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Crafting Innovation Policy to Win the Race

Countries that want to lead the pack in the race for global innovation advantage must craft and implement a range of constructive policies to support the innovative capacity of their economies. To that end, some three dozen countries have created formal national innovation strategies and at least two dozen have established national innovation agencies, actions that have only further intensified the global competition for innovation leadership. These countries are not content to let their government policies and actions influence innovation in a haphazard and uncoordinated way. They seek to develop mechanisms to assess their nation's strengths and weaknesses, to examine other nations' policies in order to learn from them, and to assess and revise their own policies in a broad array of areas that could influence their innovation and competitiveness.

The countries leading the world in developing innovation policy have followed a three-step process. First, they recognized the need to approach innovation systematically. Second, they effectively brought attention to the need for innovation to the body politic, putting forth an inspirational vision and strategy for action, replete with clearly articulated goals and ambitions. These goals and a game plan for achieving them are clearly set forth in their

national innovation strategies. Finally, these countries made the tough decisions necessary to not only implement institutional reforms to drive their innovation strategies but also to adequately fund them (including providing tax incentives), even at the expense of other government spending or lower taxes for individuals.

The Innovation Policy "I's"

Rather than offer a laundry list of programs and policies that countries are implementing to support innovation, we instead present seven broad areas that a national innovation policy effort must get right. We call these the seven "I's" of innovation policy: Inspiration, Intention, Insight, Incentives, Institutions, Investment, and IT (information technology).[1]

Inspiration: Setting Ambitious Goals

Holders of free-market ideology will claim that nations should not set goals for their economies because, by definition, whatever economy the market produces is the right one and superior to any economy dictated by goals, whether they are "Stalinist" five-year plans or the most market-friendly innovation policies. This is one reason why the United States has generally not set innovation goals, other than recently with respect to broadband and clean energy. But as we discuss in chapter 5, markets acting alone will underperform when it comes to innovation, and that's why at least thirty-five nations have implemented national innovation strategies. As part of these strategies, many countries unabashedly state their intention to lead the world in certain industries, technologies, or application areas, and they commit to supporting these goals with the necessary resources. These countries believe that without ambitious goals to work toward, the private, nonprofit, and government sectors will not be adequately motivated to take the needed steps.

Perhaps the best example of a nation that sets ambitious goals is Singapore. In the late 1990s, the country set a goal to drive its economy through and to become a world leader in innovation. Singapore openly declared that it sought world leadership in the life sciences, digital media, and

water/environment industries. Ten years later, Singapore has succeeded. As the Information Technology and Innovation Foundation (ITIF's) *Atlantic Century* report found, in 2009, Singapore ranked first among forty nations or regions in innovation-based competitiveness, making the second-fastest progress of any of these nations from 1999 to 2009 (with only China showing faster progress). Singapore also placed first when ITIF released *The Atlantic Century II* report in July 2011. Singapore clearly followed through on its goals with innovation policies: In 2003, the country launched Biopolis, a two-million-square-foot biomedical research center to support its goal of becoming a world leader in life sciences. Biopolis has attracted almost seven thousand Ph.D. graduates in the life sciences, including many of the world's preeminent biomedical researchers. To put this in perspective, the United States has about ten thousand life sciences Ph.D.s. Thus, as Azeem Ibrahim, a research fellow at Harvard's Kennedy School, puts it, "a country with roughly the same population as Alabama can now compete with the U.S. as a whole."[2] Near Biopolis, Singapore's Fusionopolis houses six thousand scientists in fields such as materials science, clean technology, and digital media.

Likewise, China has signaled its clear intention to move to the front of the pack in the race for global innovation advantage. In January 2006, China initiated a fifteen-year "Medium- to Long-term Plan for the Development of Science and Technology." The plan aims for China to become an "innovation-oriented society" by 2020, to develop indigenous innovation capabilities, to leapfrog into leading positions in new science-based industries, to increase research and development (R&D) expenditures to 2.5 percent of gross domestic product (GDP) by 2020, to increase the contribution to economic growth from technological advances to 60 percent, to limit dependence on imported technology to 30 percent, and to become one of the top five countries in the world in the number of patents granted.[3] On February 9, 2011, China announced its updated "China Innovation 2020" goals. The country plans to invest $1.5 trillion on seven "strategic emerging industries":—(1) energy saving and environmental protection; (2) new generation of information technology; (3) biotechnology; (4) high-end equipment manufacturing; (5) new energy; (6) new materials; and (7) new energy vehicles.[4] To get a sense of the level of this investment, for the United States to match this on a per-GDP basis it would have to pass an American Recovery and Reinvestment Act (the 2008 "stimulus bill" that appropriated over $800 billion) every year for the next five years and have all the funds go to making U.S. industries more competitive.

Other nations also focus on technology areas or broad industries they seek to lead. For example, Australia, Canada, Denmark, Finland, Ireland, Japan, Korea, the Netherlands, Singapore, and Sweden have openly declared an aspirational goal to lead the world in transitioning to a digital economy. Leadership in the digital economy entails ensuring that almost all citizens have access to high-speed broadband connections; that the population is digitally literate; that government puts all services online; and that information technologies suffuse transportation, energy, and health networks as well as business enterprises. Savvy countries recognize that digital infrastructure applications—such as mobile- and wired-broadband, the smart electric grid, health IT, intelligent transportation systems, mobile payments, digital signatures, e-government, and kiosks and other self-service technologies—can transform their economies.

The Japanese government has identified advanced battery technology as a key driving force behind its competitiveness, and views battery technology as an issue of "national survival."[5] As a result, it committed more than ¥25 billion ($275 million) in funding for lithium-ion battery research over the five-year period from 2007 to 2012, and has committed to a twenty-year advanced battery research program. Likewise, China has targeted a number of clean energy sectors, including wind energy, solar power, rail, carbon capture and sequestration, and clean nuclear power as sectors in which it seeks technological leadership.[6]

Many nations identify a range of core industries they seek leadership in. For example, Finland's National Innovation Strategy identifies six industries central to its economy for which it seeks global leadership: forestry products, information and communications technology, health care, energy and the environment, construction, and mechanical engineering.[7] For each of these industries, Finland has created a Strategic Center for Science, Technology, and Innovation, partnerships in which companies, universities, and research institutes agree on a joint strategic technology research road map for the industry. Such "road mapping" exercises identify technology

challenges and key areas of need over the next decade, providing a road map for technology development and subsequent rounds of research funding. More broadly, Finland's National Agency for Technology and Innovation, Tekes, has identified twenty-two key technology and application areas—such as nano-sensors, wireless technologies, broadband, advanced machining, lean manufacturing, and services innovation—in which it seeks cutting-edge advantage for its companies and industries and funds research accordingly. The Netherlands has targeted innovation leadership in the creative and financial services, retirement and pensions, logistics, and supply chain management sectors. And Denmark has targeted the IT services, retail, pension management, and transportaton sectors.

