SCIENCE POLICY

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Benchmarking Foreign Innovation

The United States Needs to Learn from Other Industrialized Democracies

By Stephen Ezell

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

While many nations have taken the innovation challenge to heart and put in place a host of policies to spur innovation, the United States has done little, consequently falling behind in innovation policies and risking falling behind in innovation performance as well. We see this gap in at least five main areas: programs to establish civilian technology and innovation promotion agencies;[1] services innovation initiatives; national levels of research-and-development funding; tax incentives for research and development; and policies regarding high-skill immigration.

In the pages that follow, we will examine each of these five areas to see what our nation could learn from benchmarking new innovation policies to those of our rival industrialized competitors in Europe and Asia.

CIVILIAN TECHNOLOGY AND INNOVATION PROMOTION AGENCIES

A number of advanced countries are well ahead of the United States in creating national agencies that support innovation. In recent years, Finland, France, Iceland, Ireland, Australia, Japan, the Netherlands, New Zealand, Norway, South Korea, Canada, Germany, Taiwan, Switzerland, and Great Britain have either established or significantly expanded separate technology- and innovation-promotion agencies. Other nations, such as Denmark, Sweden, and Spain, have longstanding agencies of this type.[2] All these countries have science- and university-support agencies similar to America's National Science Foundation, which largely fund basic research, universities, and national laboratories. But these countries realized that if they were to prosper in the highly competitive, technology-driven global economy, they needed specifically to promote technological innovation, particularly in small and mid-sized companies and in partnership with universities.

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

Similarly, Japan's New Energy and Industrial Technology Development Organization is a quasi-public agency that receives its $2 billion budget from the Ministry of International Trade and Industry. Great Britain's new Technology Strategy Board is a non-departmental public body (similar to an independent government agency in the United States) whose mission is to drive forward the government's national technology strategy. South Korea's Korea Industrial Technology Foundation, established in 2001, engages in a wide range of technology activities, including providing training to develop industry technicians and cooperating with international entities to promote industrial technology development. A host of other nations have similar bodies dedicated specifically to promoting innovation and competitiveness.[3]

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.

Adequately investing in and developing innovation-enhancing policies is crucial to national innovation competitiveness, as Professors Jeffrey Furman and Richard Hayes found in a study of the national innovation capacity (an economy's potential for producing a stream of commercially relevant innovations) of twenty-three countries from 1978 to 1999.[4] Starting in 1979, they classify countries as either world-leading innovators (the United States, Germany, Japan), middle-tier (Great Britain, France, Australia), third-tier (Spain, Italy), or "emerging" innovators (Ireland, Taiwan) based on countries' patenting activity per capita, a proxy for commercialized innovations.

A number of these "emerging innovators"—among them Ireland, Finland, Singapore, South Korea, Denmark, and Taiwan, in particular—achieved remarkable increases in innovative output per capita, moving to the world's technological frontier and *overtaking* the innovative capacities of many mid- and third-tier countries, including Great Britain, France, and Italy, whose economic conditions started off much more favorably in the early1980s. Furman and Hayes conclude that innovation leadership among countries requires not only the development of innovation-enhancing policies and infrastructure, such as strong IP protections, openness to trade, highly competitive markets, and strong industry clusters, but also *a commitment to maintaining substantial financial and human capital investments in innovation.*

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

If the United States wanted to match Finland's outlays per dollar of GDP in innovation-promotion efforts, it would have to invest $34 billion per year. While other nations invest less in their innovation-promotion agencies than Finland, they still invest considerably more than the United States. As a percent of their countries' GDPs, Sweden spends 0.07 percent, Japan 0.04 percent, and South Korea 0.03 percent on their innovation promotion agencies. To match these nations on a per-capita basis, the United Sates would have to invest $9 billion to match Sweden, $5.4 billion to match Japan, and $3.6 billion to match South Korea.[5] It is astounding that economies a fraction the size of the United States spend more on innovation-promotion in *actual dollars,* let alone as a percentage of their economy.

