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China's Innovation Policy Is a Wake-Up Call for America

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AsiaPacific

ISSUES

Analysis from the East-West Center
No. 100
May 2011

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SUMMARY In the three decades since it opened to the world economy, China has become a serious global competitor, not only in terms of price, but also technology. China's accelerating innovation efforts have been truly impressive. Patent applications by Chinese companies are up dramatically, as are R&D investments and the number of science and engineering PhD graduates. China has become one of the leading countries in science and technology publications and in high-tech industry exports. The US government believes that markets should drive innovation, while China's government emphasizes the critical role of public policy in fostering indigenous innovation. But China's innovation policy is not a threat to US leadership in science and technology. Instead, China's progress in innovation should be seen as a wake-up call for America. Both the US government and the private sector need to join forces and develop a national strategy to upgrade its own innovation system in order to cope with the challenge of China's innovation policy from a position of strength.

When China's President Hu Jintao visited the United States in January 2011, public debates focused on widespread fears that China's emerging role in high-tech industries, R&D (research and development), and innovation will challenge American leadership in the global knowledge economy. An important concern is that China's innovation policy is discriminatory; that it is used as a trade-distorting ploy against US exports of manufactured goods and services; and that it forces US companies to offshore well-paid jobs in engineering, as well as in product development and research.

Only a few years ago, China's approach to innovation hardly played a role in international economic diplomacy. With China's economic power on the rise, that has changed. Today, China's innovation policy and its perceived threat to American innovation are a hot topic in US-China economic relations, adding further to contentious disputes about exchange rates, trade, and foreign direct investment.

China's innovation policy adds to disputes about exchange rates, trade, and foreign direct investment

How serious a challenge is China's innovation push for America? While China has made considerable innovation progress—China has grown to be a serious competitor, not only on price but also on technology—this progress need not provoke fear that China's innovation is overtaking that of the United States. Rather, much of the available data strongly argues against China's innovation policy being a threat. China's rise should, instead, serve as a wake-up call for America.

Defining Innovation

The United States and China share a fundamental objective—they seek to promote innovation to enhance international competitiveness in the dramatically altered postcrisis environment. Both governments see innovation as the necessary catalyst for a sustainable recovery that will last well beyond short-term stimulus packages. As a source of sustainable economic growth, innovation ideally combines enhanced productivity with welfare gains and environment-friendly technologies. The assumption that innovation is good under all circumstances, however, is problematic. The recent global financial crisis has established beyond doubt that certain financial innovations are evidently wasteful and even destructive. The same is true for innovations that fail to address critical societal concerns with regard to climate change, health, or product safety.

So how, precisely, should "innovation" be defined? Most people think about radically new products or services, like the discovery of new drugs or the Internet. Such *radical* innovations require top scientists and engineers who work at the frontier of basic and applied research, but such technological breakthroughs are only the tip of the iceberg.

To capture the essence of innovation, a broader definition is necessary: innovation converts ideas, inventions, and discoveries into new products, services, processes, and business models.[1] It is important to emphasize that innovation is more than research and product development; that users must perceive an advantage to pay for the innovation; and that innovators are not just founders of Internet start-ups, but that they continue to play a critically important role in manufacturing, including seemingly low-tech industries like textiles or light bulbs.

In short, innovation requires complex interactions among many diverse stakeholders in geographically dispersed innovation networks.[2] Innovations also differ in the complexity of the capabilities required to foster and implement them. On a scale from high to low complexity, it is useful to examine, in addition to radical innovations, *architectural* and *incremental* innovations.[3]

Architectural innovations (like Apple's iPhone or iPad) use existing component technologies but change the way they work together. A defining characteristic is a capacity to leverage a deep understanding of market and user requirements in order to break new ground in product development. In contrast to radical innovations, architectural innovations need less science inputs and investment, but they require strong system integration and strategic marketing capabilities.

Incremental innovations, in turn, do not require substantial inputs from science, but they do require considerable skill and ingenuity to introduce continuous improvements to an existing product or process, often through reverse engineering of foreign technologies. The reverse engineering technique, used to discover the technological principles of a product or process, often involves taking apart a mechanical device, an electronic component, or a software program, and analyzing its workings in detail in order to redesign and improve them.

Finally, attempts to measure innovation typically distinguish *input* indicators like R&D investments and the number of engineers and scientists (and their shares in GDP or sales), and *output* indicators like science and technology publications, patents, and licensing fees. All of these indicators face substantial methodological problems. But these problems are well studied, and hence the above indicators are widely used as proxy measures of innovation.