Other nations have set specific goals, akin to a football team's goal of being in the top five teams in scoring. For example, in 1997, Korea set a goal to raise R&D as a share of the government budget from 3.6 to 5 percent and almost got there, moving it to 4.7 percent. Turkey set a goal of raising R&D from 1.7 percent of GDP to 2.5 percent. Since 1999, China has increased its R&D expenditures by 21 percent a year, and the country seeks to increase its R&D intensity by 50 percent by 2020.[8]

While setting an ambitious goal is useful, sometimes the goals set by nations or regions are unrealistic. A case in point is Europe. In 2001, the European Union (EU) articulated its so-called Lisbon Strategy, which set a goal for Europe to become "the most competitive and dynamic knowledge-based economy in the world by 2010." This was never realistic and needless to say, Europe failed, if for no other reason than because it did not invest the funds to make that a reality and in part because, as chapter 10 describes, it isn't really sure if it wants more innovation, at least of the kind that leads to "creative destruction." But still, the agenda did help provide support for policymakers who wanted to make innovation more of a priority.

Intention: Making Innovation-Based Competitiveness a National Priority

It's one thing to set a goal; it's another thing to make the invariably tough choices needed to achieve it. As we have seen, Europe's Lisbon Strategy set an ambitious goal, but it lacked intention and follow-through. One nation

that didn't lack resolve was Finland. When the Soviet Union broke up in 1991, the collapse sent Finland, its largest trading partner, into an economic tailspin. GDP plummeted 9 percent in two years, unemployment rocketed to 20 percent, and exports fell by 13 percent in 1991 alone. (By comparison, in the 2008–2009 recession, U.S. GDP shrank by 2.6 percent and unemployment peaked at 10 percent.) What did Finland do? Did it hunker down and try to ride out the storm by cutting investment in innovation, as the United Kingdom is doing and many in the United States advocate, in an effort to balance the budget? To the contrary, while slashing overall government spending, the Finnish government significantly expanded its support for R&D, in part through boosting funding for its national innovation agency, Tekes, and in part by putting in place innovation-based tax incentives for businesses. Finland increased its R&D intensity from less than 3 percent in the 1990s to nearly 4 percent by 2008.[9] On top of those measures, the Finnish government slashed the corporate income tax rate from 33 percent to 25 percent in 1990 and lowered it to 19 percent in 1992, all while staring in the face of huge budget deficits.[10] In other words, in the midst of an economic disaster of the first order, Finland went all out to make a massive bet on competitiveness, innovation, and productivity, while at the same time cutting spending that did not contribute to that goal.

And the bet paid off. Finland diversified its economy. Nokia, once a manufacturer of rubber boots and paper products, transformed itself into a cellular phone company that, at least until the emergence of smart phones, was a world leader. The country turned a budget deficit into a surplus. From 1993 to 1997, the Finnish government's budget deficit averaged −5.2 percent of GDP. But starting in 1998, the string of deficits turned into a string of surpluses, which averaged 3.8 percent of GDP from 1998 to 2002 and reached 5.2 percent of GDP by 2007.[11] From 1993 to 2009, Finland's GDP per capita (at purchasing power parity [PPP]) grew 50.2 percent while America's grew 28.4 percent.[12] During that same period, the dollar value of Finland's high-tech exports (in current $US) increased almost eightfold, while the dollar value of U.S. high-tech exports barely doubled. Today, Finland is widely recognized as one of the most innovative countries in the world and has, as one commentator put it, "as well-designed an innovation ecosystem as exists on the planet."[13] Likewise, Switzerland's response to

the economic crisis of 2009 was to expand the country's investments in science, technology, and innovation, as the Swiss parliament increased R&D funding levels and launched an innovation voucher program to support innovation in small businesses.

A number of other countries, including Ireland, Korea, and Singapore, have also developed national innovation strategies and institutions as a response to severe economic crises. They followed the logic of Mancur Olsen's 1982 book *The Rise and Decline of Nations*, which argued that countries whose economic foundations have suddenly been shaken tend to grow and innovate faster than more stable nations, as dramatic change becomes an issue of national survival. Certainly the Great Recession has likewise shaken America's economic foundation. The question is: Will it be able to emulate the paths of these countries and make the tough decisions needed to strengthen its innovation-based competitiveness or will it get locked in an interest-group and partisan stalemate?

Insight: Improving Understanding of Innovation Performance

Once nations set a goal to lead in innovation and develop the will to act, the next step is to acquire the insight to do the right thing, not just anything. At least thirty nations have done the right thing, as evidenced by their national innovation strategies.

A core component of these strategies is analysis and insight gathering. This can take several forms. Many nations undertake a comprehensive analysis of their competitiveness and benchmark it against other nations at both broad economic and major industry levels. Among other things, they assess the national tax, trade, and regulatory climate for the competitiveness of their traded sectors and how their science and technology (S&T) and education and training policies affect competitiveness at the sector level. These nations further identify critical emerging technology areas, chart research road maps needed to keep their companies at the cutting edge of these emerging technologies, look to identify gaps or shortfalls in investments or technology competencies, and attempt to bridge those gaps. The innovation strategies of many countries also support the coordination of technology development within industry across a vertically fragmented

industrial ecosystem in order to align with larger commercial, societal, or security goals.[14] For example, Germany's *High-Tech Strategy for Germany*, released in 2006, identified seventeen advanced cross-cutting technologies (ranging from biotechnology, nanotechnology, and microsystems technology to optical, materials, production, and information and communications technologies) that are critical to the ability of German industries and its broader economy to compete. For each technology, the strategy undertakes a SWOT (strengths, weaknesses, opportunities, and threats) assessment of where Germany (that is, its enterprises, universities, and research institutions) stands with regard to the development and deployment of the technologies. The strategy helps to identify gaps and to coordinate the limited resources of Germany's government, enterprises, and universities toward charting technology road maps (and making the requisite investments) to ensure German leadership in these technologies.[15] The 2010 update of the *High-Tech Strategy* noted that the "German Federal Government's innovation policies are geared towards five fields of action: climate/energy, health/nutrition, mobility, security, and communication," and charted "forward-looking projects and R&D programs" in each field of action.[16]