This places U.S. industries and corporations operating alone at a disadvantage against foreign corporations that benefit from coordinated and enlightened national strategies among universities, governments, and industry collaborations to foster competitiveness. For example, the Japanese government has recognized advanced battery technology as a key driving force behind its competitiveness, and views battery technology as an issue of "national survival."[6] It is funding Lithium-ion battery research over the five-year period from October 2007 to October 2012 at $215 million (¥25 billion)—a level 10 times the amount of announced U.S. Lithium-ion battery research investment—and longer term, has committed to a 20-year Li-ion battery research program.

Germany's government will provide a total of €1.1 billion ($1.4 billion) over 10 years to applied research on automotive electronics, lithium ion batteries, lightweight construction, and other automotive applications.[7] U.S. automakers, receiving only a fraction of this support, are disadvantaged from the get-go. Those who believe that any kind of proactive government support or intervention for U.S. businesses is tantamount to industrial policy and that free markets alone will provide the price signals companies need to make investment decisions will indeed see the marketplace introduce hybrid and electric vehicles, but it will likely be by foreign auto companies, to the detriment of employment in, and long-term survivability of, domestic U.S. automobile manufacturers.

To be sure, a number of "third party" organizations in the United States fill in for some of the roles played by innovation promotion agencies in other countries. Case in point: The U.S. semiconductor industry and federal government partnered in the 1980s on SEMATECH, a collaborative partnership

to restore U.S. innovation and competitiveness in microprocessor chips. The National Academy of Sciences' Government-University-Industry Research Roundtable works collaboratively to identify and target promising new technologies for R&D funding and to promote a highly skilled U.S. workforce. Several states support "regional cluster" initiatives to drive competitiveness of regional industry clusters, among them The Massachusetts Life Sciences Collaborative and Southeast Michigan's Automation Alley in industrial automation.[8]

But many in Washington have recognized that these dispersed and unconnected initiatives will be insufficient to close the growing gap between the United States and peer countries in creating a coherent and coordinated national innovation strategy. The National Academy of Sciences will release a report (funded by the America Competes Act) by the end of 2008 documenting barriers to innovation in the United States. It will be the first NAS report addressing innovation as distinct from technology and research and development.

To address these critical innovation challenges, the Washington-based Information Technology and Innovation Foundation and The Brookings Institution have called for the creation of a National Innovation Foundation—a new, nimble, lean, and collaborative entity devoted to supporting firms and other organizations in their innovative activities. NIF's mission will be to boost the nation's innovation leadership for the 21st century and raise productivity and incomes.[9] Sens. Susan Collins of Maine and Hillary Clinton of New York have authored Senate Resolution 3078 to create a National Innovation Foundation, and the Obama administration should stridently support and promote this legislation.

SERVICES INNOVATION INITIATIVES

A dramatic macroeconomic shift from goods to services has occurred in Western economies, with services now accounting in the United States for 82 percent of output and 84 percent of employment and for 86 percent of output in Great Britain.[10] From an employment perspective, low employment in domestic services sectors accounts for almost all of the variability in employment rates between industrialized member nations of the Organization for Economic Cooperation and Development. As services increasingly drive employment, productivity, and economic growth, a number of countries have developed explicit national services innovation policies focused on spurring innovation in the services sectors of their economies. Policymakers in these countries have recognized that knowledge of services innovation has largely been informed by studies of the manufacturing sector, and acknowledged the need to tailor unique measures to the needs of services firms and industries.[11]

The focus on service innovation began in the mid-2000s with a coterie of small Northern European countries—Finland, Denmark, Norway, The Netherlands, and Sweden—and has since grown to include additional small countries in Europe and Asia (Taiwan, Ireland, and Singapore) and large nations (Great Britain, Canada, and Germany).

Finland was the first to implement a national services innovation policy, with a five-year, €100 million[12] program launched in 2006 called "SERVE—Innovative Services Technology Programme."[13] Finland's neighbors soon followed suit, recognizing the increasing importance of services as their domestic manufacturing industries departed for cheaper production centers abroad, particularly in the form of "near-shoring" to Baltic and Eastern European countries. The same phenomenon affected developed Pacific Rim countries, as manufacturing moved first from Japan and Taiwan to cheaper production centers in China, and now out of China and on to the poorer nations of Southeast Asia. This process has forced almost all industrialized countries to seek to migrate their economies up the value chain towards knowledge-based, high-value-added services activities such as R&D, design, finance, consulting/training, and post-installation service and support.