Conflicting Perceptions of China's Policy

As the United States and China display fundamental differences in their levels of development and in their economic institutions, they pursue quite different approaches to innovation policy. The American consensus is that market forces and the private sector should play a primary role in innovation, while China relies much more on the government to define the strategic objectives and key parameters.

In the United States, there is a widespread expectation that further reforms of China's innovation system will "naturally" converge to a US-style market-led system. Yet, limited convergence goes hand in hand with persistent differences. China's primary concern is to develop this vast quasi-continental country as rapidly as possible, and to catch up with the productivity and income levels of the United States, the European Union, and Japan. For China's government, strengthening China's domestic innovative capacity is the key to a sustainable transformation of its economy beyond the export-oriented "Global Factory" model.

Strengthening China's domestic innovative capacity is the key to a sustainable transformation of its economy beyond the "Global Factory" model

In turn, the US government considers China's innovation policy to be discriminatory, because it "unfairly favor[s] domestic producers at the expense of foreign firms" and because of its "threat to global intellectual property protections, fair government procurement policies, market competition and the freedom of US companies to decide how and when to transfer technology."[4] And a recent report by the US Chamber of Commerce claims that China's innovation policy is "a blueprint for technology theft on a scale the world has never seen before."[5]

These complaints have led to an investigation by the US International Trade Commission (ITC).[6] During the first ITC hearing, the US Chamber argued that China's innovation policy "restricts the ability of American companies to access the market and compete in China and around the world by creating advantages for China's state-owned enterprises and state-influenced champions" and has "the potential to undermine significantly the innovative capacity of the American economy in key sectors, and, consequently, harm the competitiveness and livelihood of American business and the workers that they employ."[7]

China's leadership considers the American critique of its innovation policy to be unfair and hypocritical, and suspects that the United States is trying to contain China's rise. China's innovation policy is laid out in quite some detail in the *Medium- and Long-Term National Plan for Science and Technology Development* (MLP), issued by China's State Council in February 2006.

The MLP's defining characteristic is a focus on *indigenous innovation* to redress China's weak record of firm-level innovation in commercial technologies that offer solutions to China's fundamental development needs. The challenge, in the words of Premier Wen Jiabao, is to overcome "an irrational economic structure, the over-production of low-quality goods, low rates of returns, and increasingly severe constraints resulting from energy and other resource scarcity and severe environmental degradation."[8] China's leadership believes that innovation is necessary to upgrade its economy, so that it can raise wages and living standards. China also needs innovation to improve its international competitiveness and to catch up with incumbent global industry leaders.

Specifically, the plan calls for utilizing science and technology to lead future economic growth, especially in areas such as alternative energy sources, energy and water conservation, environment protection, and public health. The plan also calls for "leapfrogging" to research frontiers in key scientific disciplines, such as biotechnology and nanotechnology.

China's efforts to strengthen its innovation capacity should not come as a surprise. It is part and parcel of intensified global technology-centered competition. China (like the United States) has no choice but to participate in a global "innovation arms race" in which no country dares to fall behind the others in the creation and use of new products and processes.[9]

Furthermore, innovation policy nearly everywhere has been tarred with a protectionist brush, as demonstrated in persistent trade conflicts between the United States and the European Union—for instance, in the telecommunications, aerospace, defense, and life science industries. Again, China is no exception. What distinguishes China is that the implementation of its innovation policy is still shaped by the legacy of the planned economy.

There is no doubt that the MLP contains techno-nationalist notions of self-reliance. This reflects the initial objective of Chinese policymakers—to reduce China's dependence on foreign companies' intellectual property and the resultant high patent licensing fees. For instance, the MLP states that by 2020, China should reduce its dependence on technology from other countries to 30 percent or less (down from 50 percent today, as measured by the spending on technology imports as a share of the sum of domestic R&D funding plus technology imports).

But China's MLP also states that sustained economic growth requires establishing a proper balance between domestic innovation and the use of imported technology. This signals the commitment of China's leaders to acquire the knowledge and to develop the capabilities that are necessary to solve the problems of its export-oriented development model before they become overwhelming. The plan acknowledges that for China's innovation strategy to succeed, maintaining open markets and international linkages is of critical importance.

China's definition of products that contribute to indigenous innovation and the treatment of foreign companies in China's government procurement are among the issues that are at the center of US complaints.[10] There was initially considerable concern in the international business community that China's definition of indigenous innovation products would create barriers for sales of foreign companies in the China market. Similar complaints were expressed about China's regulations on government procurement, a market that is estimated to be worth at least $90 billion.