To this end, most innovation agencies—including Finland's Tekes and Sweden's VINNOVA—operate a number of overseas technology liaison offices that conduct "technology scanning," seeking out emerging technologies bearing on the competitiveness of domestic industries, and sponsoring outreach efforts to help their domestic companies partner with foreign businesses and researchers. The mission of these technology liaison offices is to assure that their countries stay on top of the latest developments in cutting-edge technologies and to give their countries' businesses exposure to new technologies and business practices emerging in other parts of the world.

Creating new knowledge is a central goal of many countries' innovation strategies. This involves not only providing financial support to research universities but also creating new knowledge about innovation processes, methods, techniques, measurement, and how best to diffuse innovation throughout an economy. For example, through its *Technology Review* series, Finland's Tekes has a long history of funding research that seeks to create new knowledge about innovation. For example, "Tekes Technology Review

205: Seizing the White Space: Innovative Service Concepts in the United States" surveyed innovative business models in U.S. financial services, professional services, logistics, and retail trade industries and explained how Finnish small and medium-sized enterprises (SMEs) could adapt those models.[17]

In the United States, the National Science Foundation (NSF) has launched the Science of Science & Innovation Policy (SciSIP) program to support interdisciplinary and multidisciplinary research aimed at developing theoretical models and empirical evidence to advance understanding of scientific, research, and innovation processes. The objective is to provide a scientifically rigorous, quantitative basis upon which policymakers can assess the impacts and dynamics of the scientific and engineering enterprise and improve outcomes.[18] One goal of SciSIP will be to help policymakers understand how the United States can enhance its R&D efficiency, or return on invested R&D dollar, an objective shared by almost all nations. Likewise, the United Kingdom has invested heavily to understand the role of "service design" in innovation, while Norway has sponsored a large research program into "value-driven service innovation."

General Electric's (GE's) Jack Welsh famously said, "You can't manage what you can't measure." But because innovation is such an intangible concept—it can't be measured as easily as barrels of oil or counted like cars coming off the assembly line—and because it includes difficult-to-quantify activities such as changes in business and organizational models, developing accurate measures and metrics for innovation has been a challenging task for many countries (and companies) and is a common focus of many nations' innovation strategies. The United Kingdom's NESTA (National Endowment for Science, Technology, and the Arts) has been at the forefront of this effort. Its 2008 report *Measuring Innovation* argued that "existing innovation metrics bear little relation to the innovation that is most relevant to the modern U.K. economy."[19] NESTA points out that traditional innovation measurements, based around S&T policy and the manufacturing economy, emphasize quantifiable activities—such as number of patents granted, number of scientific publications, or amount of money invested—but that these traditional metrics fail to adequately capture "hidden innovation" in services industries, creative industries, and the public sector, or

to recognize new methods of open and user-led innovation. Since December 2008, the United Kingdom has issued annual innovation progress reports that score the country on implementation of its national innovation strategy.[20]

Incentives: Encouraging Innovation, Production, and Jobs

Many countries that have come to recognize incentives as indispensible tools in building global competitiveness provide rewards ranging from grants and tax breaks for specific corporate projects and desired behavior (e.g., performing R&D or investing in new equipment) to general reductions in corporate taxes. Whether it's China providing tax holidays to attract a high-tech factory, France offering generous R&D tax credits, or Ireland providing one of the lowest corporate tax rates (10 percent), many nations actively encourage innovation and domestic investment. Indeed, as competition for internationally mobile investment has increased over the last quarter century, most nations have established more competitive corporate tax codes. Deveraux, Lockwood, and Redoano find that corporate tax rates for Organization for Economic Cooperation and Development (OECD) nations declined from nearly 50 percent in the early 1980s to less than 35 percent in 2001, and that international tax competition was the principal driver of those reductions.[21] By 2009, the non-U.S. OECD rate had declined even more, to just below 30 percent (while the combined state-federal U.S. rate remained at 39 percent).

Recognizing that incentives are an important driver of innovative behavior, a number of countries have begun to offer generous (and stable) R&D tax credits both to encourage existing companies to expand R&D activity and to attract globally mobile R&D activity. For instance, India and France now offer the world's most generous R&D tax credits, almost six times higher than that of the United States.[22] (In part because of aggressive reforms, corporate taxes as a share of French GDP are now lower than the European average and even lower than Ireland's.) Israel's R&D credit is four times greater than that of the United States. Despite the fact that the United States invented the R&D tax credit in 1981, and long offered the world's most generous credit, U.S. R&D tax credit generosity has slipped markedly.

In fact, America ranks twenty-first of twenty-four OECD countries assessed for rate of change in tax credit generosity between 1999 and 2008. By 2012, the United States ranked just twenty-seventh out of forty-one countries in R&D tax credit generosity, and had even fallen behind the non-OECD nations of Brazil, China, and India in R&D tax credit generosity.