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

Second, with this supportive policy framework in place, these countries implemented specific programs to support innovation in services businesses. Specific efforts (and at least one sample country implementing them) include:[14]

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

Unfortunately, the United States lags behind these countries in developing policies to support innovation in its service sectors. In fact, the whole edifice of U.S. policies toward services industries is underdeveloped. For instance, U.S. trade law contemplates foreign corporations "dumping" (selling products in the United States below their cost of production or sale in the home country) only physical products, not services, in the United States. So even if a U.S. company could prove that a foreign corporation is "dumping" services onto the U.S. market—say a firm of radiologists in India sold medical imaging analysis services in the United States at a price far below the actual cost of providing the service—it would be unable to pursue any kind of injunctive relief through countervailing duties. Of more immediate concern, U.S. service industry workers who lose their jobs due to globalization are not eligible to receive Trade Adjustment Assistance, unlike their counterparts in U.S. manufacturing industries who lose their jobs due to foreign competition.

To be fair, the United States has at least begun to contemplate redressing some of these imbalances. In the 2007 America COMPETES Act, Congress authorized the funding of a research project to study service science research. And while the United States has not updated its domestic trade laws to reflect the importance of services to the economy, it has aggressively pushed liberalization in service trade in the recent Doha round on international trade lib-

eralization and in bilateral trade negotiations with countries such as South Korea and Peru. The United States lags behind peer countries in inviting the rest of the world's best and brightest to participate in U.S. economic opportunity, but internally it does have flexible labor markets that direct employment to the fastest-growing, highest-value-added industries.

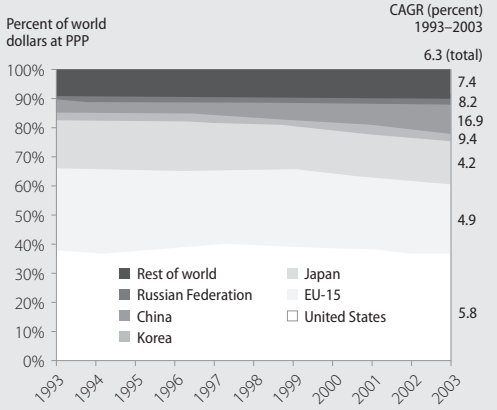
NATIONAL LEVELS OF RESEARCH AND DEVELOPMENT FUNDING

While the United States does lead the world in aggregate (combined federal and corporate) R&D expenditures, it lags behind other industrialized democracies in its level of national R&D intensity (R&D as a percentage of GDP) at a time when many countries are renewing their focus on research and development activities and proactively increasing government-funded R&D investment.[15]

In 2003, the United States invested $292.4 billion in R&D, accounting for 36.1 percent of global R&D (see Figure 1). In that year, the European Union (EU)-15[16] and Japan came in second and third, with 25 percent and 13.9 percent, respectively, of world R&D expenditures.[17] While the United States does lead the world in aggregate R&D investment, its global share of R&D has recently been weakening. In fact, as Figure 1 illustrates, whereas U.S. total R&D investment represented an *increasing share* of world R&D investment from 1993 to approximately 1998, the U.S. share of world R&D investment has been receding since then. The major reason for this slippage has been a slowdown in federal R&D investment since the mid-1990s, as total federal R&D spending grew at a sluggish 2.5 percent per year from 1994 to 2004—much lower than its long-term average of 3.5 percent growth from year from 1953 to 2004.[18]

