 10212 (Cambridge, MA; National Bureau of Economic Research, 2004); Philip Shapira, "Evaluating Manufacturing Extension Services in the United States: Experiences and Insights," in Philip Shapira and Stefan Kuhlmann (eds.), *Learning from Science and Technology Policy Evaluation* (Cheltenham, U.K.: Edward Elgar, 2003); Eric Oldsman, "Do Manufacturing Extension Programs Matter?" in Philip Shapira and Jan Youtie (eds.), *Evaluating Industrial Modernization: Methods and Results in the Evaluation of Industrial Modernization Programs* (Atlanta: School of Public Policy and Economic Development Institute, Georgia Institute of Technology, 1995).

[43] Sandra E Black and Lisa M. Lynch. "How To Compete: The Impact Of Workplace Practices And Information Technology On Productivity," *Review of Economics and Statistics* 83.3 (Aug. 2001): 444.

[44] See, e.g., Sandra E. Black and Lisa M. Lynch, "What's Driving the New Economy? The Benefits of Workplace Innovation," *Economic Journal* 114 (2004): F97-F116.

[45] 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), pp. 57-110.

[46] 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.

[47] 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: MIT Press, 2000).

[48] On the globally integrated enterprise, see Samuel J. Palmisano, "The Globally Integrated Enterprise," *Foreign Affairs* 85 (May/June 2006): 127–136.

[49] See Peter Navarro, "Deconstructing the China Price," *Economists' Voice* 4 (1), article 5, available at www.bepress.com/ev/vol4/iss1/art5.

[50] Available evidence shows that R&D tax credits are effective in stimulating R&D. However, tax credits by themselves may under- or overstimulate R&D relative to society's needs because they do not induce firms to undertake projects with the largest gaps between social and private rates of return. See Bronwyn H. Hall and John van Reenen, "How Effective Are Fiscal Incentives for R&D? A Review of the Evidence," NBER Working Paper 7098 (Cambridge, MA: National Bureau of Economic Research, 1999); Robert Atkinson, "The Research and Experimentation Tax Credit: A Critical Policy Tool for Boosting Research and Enhancing U.S. Economic Competitiveness" (Washington: Information Technology and Innovation Foundation, 2006).

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

[52] Dan Breznitz, *Innovation and the State* (New Haven: Yale University Press, 2007), p. 29.
[53] Ibid., p. 32.

[54] For a critique of this type of supply-side policy see Robert D. Atkinson, *Supply-Side Follies* (Lanham, MD: Rowman & Littlefield, 2006).

[55] Schacht, "Industrial Competitiveness."

[56] For a history of recent Administration and congressional attempts to eliminate or drastically cut these programs, see Wendy H. Schacht, "Industrial Competitiveness and Technological Advancement: Debate Over Government Policy," CRS Report to Congress (Washington: Congressional Research Service, 2007).

[57] America COMPETES Act, section 3001(b)(3), P.L. 110-69, 121 Stat. 593 (2007). The funding increases authorized in the America COMPETES Act will occur only to the extent that Congress appropriates the necessary funds by passing separate appropriations legislation. In fiscal 2007, for example, it did not appropriate the additional funds for MEP and TIP that the America COMPETES Act authorized.

[58] America COMPETES Act, section 3002(a)(1), P.L. 110-69, 121 Stat. 593 (2007).

[59] 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.

[60] Robert D. Atkinson, "Expanding the R&D Tax Credit to Drive Innovation, Competitiveness, and Prosperity" (Washington: Information Technology and Innovation Foundation, April 2007).

[61] OECD 2004, op. cit.

[62] National Science Foundation, "Federal Science and Engineering Support to Universities, Colleges, and Nonprofit Institutions: FY 2004," NSF 07-316 (Arlington, VA: National Science Foundation 2007). The main campuses of these universities were located in the following metropolitan areas: Baltimore, MD; Seattle, WA; Philadelphia, PA; Ann Arbor, MI; San Jose, CA; Los Angeles, CA; Madison, WI; San Diego, CA; Boston, MA; San Francisco, CA; Durham, NC; St. Louis, MO; New York, NY; Pittsburgh, PA; Boulder, CO; New Haven, CT; Ithaca, NY; Minneapolis, MN; Nashville, TN; Oakland, CA; Houston, TX; Cleveland, OH; Rochester, NY; Birmingham, AL; Chicago, IL; and Sacramento, CA.