Not only have other nations put in place more generous research incentives, they also have been more innovative in using novel incentives to spur research and innovation. For example, some countries—including Denmark, the Netherlands, and Norway—have begun to extend R&D tax credits to cover process R&D activities, effectively extending the R&D tax credit from goods to services industries as well. Other nations have more generous credits for companies cofunding research at national laboratories or universities. For example, in France, companies funding research at national laboratories and universities receive a 60 percent credit on every dollar invested. Denmark, Hungary, Japan, Norway, Spain, and the United Kingdom provide firms more generous tax incentives for collaborative R&D undertaken with public research institutions (than for R&D activity undertaken independently).[23]

Several countries have recently adopted or expanded tax incentives designed to spur the commercialization of R&D. These incentives, or "patent boxes" (so-called because there is a box to tick on the tax form), allow corporate income from the sale of patented products (or in some cases from innovation-based products) to be taxed at a lower rate than other income.[24] For example, Ireland does not tax income received from patents, and Belgium taxes such income at a rate not greater than 6.8 percent. Switzerland has reduced corporate taxes on income from all intellectual property to between 1 and 12 percent. In 2010, the Netherlands expanded this incentive such that income derived from patents or R&D is taxed at just 10 percent, instead of its normal 25 percent rate.[25] China, France, Luxembourg, and Spain also tax income from patents at reduced rates. In fact, China's patent box also goes beyond patents by providing the lower patent box rate to firms that spend at least 3 to 6 percent of gross revenue on R&D (depending on firm size), have 60 percent of firm revenue from core intellectual property (IP; defined as inventions, utility model patents, software, copyrights, proprietary layout designs, and new plant varieties), have 30

percent of their workforce with a college degree, or have 10 percent of their workforce employed in R&D or high-tech occupations.[26]

A number of countries also have implemented innovative tax policies offering preferential tax treatment to small businesses, especially those engaged in innovative activities. For example, France's Jeunes Enterprises Innovantes (JEI) program targets young companies that are less than eight years old, have fewer than 250 employees and less than €50 million in turnover, devote at least 15 percent of their expenditures to R&D, and are independent and not listed on a stock exchange. Another innovative tax technique France uses to support entrepreneurs is giving wealthy individuals the opportunity to invest in start-ups in lieu of paying a wealth tax.

Australia, Canada, France, Norway, and the United Kingdom also offer young innovative firms refundable R&D tax credits in lieu of using carry-forward or carry-backward provisions on business losses. Within the EU, governments also can give extra incentives to firms less than six years old that invest more than 15 percent of their total revenues on R&D across all regions and sectors without breaking EU state aid rules.[27]

Other nations offer very generous investment credits to encourage companies to invest in new capital equipment and other growth-producing investments. For example, Taiwan's Statute for Upgrading Industries, established in 1991, provides a package of corporate tax incentives, including accelerated depreciation and tax credits for investments in R&D, automation, worker training, pollution controls, and investments in newly emerging important and strategic industries. Thus, a company may take a credit of up to 20 percent for funds invested in hardware, software, or technology that can promote an enterprise's "digital information efficiency."

Such nations understand the importance of productivity to being internationally competitive. In one description of Taiwan's program to provide tax credits for companies to adopt automation, Wen-Jung Lien et al. note: "Companies are encouraged to adopt automation instead of the conventional labor-intensive production method so they can be less dependent on labor and less concerned about industrial hollowing-out."[28] And, in fact, one study found that the tax credit actually reduced unemployment by a small amount (0.06 percent). Lien et al. also find the Taiwanese R&D tax credit more than pays for itself, costing the government NT$10.4 billion

($358 million), but increasing tax revenue by NT$22.8 billion ($785 million).[29] They find the same result for a tax credit for investing in automation, a cost of NT$7.8 billion ($268 million) that led to an increase in overall tax revenues of NT$13.3 billion ($458 million). These incentives account for about 0.3 percent of Taiwanese GDP. To match these incentives as a share of GDP, the United States would have to offer tax incentives of $42 billion, far in excess of the $8 billion it offers in the R&D credit.[30]

Many other nations have corporate tax incentives for investment. Companies in Malaysia can depreciate general plant and equipment over six years, with heavy machinery over four years, and computer and IT equipment even faster.[31] In the United Kingdom, firms can expense investments for plant and machinery up to £100,000 ($156,000) in the first year. Singapore allows firms to expense in the first year all computer and prescribed automation equipment, robots, and energy-efficient equipment.[32] In Canada, purchases of computers are eligible for a 55 percent declining-balance capital cost allocation rate in the first year. Manufacturing equipment is also eligible for accelerated depreciation.[33] It should be noted that all of the incentives described here are not targeted at particular firms, but rather are open to all firms in all industries that make growth- and innovation-inducing investments.

Many nations also offer large incentives to multinational technology-based companies to move operations to their borders. Intel's experiences provide a good example. Of the $7.3 billion Intel has invested in Israel, $1.2 billion was subsidized by the Israeli government.[34] In India, Intel can take advantage of a ten-year tax deduction that is available for 100 percent of profits derived by exports of certain products from free-trade zones. In addition to tax breaks, as part of its "semiconductor policy" India offers interest-free loans amounting to 20 percent of capital expenditures for projects in special economic zones (and 25 percent in selected other locales) for investments of greater than $570 million.[35] India put these policies in place in 2007 after it lost out to Vietnam on a $1 billion Intel assembly and test facility, which Vietnam lured to Ho Chi Minh City thanks to its own generous incentives and tax breaks. For the Vietnam facility, Intel will not pay corporate taxes for the first four years of operation and will enjoy a 50 percent tax break the following nine years, after which

Intel will pay only 10 percent in taxes, compared with the normal 28 percent corporate rate.[36] (Such incentives are offered to all businesses that invest in the Ho Chi Minh City high-tech economic zone.) It is a bit ironic that a country with a city named after the iconic Communist leader Ho Chi Minh is better at attracting global capital investments than the United States. China offers similar tax breaks. It costs Intel $1 billion less to build a factory in China than in the United States—and the cost difference is only slightly attributable to cheap labor. Ninety percent of the difference comes from the Chinese government providing Intel with capital grants, equipment grants, tax holidays, and incentives.[37] Likewise, Korea offers its major high-tech companies virtually tax-free status, and interest-free loans to keep their investments in country.

As Intel CEO Paul Otellini explains, like it or not, offering incentives as part of the global competition to attract mobile high-tech investment is here to stay: "We're building factories in Ireland, Israel, China, or Malaysia and you get an incentive package that [includes] an end-of-the-year tax holiday or equipment credits or something like that worth several hundreds of millions of dollars because people want companies like ours to invest there and to hire their folks. What's different about Mississippi versus Malaysia? You're not taking anything away from the tax rolls that is there on the day you give the grant."[38] Intel's still investing in the United States (75 percent of its factories remain in America, though it sells 75 percent of its product overseas), but it's telling that Intel is one of the only semiconductor companies to open a new plant in the United States in the past half decade, with almost all others being offshored. The United States is going to have to get used to competing for globally mobile high-tech investments. But unlike virtually every other advanced country, it lacks any kind of coordinated federal capability to do so, has among the highest effective corporate tax rates, and has minimal investment tax incentives.