However, possibly in response to a wave of complaints from foreign business associations, China's government has released revised draft provisions during 2010 that would make most products made by foreign companies in China eligible for accreditation as indigenous innovation products as well as for preference in government procurement. This shift toward greater pragmatism in the implementation of China's innovation policies is confirmed by executives of leading US multinationals. For instance, GE's CEO has publicly stated that China's president Hu Jintao had promised during his January 2011 US visit that foreign companies with facilities in China would be "able to compete toe-to-toe with everybody else" for government procurement.[11]

China's pragmatism reflects the importance of collaboration and alliances with leading foreign companies to gain access to the latest technology. Liu Xielin, who has played an important role in advising the government on the MLP, argues that without such international cooperation, "catching-up is almost impossible."[12] This position is supported by leading Chinese high-tech firms which have accumulated a critical mass of intellectual property rights and are expanding into global markets. But there are also countervailing forces who seek to slow down these adjustments, especially in China's security and military establishment. In these circles, a muscular policy of techno-nationalism is viewed as a necessary protection against perceived attempts by the United States to slow down China's rise as a regional power.

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It is difficult for outsiders to assess which of these conflicting positions has greater leverage in shaping decisions on China's innovation policy. While there are signs of a hardening of China's internal security policies, there are also indications that China's deep integration into the global economy is shifting the balance of power toward greater pragmatism.

China's Evolving Innovative Capabilities

Does China's innovation policy strengthen or constrain the country's innovation capacity? In a 2005 article that has been widely quoted, economists Anne Stevenson-Yang and Ken DeWoskin argued that in its efforts to create Chinese intellectual property, China's innovation policy "actually obstructs the path to market of inventions that are blooming in laboratories and start-up companies all over the country. That's because these conflict with the commercial interests of politically supported state companies that innovate far less than private, entrepreneurial ones."[13] Recent research, however, comes to a more positive assessment. Drawing on data on R&D investments and the number of engineers and scientists, the Battelle Memorial Institute (a provider of such data), argues that China's innovation policy is highly effective: "From an R&D standpoint, it's very difficult to find fault or weaknesses in any of the policies China is pursuing."[14]

A sustained commitment to a rapid expansion of R&D sets China apart from the crisis-induced cuts in the United States and Europe

Since 2000, China has made massive investments in R&D infrastructure "on a scale and speed never seen before."[15] China has increased R&D spending roughly 10 percent each year—a pace the country maintained even during the 2008–2009 recession. This sustained commitment to a rapid expansion of R&D sets China apart from the crisis-induced cuts in the United States and Europe. China's share in global R&D spending has increased from 9.1 percent in 2008 to 12.3 percent in 2010, while the US share has declined from 35.4 to 34.4 percent. China's share is projected to grow further to 12.9 percent in 2011, overtaking Japan as the second largest R&D investor.

China's government has heavily invested in a rapid expansion of higher education and universities as centers of basic and applied research. Since 1998, the amount of GDP devoted to its expansion of education has tripled. In that period, the number of colleges has doubled and the number of students quintupled, from 1 million in 1997 to 5.5 million in 2007. "At a time when universities in Europe and state universities in the US are suffering the impact of budget cuts, China is now moving in the opposite direction."[16] An important indicator of success is that, since the early 1990s, China's domestic science and engineering doctorate awards have increased more than tenfold over the period—to about 21,000 in 2006—nearing the number of science and engineering doctorates awarded in the United States.[17]

In addition, China's government now seeks to repair some of the qualitative problems that have accompanied this massive increase of university graduates. For instance, exchange programs between universities and industry (both Chinese and foreign) help to reduce the mismatch between curricula and required skills that have given rise to graduate unemployment. And international cooperation with leading universities (including the exchange of faculty and students) is used to improve the quality of teaching and postgraduate education.