[63] Changes in workers' skills, the interface between the consumer and the service provider, organizational knowledge, and/or "hard" technology may lead to innovation and productivity growth in the services. See Faiz Gallouj, *Innovation in the Service Economy* (Cheltenham, U.K.: Edward Elgar, 2002). Some of these changes may involve movement in the direction of greater standardization of non-standardized service processes, while others may involve improving workers' abilities to interpret consumers' needs or solve nonroutine problems. See Stephen A. Herzenberg, John A. Alic, and Howard Wial, *New Rules for a New Economy* (Ithaca, NY: Cornell University/ILR Press); Richard K. Lester and Michael J. Piore, *Innovation: The Missing Dimension* (Cambridge: Harvard University Press, 2004). Little is known about what kinds of changes will produce the greatest productivity gains in which types of service processes.

[64] See Tadahiko Abe, "What is Service Science?" Research Report 246, Fujitsu Research Center, Tokyo, Japan, December 2005.

[65] America COMPETES Act, section 1005, P.L. 110-69, 121 Stat. 593 (2007).

[66] Virtually every issue of the State Science and Technology Institute's *Weekly Digest* provides examples (www.ssti.org).

[67] Dan Berglund, State Science and Technology Institute, personal communication.

[68] Other examples, include Utah's Research Centers of Excellence program, which helps spin off technologies from universities by supporting a professional business consultant to principal investigators develop commercialization strategies, and San Diego's CONNECT, a nonprofit organization that connects businesses to local universities and helps local startup companies commercialize faculty inventions. CONNECT is unique because it is separate from university technology transfer offices. Its objective is to promote networking and information flow among university researchers, private firms, venture capitalists, and others. See CONNECT Web site, www.connect.org/about/index.htm.

[69] Connecticut's Yankee Ingenuity program and Pennsylvania's Ben Franklin Technology Partners program work in a similar manner. See Yankee Ingenuity Competition Web site, http://www.ctinnovations.com/funding/ccef/yankee.php, and Ben Franklin Technology Partners Web site, http://www.benfranklin.org/about/index.asp.

[70] 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. Competitors have a chance to win seed capital and valuable services (e.g., legal, accounting and consulting) and other opportunities to help entrepreneurs launch or grow a business.

[71] Hosiery Technology Center Web site, www.hosetech.com. Other programs include Cleveland's WIRE-Net, a local trade association that provides expertise that meets the needs of manufacturers, connects manufacturing leaders to each other, and engages them in their communities, and New York's Garment Industry Development Corporation, which provides marketing, buyer referrals, and training and technical assistance to New York apparel manufacturers and workers. See Westside Industrial Retention &

Expansion Network (WIRE-Net) Web site, www.wire-net.org, and Garment Industry Development Corporation Web site, www.gidc.org.

[72] National Governors' Association, *State Sector Strategies: Regional Solutions to Worker and Employer Needs,* (Washington: National Governors' Association, 2006).
[73] Robert D. Atkinson and Daniel K. Correa, *The 2007 State New Economy Index: Benchmarking Economic Transformation in the States* (Washington: Information Technology and Innovation Foundation , 2007): 59.

[74] The material in this box is drawn from the Wisconsin Regional Training Partnership Web site www.wrtp.org, and from Stephen A. Herzenberg, John A. Alic, and Howard Wial, *New Rules for a New Economy* (Ithaca, NY: Cornell University/ILR Press), pp. 135-136.

[75] Kentucky Entrepreneurial Coaches Institute Web site, www.uky.edu/Ag/KECI/about.html.

[76] 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 Westerstrahle of Tekes; France—*OECD Reviews of Innovation Policy: France* (Paris: Organisation 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.zte.gov.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.

[77] 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 www.tekes.fi/julkaisut/FENIX_arviointi.pdf (in Finnish, with English summary).

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

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

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

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

[82] Because the problems of agricultural innovation are quite different from those of other industries and because the Department of Agriculture already addresses them, through various programs including the Cooperative State Research, Education, and Extension Service, NIF would not deal with innovation in farming.

[83] Donald Stokes, *Pasteur's Quadrant* (Washington: Brookings Institution, 1997).