Many countries are also experimenting with measures to increase their R&D efficiency by using existing funding for scientific research to incent universities to focus more on technology commercialization. For example, in Sweden, 10 percent of regular research funds allocated by the national government to universities are now distributed using performance indicators. Half of these funds are allocated based on the amount of external

funding the institutions have been able to attract, with the other half based on the quality of scientific articles published by each institution (as determined through bibliometric measures such as the number of citations).[39] Finland also has started to base its university budgets on performance—25 percent of the research and research training budgets of Finnish universities are based on "quality and efficacy," including the quality of scientific and international publications and the university's ability to attract research investment from businesses.[40] In other words, without increasing government budgets, these nations are using existing funds to provide a strong incentive for universities to be greater engines of national innovation.

In addition to incenting innovation, it's also important that countries remove impediments to innovation, such as the needlessly complex process of starting a business or inefficient regulations. For example, it takes forty-seven days to start a business in Indonesia or Spain—and an astounding average of 120 days to start a business in Brazil.[41] Yet the evidence clearly shows that delays caused by entry regulations are associated with lower rates of firm entry.[42] Some countries have streamlined their new business registration procedures, often with dramatic results. Portugal's "On the Spot Firm" initiative enables new businesses to register with the government online in just forty-five minutes, and has been so successful that sixty thousand new firms formed that way in just two years.

Smart governments also systematically review their regulatory regimes to remove regulatory barriers that hinder innovation. For example, Britain's Web site businesslink.gov.uk empowers businesses to directly influence how the regulations that affect them are devised and delivered.[43] Businesses may submit proposals on the Web site, outlining how specific regulations can be improved, such as ideas about how to reduce the amount of time it takes to complete forms or about how regulations that overlap or contradict can be rationalized.

Institutional Innovation

Technological innovation is not enough; nations need to drive institutional innovation as well. In other words, nations need to redesign a wide

array of institutions to work more effectively, and not just science and technology institutions (although that's a good place to start). One way nations have done this is to create national innovation agencies. Recognizing that neither traditional science support agencies nor large, inflexible economic ministries can adequately support innovation, more than two dozen nations have created national innovation foundations, many just since the year 2000 (a selected list of nations is shown in table 6.1).

In 2000, India launched its National Innovation Foundation; Sweden created VINNOVA in 2001; Portugal introduced its Agência de Inovação in 2003; in 2004, Norway created Innovasjon Norge and the Netherlands launched Senter Novem; in 2006, Denmark created the Danish Agency for Science, Technology, and Innovation and South Africa launched its National Advisory Council on Innovation; and Uruguay launched its National Research and Innovation Agency in 2008. In June 2009, the United Kingdom reorganized several cabinet-level agencies to create the Department of Business, Innovation, and Skills and announced the creation of a $230 million fund to invest in technology-based U.K. businesses with high growth potential. Thus, while some countries do boast innovation agencies with a longer pedigree—Taiwan's Industrial Research Technology Institute (ITRI) dates back to 1973; Finland's National Agency for Technology and Innovation, Tekes, to 1983; and Ireland's Forfas to 1994—the past decade has seen a multitude of nations becoming serious about innovation-based competition and developing the institutional capacity to support it.

In addition, Australia, Austria, Chile, France, Germany, Iceland, Italy, Malaysia, New Zealand, Spain, and Switzerland also have dedicated innovation-promotion agencies.[44] And it's not just developed countries that have created innovation agencies and strategies. Uruguay has a staff of thirty at its National Research and Innovation Agency in Montevideo charged with driving innovation throughout the Uruguayan economy. Even tiny Ghana and Rwanda have articulated innovation strategies, while Ghana is in the process of launching its own national innovation agency. Nigeria launched a science, innovation, and technology policy in February 2012.

All these countries have agencies similar to America's National Science Foundation, which largely fund research at universities and national laboratories. But these countries realized that if they wanted to prosper in the

Table 6.1. Selected Countries with a National Innovation Strategy or Agency

Country	Has articulated a national innovation strategy	National innovation agency/foundation	Year agency introduced
Brazil	Yes	Brazil Innovation Agency	1967
China	Yes	Ministry of Science and Technology	1998
Denmark	Yes	Danish Agency for Science, Technology, and Innovation	2006
Finland	Yes	Tekes	1983
France	Yes	OSEO	2005
India	Yes	National Innovation Foundation	2000
Ireland	Yes	Forfas	1994
Italy	Yes	ENEA (National Agency for New Technologies, Energy and the Environment)	1999
Japan	Yes	New Energy and Industrial Technology Development Organization (NEDO)	1980
Korea	Yes	Korea Industrial Technology Foundation	2001
The Netherlands	Yes	Senter Novem	2004
Norway	Yes	Innovasjon Norge	2004
Portugal	Yes	Agência de Inovação	2003
South Africa	Yes	National Advisory Council on Innovation	2006
Sweden	Yes	VINNOVA	2001
Taiwan	Yes	Industrial Technology Research Institute	1973
Thailand	Yes	National Innovation Agency	2003
United Kingdom	Yes	Department of Business, Innovation, and Skills	2009
United States	Yes	N/A	N/A
Uruguay	Yes	National Research and Innovation Agency (ANII)	2008

competitive, technology-driven global economy, they needed an institution whose mission was specifically to promote technological innovation, particularly in small and midsized companies and in partnership with universities.

Foreign agencies that promote innovation are today a far cry from the strongly directive Japanese Ministry of International Trade and Industry (MITI) of the 1980s. While such agencies do seek to identify industries and technologies that their countries are well positioned to compete in and make research investments accordingly, they do not "pick winners and losers" in the sense of picking individual firms to champion. As Philip Rycroft, director general, innovation and enterprise at the U.K. Department of Business, Innovation, and Skills, who has overseen development of Britain's innovation policy, explains: "We're determined not to second-guess the future by trying to pick winners and losers. But we do think government can create the conditions so that new industries can rise more easily."[45] Agencies that promote innovation in their countries 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, including coinvesting in key technology areas. And they seek to better align what government already does to ensure that it best supports innovation and competitiveness.