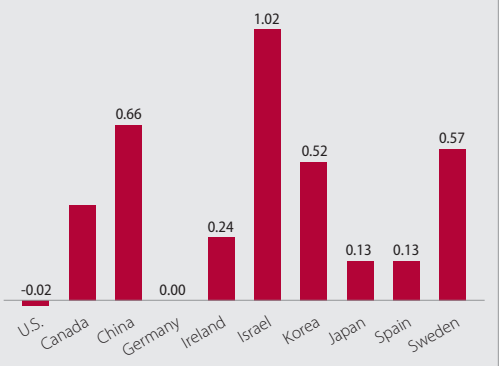
When comparing countries' R&D investment levels, it is crucial to look not only at countries' raw R&D investment levels, but also at countries' R&D investments relative to their GDPs, a measure called R&D intensity. This is important because countries' R&D intensity levels reveal the relative level at which countries are investing in the new technologies that will lead to innovative and commercializable products and services that keep a nation's corporations at the forefront of market competitiveness. On this measure, the United States is one of only a few nations where total investment in R&D as a share of GDP actually fell from 1992–2005, largely because of that decline in public R&D support.[19] Figure 2

FIGURE 1
R&D funding in current dollars at PPP (1993–2003) as percentage of world total



Source: OECD (2006b, 2006c), cited from Titus Galama and James Hosek, *U.S. Competitiveness in Science and Technology* (Santa Monica, California: RAND Corporation, 2008): 22.

FIGURE 2
Percent change in R&D/GDP ratio, 1991–2003



Source: ITIF.

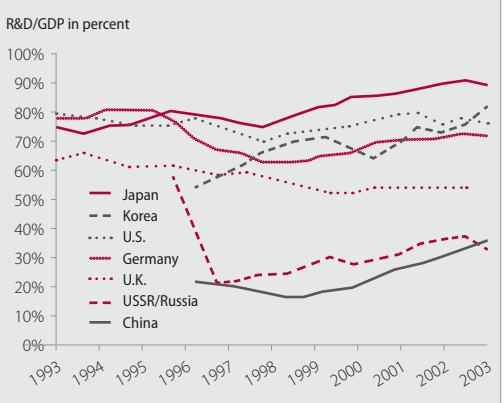
plots the percent change in R&D/GDP ratio for the years 1991–2003 for the United States against a group of competing industrial countries, illustrating how U.S. R&D intensity has weakened against peer countries.[20]

In fact, a recent report from the RAND corporation, "U.S. Competitiveness in Science and Technology," examined seven countries' levels of R&D intensity, comparing U.S. R&D intensity from 1985–2005 against that of China, Germany, Japan, Korea, the United Kingdom, and Russia/USSR (see Figure 3).[21]

In this comparison of countries above, Japan clearly leads in R&D intensity from 1985 to 2005. While at first glance U.S. performance appears strong—the United States holding second place for most of this period—the graphic reveals several disturbing trends. One, South Korea has surpassed the United States; South Korea set a goal in 1997 to raise its R&D from 3.6 percent to 5 percent, and these results bear proof of that policy's success, with South Korean R&D intensity reaching 4.7 percent in 2007. Second, every other country in this comparison set (except for the U.K.) exhibits increasing levels of R&D intensity, whereas U.S. levels have decreased then flattened out.

FIGURE 3

R&D intensity: gross domestic expenditure on R&D as a percentage of Gross Domestic Product, 1985–2005



Source: Reproduced from Eaton and Kortum (2007); OECD (2006b, 2006c).

But as Will Straw documents in his companion piece in this volume, "*UK Innovation Policy*," that country is making concerted efforts to energize its national innovation strategy and ramp up R&D investments. What's more, this comparison excludes acknowledged world leaders in R&D intensity, such as Finland, Singapore, and Israel. Finland, for example, has consistently devoted about 3.5 percent of its GDP to R&D, and has recently embarked on a strategy to push that level to 4 percent.[22]

In fact, when U.S. R&D intensity is compared to other OECD countries, we find that at 2.6 percent of GDP devoted to R&D investment, the United States ranks only seventh in R&D intensity, behind a list of countries including Japan, South Korea, Finland, and Sweden.[23] In more recent rankings (2006) from the OECD, the United States places only 22nd in the fraction of GDP devoted to non-defense research.[24] While R&D, as with any type of investment, confronts diminishing returns at a certain point, the United States has clearly slipped below OECD averages for national R&D intensity.