[84] Center for Wireless Communications Web site, www-cwc.ucsd.edu/members.php.

[85] See Focus Center Research Program Web site, http://fcrp.src.org/member/about/fcrpqa.asp.

[86] National Center for Manufacturing Sciences Web site, www.ncms.org.

[87] Under TIP, any company that is majority owned by U.S. citizens is eligible for funding. A foreign –owned company is also eligible if the director of TIP finds that that company's participation "would be in the economic interest of the United States, as evidenced by" investments in U.S. research and manufacturing, significant contributions to U.S. employment, and agreement to promote the production in the United States of products; and if the foreign country protects intellectual property and provides U.S.-owned companies with comparable investment and research opportunities. America COMPETES Act, section 3012(b), P.L. 110-69, 121 Stat. 593 (2007). The National Institute of Standards and Technology, TIP's parent agency, may require repayment of grants if firms do not meet the requirements regarding domestic commercialization. NIF should include all these requirements and apply the requirements of investment in U.S. research and manufacturing and agreement to promote production in the United States to U.S.-owned firms as well as foreign firms.

[88] Such an assessment would be based on the informed judgment of NIF staff. It would be only one factor that NIF would take into account, not the only factor.

[89] America COMPETES Act, section 3012(b), P.L. 110-69, 121 Stat. 593 (2007).

[90] This kind of assistance to states with low-scoring 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 the Web sites of JumpStart (www.jumpstartinc.org/Process/Assist.aspx) and Adena Ventures (www.adenaventures.com/serviceprograms/opsassist.aspx).

[91] See, e.g., Daniel Castro, "Improving Health Care: Why a Dose of IT May Be Just What the Doctor Ordered" (Washington: Information Technology and Innovation Foundation, 2007).

[92] See Stephen A. Herzenberg, John A. Alic, and Howard Wial, *New Rules for a New Economy* (Ithaca, NY: Cornell University/ILR Press, 1998).

[93] See European Commission, *Innovation in Europe: Results for the EU, Iceland, and Norway* (Luxembourg: Office for Official Publications of the European Communities, 2004).

[94] NSF conducted one-time pilot surveys of firm-level innovative activities in the manufacturing and software industries in the mid-1990s and in the information technology industry in 2001. These surveys were the closest American analogues to Europe's Community Innovation Survey. See National Science Foundation, Division of Science Resources Statistics, *Information Technology Innovation Survey: Fall 2001*, NSF 04-305 (Arlington, VA: National Science Foundation, 2004).

[95] Although NIF would help promote innovation in energy technologies and small businesses, it would not take over all the energy-specific innovation work of the Industrial Technologies Program or all the small business-specific funding of SBIR and STTR. Therefore, we do not propose incorporating these agencies into NIF.

[96] America COMPETES Act, section 3001(b)(3), P.L. 110-69, 121 Stat. 593 (2007).

[97] "Expensing of exploration and development costs" were $1.1 billion in fiscal 2007 and are expected to be $0.5 billion in fiscal 2010. "Excess of percentage over cost depletion" was $1.1 billion in fiscal 2007 and is expected to be $1.2 billion in fiscal 2011. *Estimates of Federal Tax Expenditures for Fiscal Years 2007-2011*, prepared for the House Committee on Ways and Means and the Senate Committee on Finance by the staff of the Joint Committee on Taxation (Washington: Government Printing Office, 2007), table 1, p. 24, available at http://www.house.gov/jct/s-3-07.pdf.

[98] America COMPETES Act, section 3012(b), P.L. 110-69, 121 Stat. 593 (2007).

[99] Ronald S. Jarmin, "Evaluating the Impact of Manufacturing Extension on Productivity Growth," *Journal of Policy Analysis and Management* 18 (1999): 99-119; Nexus Associates, Inc., "The Pennsylvania Industrial Resource Centers: Assessing the Record and Charting the Future," October 1999; Eric S. Oldsman and Christopher R. Heye, "The Impact of the New York Manufacturing Extension Program: A Quasi-Experiment," in Philip Shapira and Jan Youtie (eds.), *Manufacturing Modernization: Learning from Evaluation Practices and Results* (Atlanta: School of Public Policy and Economic Development Institute, Georgia Institute of Technology, 1997).

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