Another area of institutional innovation that countries are increasingly focusing on is reforming their education systems. These countries recognize that talent is an important source of competitive advantage and thus have made education and training a core component of their innovation strategies. For example, Finland has set a goal that all its young citizens will have the technical, analytic, and communications skills required for them to be competitive in a global economy the day they graduate from high school. Finland's *Oivallus* (*Insight*), a national educational foresight project, interviews corporations worldwide to understand what skills will be required by businesses in the years 2020 to 2030. It then advises how the Finnish education system needs to reform now so that students graduating in the future will be prepared to compete.[46] Sweden introduced universal school vouchers that can be used at any accredited private, nonprofit,

or public school in a sweeping reform to enhance the competitiveness of its secondary education system. Finland consolidated three of its institutes of higher learning—the Helsinki School of Economics, the University of Art and Design Helsinki, and the Helsinki University of Technology—into a single institution, Aalto University. Finland intends for it to become one of the world's leading academic institutions at combining business, technology, and design by 2020. Likewise, Denmark, desiring to create four very strong, globally competitive universities, merged eight universities into four.

Many nations also are reshaping how their governments buy goods and services in order to drive innovation through "intelligent demand." In most countries, public consumption accounts for approximately 20 percent of total domestic demand, so designed properly, government procurement policies can be an effective tool for fostering innovation.[47] Rothwell finds that, over longer time periods, government procurement policies triggered greater innovation impulses in more areas than did R&D subsidies, and they did so without any "buy domestic" requirements.[48] The United Kingdom, which spent £175 billion ($282 billion) on procurement in 2009, has made innovation a clear goal of its procurement process for years.[49] All British government departments are required to establish and develop an Innovation Procurement Plan and agencies at all levels of government must consider innovation when awarding government contracts. The Office of Government Procurement, the British government's procurement agency, and the Department of Business, Innovation, and Skills provide practical advice to procurers on how to ensure that innovation is incorporated into procurement practices.[50] Finland includes "innovativeness" among the criteria for public procurement decisions and reserves a percentage of appropriations granted to administration agencies to go toward innovation and development activities.[51] While these countries recognize that innovation should be a key element of government procurement, according to a report by the EU, "the United States has a strategic orientation in their public procurement as well, but not primarily connected to innovation."[52]

Government itself is the one area where needed institutional innovation is most lagging. In many nations, public-sector unions have become a heavy anchor on innovation, both in terms of the amounts of public monies they siphon off (largely for overgenerous pensions and overstaffing) that could be used for making investments in public-sector innovation and, more important, in terms of their own often deep resistance to institutional innovation. In the United States, for example, teachers' unions are the biggest barrier to real education reform, but at all levels of government public-sector unions have been a barrier to reinventing and automating government. In many nations, public-sector unions fight automation and institutional innovation, not to mention just simple downsizing to remove "dead wood" staff. Even in Scandinavia, a region where unions are relatively enlightened, public-sector unions limit innovation, particularly in health care. Perhaps one exception is Denmark, where the government funds pilot programs to demonstrate how technology can automate and actually eliminate government jobs without sacrificing high-quality services. This is possibly one reason why each Danish tax collection employee collects double the taxes that each Japanese employee does.

Investment: Increased Public Funding for Innovation

Many countries invest substantially in innovation on a per capita basis, and many have increased those investments since the late 1990s. While U.S. R&D intensity (R&D as a share of GDP) increased by a paltry 10.4 percent from 1995 to 2008, it increased substantially more in most other nations, including Germany (20.5 percent), Japan (26.2 percent), Korea (42.2 percent), Taiwan (61 percent), Finland (65 percent), Singapore (135.1 percent), and China (170.2 percent).[53]

Other countries also outstrip the United States in direct funding of efforts to promote innovation. In 2009, Finland invested €590 million ($801 million) in Tekes. Sweden's VINNOVA invests €220 million ($300 million) annually to promote growth in Sweden by funding needs-driven research and the development of effective innovation systems (this amount is effectively doubled to €440 million annually, since VINNOVA requires equal cofinancing of all projects).[54] Sweden invests 0.07 percent of GDP, Japan 0.04 percent, and Korea 0.03 percent in their agencies promoting innovation. In contrast, in fiscal year 2006, the U.S. government invested just $2.7 billion or 0.02 percent of GDP on its innovation programs, 28 percent less than in 1998. If the federal government were to invest the same

share of GDP in these programs as many other nations have done, it would have to invest considerably more. For example, to match Finland's outlays per dollar of GDP, the United States would have to invest $34 billion per year.[55]

Many governments also directly support applied research activities, sector-based research, and industry-university research partnerships in their efforts to directly facilitate technology development and commercialization. For example, many countries offer competitive grants to national industry consortia for sector-specific research at universities and other research institutions, effectively bringing together researchers in the private, nonprofit, and public sectors. Such programs bridge the gap between basic research at universities and the introduction of new products and processes by industry.

Case in point is Germany's Fraunhofer Institutes, which undertake applied research of direct utility to private and public enterprise and of wide benefit to society. Whereas Germany's Max-Planck Institutes (like U.S. national laboratories) perform basic research wholly funded by government, Germany's fifty-nine Fraunhofer Institutes—funded 70 percent by industry and 30 percent by state and federal government—perform applied research that translates technologies into commercializable products.[56] The Fraunhofer Institutes, with an annual research budget of $2.35 billion, conduct industrially relevant cutting-edge research into a wide variety of sectors and technology platforms, including advanced machining, optics, robotics, microelectromechanical systems, nanotechnology, wireless technologies, and many others.[57] All firms in the country can avail themselves of these shared ecosystem support networks, participating in research programs to develop their capabilities and expertise in these functions and sectors. The German government also sponsors seventeen projects in industries including environmental technologies, medical technology, life sciences, information and communications technology (ICT), and transportation in collaboration with international partners to develop new research clusters in Germany. In addition, Germany's government is providing a total of €1.1 billion ($1.4 billion) over ten years to applied research on automotive electronics, lithium-ion batteries, lightweight construction, and other automotive applications.[58]

This is one reason why Germany still runs a manufacturing trade surplus, even though compensation for German manufacturing workers is almost 40 percent higher than for American manufacturing workers. Moreover, when the governments of Germany, Japan, and Korea are directly supporting their automotive sectors (and other industries) with hundreds of millions in research funding for the development of cutting-edge technologies like advanced batteries, it's increasingly difficult for American firms, not receiving such coordinated support, to simply "go out in the market" alone and compete against foreign rivals. While neoclassical economists persist in romanticizing a stylized view that companies compete as individual profit maximizing actors in international markets, the reality is that U.S. firms are increasingly running up against companies from other countries that are the beneficiaries of thoughtful and strategic government-funded advanced research programs into critical technologies that help their private sectors compete more effectively.