These findings are cause for concern because the payoff for government support for research and development funding is indeed considerable, as Fred Block and Matthew R. Keller argue in "Where Do Innovations Come From? Transformations in the U.S. National Innovation System, 1970–2006." The study by The Information Technology and Innovation Foundation documented the crucial importance of federal R&D funding to innovation in the United States, finding that in 2006 only 11 of the 88 entities that produced award-winning innovations were not beneficiaries of federal funding.[25]

TAX INCENTIVES FOR RESEARCH AND DEVELOPMENT

The tax incentives the U.S. government provides corporations for R&D activities have fallen from the most generous in the world in the late 1980s to 17th among 30 OECD countries in 2004 (see Fig-

ure 4.)[26] Many nations now provide significantly more generous tax incentives for research than does the United States. From leading the world in the late 1980s,[27] the United States by 1996 fell to seventh most generous among OECD nations, behind Spain, Australia, Canada, Denmark, the Netherlands, and France.[28] By 2004, we had fallen to 17th in generosity for general R&D; 16th for machinery and equipment used for research; and 22nd for buildings used for research.[29]

Among nations with a tax incentive for R&D, the United States now provides one of the weakest incentives, below our neighbors Canada and Mexico, and behind many Asian and European nations (see Figure 5). Japan's credit is almost three times as generous as the United States', and for small companies it's four times as generous. In 2004, France adopted a credit essentially equivalent to a 40 percent incremental R&D tax credit. In an explicit effort to attract U.S. corporate R&D, our neighbor to the north is even more generous. In Canada, large companies are eligible for a flat 20 percent credit while small companies can receive a 35 percent credit; in many provinces, equally generous credits can be taken on top of the federal credit. Indeed, over the past decade, all other nations with R&D tax incentives have boosted the generosity of their R&D tax incentives, particularly since 2000.[31]

At a time of increased concern about America's growing competitiveness challenge, our tax credit has been getting weaker, both in absolute terms and relative to other nations, in part because of changes made by Congress over the years that have diminished its generosity.[32] In fact, until the passage in 2006 of the Alternative Simplified Credit, the credit was about half as generous as it was in the early 1980s.[33]

FIGURE 4
U.S. rank in tax generosity of R&D among OECD nations, 2004[30]

Source: ITIF.

FIGURE 5
Tax subsidy generosity for R&D by large firms in selected OECD nations, 2004[34]

Source: ITIF.

Even with the recent increases in R&D tax incentives (the passage of the Alternative Simplified Credit in 2006 and its expansion in the Emergency Economic Stabilization Act of 2008), the United States moved up only to 14th place. However, this doesn't include non-OECD nations such as India, China and Brazil, all of which have significantly more generous tax incentives to attract multi-national R&D. India's R&D tax credit is now four times that of the United States. On top of salaries for R&D personnel that are as low as one-sixth of the costs in the United States, China provides a 150 percent deduction on R&D expenses (provided that R&D spending increased 10 percent over the prior year).

Given the relative generosity of our foreign competitors' tax treatment of R&D, it's not surprising that 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 vs. 26 percent).[35] In contrast, corporate R&D spending in the United States as a share of GDP

fell every year between 2000 and 2003, to 1.67 from 1.84 percent.[36] Moreover, as a share of GDP, corporate-funded R&D fell in the United States by 7 percent from 1999 to 2003, while in Europe it grew 3 percent and in Japan 9 percent.[37] While a number of factors have contributed to this differential in R&D growth rates, the more generous R&D tax incentives in Europe and Japan are likely one important factor.

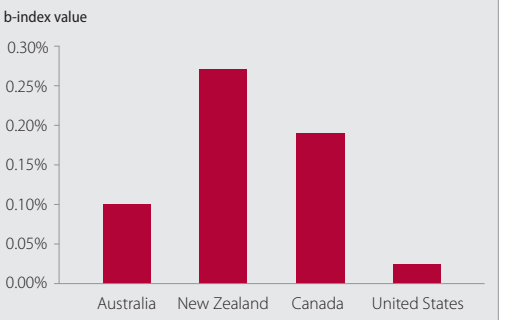
HIGH SKILL IMMIGRATION

Welcoming the world's most skilled foreign-born scientists and engineers into the land of economic opportunity that America affords has long been one of the strengths of the U.S. national innovation system. The U.S. economy and the standard of living for American citizens have benefited enormously from this influx of foreign talent. AnnaLee Saxenian, a professor at the University of California-Berkeley, has shown that Indian and Chinese entrepreneurs founded or co-founded roughly 30 percent of all Silicon Valley startups in the late 1990s.[38] Microsoft founder Bill Gates has estimated that for every foreign-born scientist or engineer Microsoft has hired, five new jobs were created for U.S. citizens.