Like Germany, Finland, and others, the U.K. Technology Strategy Board's Innovation Platforms program has identified key sectors of technology development for the U.K. economy, including intelligent transportation systems, network security, low-carbon vehicles, assisted living, and low-environmental-impact buildings.[59] In addition to high-tech and engineering sectors, the Technology Strategy Board also targets knowledge-intensive industries such as the creative and financial service sectors as key pillars of the British economy.

Supporting the innovation capabilities of their SMEs, especially in manufacturing, is a core component of most countries' innovation strategies. At least a dozen countries operate extension services whose goal is to boost the productivity, innovation, and export capacity of their SME manufacturers.[60] For example, Canada's Industrial Research Assistance Program (IRAP), Japan's Kohsetsushi Centers, the United States' Manufacturing Extension Partnership (MEP), and the United Kingdom's Manufacturing Advisory Service (MAS) teach SME manufacturers lean manufacturing, Six Sigma, and quality techniques, as well as innovation and new product development skills, while also encouraging private-sector technology adoption. In several countries, including Austria, Australia, Canada,

and Germany, similar programs also provide direct funding support for R&D, innovation, and new product development activities. However, other countries more aggressively fund these programs than the United States: Japan's Kohsetsushi Centers receive a share of GDP thirty times larger than what the U.S. MEP program receives, while Canada's IRAP program receives ten times more as a share of GDP than the U.S. program.[61]

Several countries, including Austria, Canada, Belgium, Denmark, Germany, the Netherlands, Ireland, and Sweden, have begun using Innovation Vouchers to support SMEs. These vouchers, usually ranging in value from $5,000 to $30,000, enable SMEs to "buy" expertise from universities, national laboratories, or public research institutes. The intent is to provide incentives for research institutes to be responsive to the needs of SMEs and to stimulate knowledge transfer, whether assisting SMEs with particular technical research challenges or helping them implement improved innovation systems. For example, Austria's *Innovationsscheck* (Innovation Voucher) is designed to help SMEs start with continuous research and innovation activities. SMEs receive a $7,000 voucher for a cooperation project with a research institution for preparatory studies, analysis of technology transfer, or analysis of the innovation potential of a new technology. Holland's innovation agency, Senter Novem, has found that the program substantially stimulates innovation—eight out of ten vouchers issued resulted in an innovation that otherwise would not have come to fruition and 80 percent of new R&D jobs created in Holland since 2005 are attributable to the vouchers.[62] Likewise, a 2011 review of the Austrian *Innovationsscheck* found it to be "a very useful program" that engendered positive networking effects between SMEs and research institutions and through which approximately five hundred SMEs had started an R&D effort.[63]

Information Technology

From iPads to search engines to e-commerce, IT is the principal source of innovation today. But IT also plays an increasingly vital role in driving productivity and facilitating the innovation process. For instance, 32 percent of EU companies report having innovated, with IT enabling half of the product innovations and 75 percent of the process innovations.[64]

Recognizing that smart IT policies can spur the digital transformation of their economies and societies, many countries have implemented specific IT policies. For example, Japan's New IT Reform Strategy, launched in January 2006, set a goal of making Japan "the front-runner in the world's IT revolution" and sought "to complete the IT reformation by 2010 before other countries and to create a society in which all people feel the benefits of IT." This New IT Reform Strategy focused on the application of IT to key sectors, including medical services, the environment, safety and security, transportation (intelligent transportation systems [ITS]), and e-government. In July 2009, Japan announced its successor i-Japan 2015 strategy, which seeks to make Japan "a smart ubiquitous network society by 2015." I-Japan keeps the focus on sectorial transformation through IT (particularly in e-government, health care, and education), but also sets a goal of "establishing broadband infrastructure with 1 gigabit per second (Gbps) for fixed and over 100 megabytes per second (Mbps) for mobile." According to Japan's Ministry of Internal Affairs and Communications, Japan's IT industry contributed 34 percent of the country's economic growth during 2006–2010.[65]

In 2004, Korea launched its IT 8.3.9 Information Technology Development strategy, which identified eight key services areas, three telecommunications infrastructures (ubiquitous next-generation wired and wireless broadband networks, ubiquitous sensor networks, and implementation of the IPv6 next-generation Internet protocol), and nine IT product areas in which Korea sought world leadership. Korea has since articulated a "Ubiquitous Society" vision that will allow citizens to use computers or mobile devices anytime, anywhere. The nation has invested heavily in this area, by one estimate $1 billion in e-government alone between 2003 and 2007, directly saving more than $1 billion and increasing economic activity by $16 billion through more efficient government procurement, trade, and construction.[66] Further, Korea has enacted policies to spur upgrade of its broadband networks to 1 Gbps. Korea also has implemented policies to support deployment of an Ultra-broadband Smart Network and a Ubiquitous Sensor Network (IP-USN).[67]

Likewise, Singapore has implemented a national IT strategy. Intelligent Nation 2015 (iN2015) is Singapore's ten-year IT master plan, led by the

Infocomm Development Authority of Singapore and designed to help the country maximize the potential of IT. Following the country's previous IT master plans, including InfoComm 21 (2000 to 2003) and Connected Singapore (2003 to 2006), iN2015 contemplates national strategies for the deployment of critical digital infrastructure platforms, including ITS, contactless mobile payments for both smart cards and mobile phones, health IT, and digital signatures.[68] It also includes a substantial investment in high-speed networks, including the all-fiber Next Gen Nationwide Broadband Network (NGNBN) with speeds of 1 Gbps and a ubiquitous wireless network, Wireless@SG.[69] Singapore expects coverage of the fiber-based NGNBN to reach 95 percent nationwide by mid-2012.[70]

In the United Kingdom, the "Digital Britain" initiative, crafted in January 2009, called for upgrades to wired and wireless networks and communication infrastructure; universal broadband coverage; promoting investments and innovation in digital content, applications, and services; and developing the nation's digital skills. It also reaffirmed the United Kingdom's commitment to protecting IP, noting the importance of this to domestic creative-content industries. To support digital innovation, the United Kingdom plans to invest more than £120 million ($162 million) over three years in its digital economy research programs.[71]

In March 2010, the United States finally got in the game, releasing its National Broadband Plan. It represents "a plan for use of broadband infrastructure and services in advancing consumer welfare, civic participation, public safety and homeland security, community development, health care delivery, energy independence and efficiency, education, worker training, private-sector investment, entrepreneurial activity, job creation and economic growth, and other national purposes."[72] The 2009 U.S. economic stimulus package allocated $7.2 billion for expansion of broadband access. But compare that amount to other countries, such as Sweden, which provided more than $800 million, including tax incentives, to spur broadband deployment, particularly in rural areas. For the U.S. government to match this investment at the same share of GDP, it would need to invest more than $30 billion.[73]

Many countries leverage IT to drive innovation in specific segments of their economies, such as health care. Denmark, for example, has shown early and continuous efforts in developing and revising its national health

IT strategy.[74] Denmark's first national e-health plan began in 1994, when the Danish Ministry of Research published objectives for developing an "information society" by 2000. Denmark's Ministry of Health followed up on this publication by developing an "Action Plan for Electronic Health Records" (EHRs) in 1996 and creating a parallel effort in 2000 by outlining a national strategy for health IT use in hospitals. In 2003, the ministry launched a national effort focused on using IT to directly improve health-care service. In 2007, a new cross-governmental organization was formed to ensure a consistent national strategy on health IT that emphasized a stronger role for the national government.

Like Denmark, Finland was early in establishing a national strategy for health IT adoption. In 1996, Finland's Ministry of Social Affairs and Health established the first strategy focused on using IT to create a more integrated, patient-focused health-care system. The government revised the strategy in 1998 to target specific goals for health IT, including an EHR for every patient, interoperability with legacy systems, and high levels of security and privacy.[75] Since 1998, Finland has launched a number of initiatives to further adoption of health IT, one being to move toward the goal of nationwide EHR adoption by 2007. The initial priority of the Finnish e-health strategy was to implement tools for health-care providers, such as sharing patients' information, and the secondary priority was to develop e-health services for citizens.[76]

Do Countries' Innovation Policies Work?

The countries at the frontiers of innovation shift dynamically—and have, in fact, changed considerably during the past quarter century. Professors Jeffrey Furman and Richard Hayes assessed changes in the national innovation capacity of twenty-three countries from 1978 to 1999.[77] Starting in 1979, they classify countries as either world-leading innovators (like the United States, Germany, and Japan), middle-tier (like Britain, France, and Australia), third-tier (like Spain and Italy), or "emerging" innovators (like Ireland and Taiwan) based on countries' patenting activity per capita (a proxy for commercialized innovations). Their analysis correlates changes in countries' national innovation policies with their innovative productivity during the two-decade period.

Furman and Hayes found that although a gap in innovative activity remains between the world's most innovative economies and other innovator countries, it has decreased substantially. Moreover, the set of countries that generates numerous new-to-the-world innovations has expanded significantly, as a number of formerly industrializing countries dramatically increased their levels of innovative productivity. A number of these "emerging innovators"—Ireland, Finland, Singapore, 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—notably Britain, France, and Italy—whose economic conditions started off much more favorably in the early 1980s.

These late-innovating countries accelerated their growth rates by both adopting technologies from leader countries and leapfrogging them by developing institutions that dealt with emerging challenges more effectively than nations bogged down in an older economic order. Furman and Hayes conclude that innovation leadership among countries requires not only the development of innovation-enhancing policies and infrastructure (including 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. They observe that these "once follower" countries now lead the world in developing—and funding—integrated national innovation policies that seek to tip the global economic playing field in favor of their domestic industries and corporations. While several of these countries are admittedly smaller and have the advantage of more easily generating the political will to implement aggressive innovation policies, many larger countries—notably Germany, Canada, Japan, and the United Kingdom—have studied these once-follower countries and started to implement similar approaches. As Furman and Hayes found, a country's innovation policies can have a significant impact in its standing in the race for global innovation advantage.

Other research has reached similar findings. As Richard Lipsey, Kenneth Carlaw, and Clifford Bekar write in *Economic Transformations*, "when specific needs and major externalities can be identified, and when capture and other pitfalls can be avoided," a country's innovation policies "can provide effective assistance to specific technologies, industries, and even firms." The authors cite a number of programs, including Canada's Industrial Research Assistance Program and the Defense Industry Productivity Program, as well as U.S. initiatives such as the Defense Advanced Research Projects Agency (DARPA), "that seem to have worked for some period of time."[78]

A 2009 study by the German Association of Chambers of Industry and Commerce illustrates the power of countries implementing effective innovation strategies, finding that about 30 percent of all German companies attributed their innovations "to improved research and innovation policies at the federal level."[79] Likewise, a 2011 review of the Swedish national innovation system found that its adaptation and performance had been quite successful during the previous fifteen years and attributed much of this success to Sweden's effective innovation policies.[80] Indeed, constantly measuring the success of a country's innovation policy in order to identify strengths, weaknesses, gaps, and opportunities for improvement is essential for innovation policy to succeed. As the *European Innovation Progress Report 2009* notes, "By linking investment in innovation clearly to productivity improvement," the *UK Innovation Index* "underscores the central importance of innovation to economic growth." Likewise, the *European Innovation Progress Report* concluded that "a major success element for Finland is a strategic policy review of its science, technology, and innovation policy, drawn up by the Science and Technology Policy Council every third year since 1987."[81]

As this chapter has explored, there are a number of constructive policies that countries can implement to accelerate their innovation-based growth. However, to turbocharge their climb up the innovation leaderboard, an increasing number of countries are turning to a set of mercantilist innovation policies that seek to gain unfair advantage in the global innovation competition at the direct expense of their peers, the topic to which we now turn.