Recognizing this, over the last decade many nations have liberalized their policies regarding high-skill immigration, while the United States, in stark contrast, has restricted its policies. In a study benchmarking high-skill immigration policies in eight nations (the United States, Canada, New Zealand, Australia, Japan, Great Britain, Germany, and France), *Global Flows of Talent: Benchmarking the United States*,[39] The Information Technology and Innovation Foundation found that the United States trails other peer countries in developing a proactive approach to attract high-skilled foreign workers.

Using data from 2001 to 2006, the United States received an average of about 67,000 highly skilled permanent immigrants per year, with Canada receiving 56,000 per year, Australia 20,000, and New Zealand about 10,000.[40] As a share of their populations, these rates are all several times larger than those in the United States—more than 11 times larger in the case of New Zealand (see Figure 6).

FIGURE 6
Annual inflows of highly skilled as share of total population[41]



Source: ITIF.

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

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

youngest cohort of scientists and engineers (ages 21 to 35), the percentage rose to 20 percent.

With the United States restricting the number of H-1B visas issued annually to 85,000, almost 50 percent of highly talented foreign professionals who applied for temporary work in the United States in the years 2006 to 2008 were turned away. Limiting the influx of talented foreign-born science and engineering professionals not only hurts U.S. competitiveness, it may also contribute to the decision of companies to source R&D operations abroad to be closer to local pools of S&E talent. At a time when, as *The Economist* put it, "Talent has become the world's most sought-after commodity,"[42] the United States needs an immigration strategy that once again welcomes the world's best talent to our shores.

A first step would be collecting accurate statistics about H-1B visa applicants and grantees. The Citizenship and Immigration Service (the federal agency that oversees the guest worker program) has been unable to answer basic questions such as "How many foreign-born professionals are working in the United States on H-1B visas," or "What percentage of H-1B visa holders seek green cards instead of returning home."[43] Several proposed congressional bills would raise the number of H-1B visas annually to 115,000 (with provisions to go as high as 180,000.) Andy Grove, founder of Intel Corp., and other technology leaders have called for "green cards to be stapled to the diplomas" of foreign-born individuals receiving graduate and undergraduate degrees from U.S. universities.[44]

CONCLUSION

Countries are increasingly recognizing that technology and innovation drive long-term national economic growth.[45] Most of these countries already feature robustly funded national technology and innovation agencies, and an increasing number are working to develop explicitly stated national innovation strategies and agendas that coordinate the activities of government, corporations, and universities in their countries to support innovation. Many of these countries have embraced an emerging doctrine of economics called innovation economics, which reformulates the traditional model of economic growth to place knowledge, technology, entrepreneurship, and innovation at the center of economic growth, and asserts that the central goal of economic policy should be to spur higher productivity and greater innovation.[46]

These countries understand that markets relying on price signals alone will not always be as effective as smart public-private partnerships in spurring higher productivity and greater innovation.

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

NOTES

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

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

3 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).

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

5 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.

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

7 Auto Industry UK, "Germany invests €420M in lithium-ion battery development," May 13, 2008 < www.autoindustry.co.uk/news/13-05-08_2>.

8 Karen G. Mills, Elisabeth B. Reynolds, and Andrew Reamer, "Clusters and Competitiveness: A New Federal Role for Stimulating Regional Economies" (Washington: The Brookings Institution, April 2008) <www.brookings.edu/~/media/Files/rc/papers/2008/04_competitiveness_reamer/Clusters Brief.pdf>.

9 Robert D. Atkinson and Howard Wial, "Boosting Productivity, Innovation, and Growth Through a National Innovation Foundation" (Washington: Information Technology and Innovation Foundation, April 2008) < www.itif.org/files/NIF.pdf>.

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