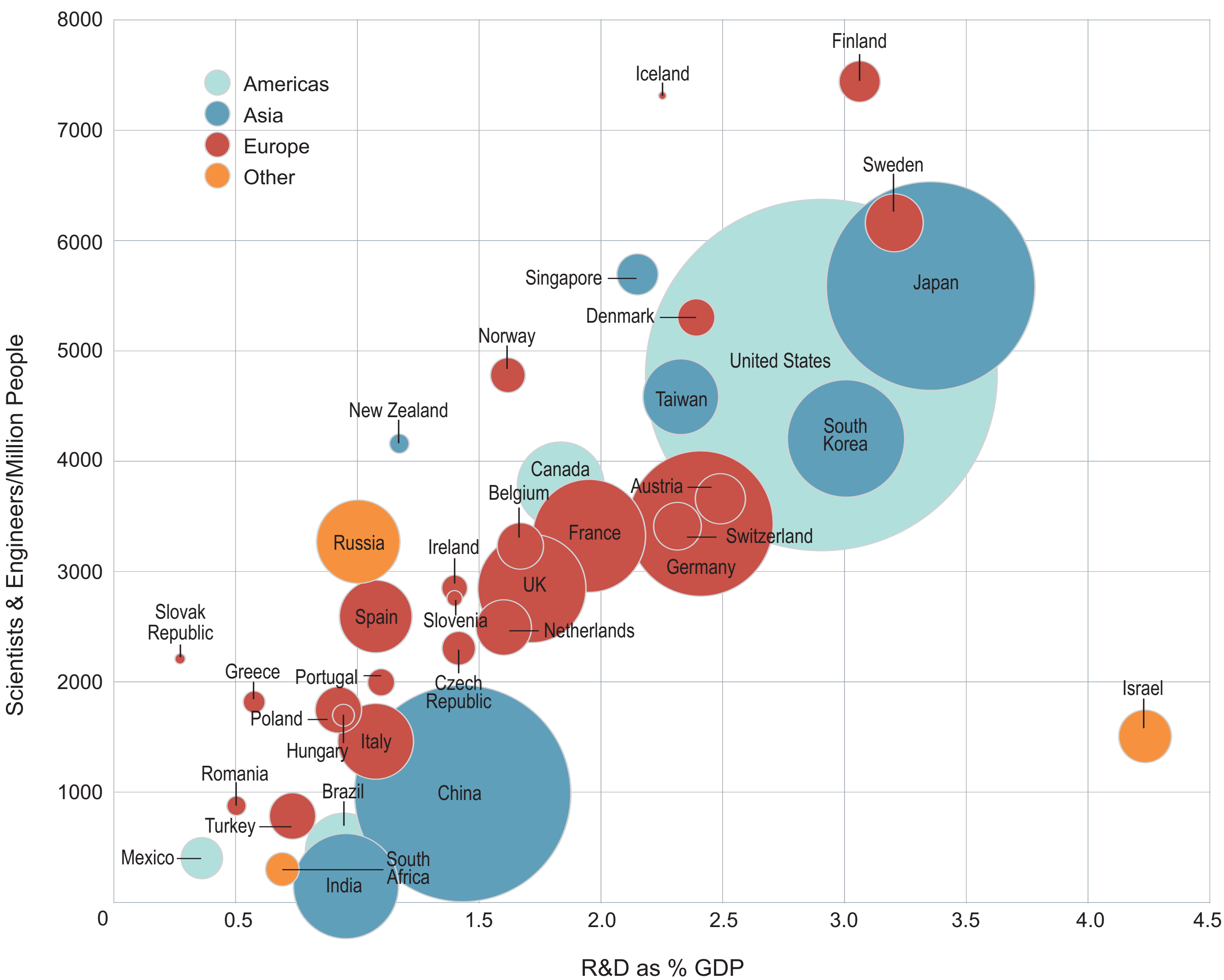
Research on output indicators comes to equally positive assessments. Drawing on its World Patents database, Thomson Reuters reports that China's patent market is booming. From 2003 to 2007, Chinese invention patent applications grew at an average of 28.4 percent per year, far outpacing China's GDP average annual growth rate of 9.75 percent.[18] In terms of total patenting activity, China has overtaken Korea and Europe, and is catching up with the United States and Japan.[19]

China's patent boom. Does China's patent boom reflect domestic innovation? In fact, domestic patent applications by Chinese nationals have overtaken foreign applications since 2003. In 2009, Chinese nationals accounted for nearly 90 percent of the 976,686 patent applications in China. This indicates that China's innovation policy has been successful, at least in quantitative terms.

But what about the quality of the patents generated by Chinese residents? Does China's innovation policy create incentives to produce a large number of low-value patents? A Shanghai-based patent attorney argues that "patents are easy to file, but gems are hard to find in a mountain of junk."[20] And SIPO, China's patent office, reports that only 26 percent of resident applications in China are for *invention* patents, which overwhelmingly dominate foreign applications. In turn, nearly three quarters of resident applications in China are for *utility model* and *industrial design* patents.

Some observers consider utility model patents as "junk."[21] However, innovation economists have emphasized that utility model patents have played an important role in fostering earlier catching-up processes in Germany, Japan, Korea, and Taiwan.[22] China's utility model patents protect any new technical solution relating to the shape and/or structure of a product, which is fit for practical use. Utility patents offer the same protection (albeit for a shorter time span) as invention patents. But they are quicker and cheaper to obtain since a utility model receives only preliminary examination rather than the full substantive examination of an invention application.

World of R&D 2010.
Size of circle reflects the relative amount of annual R&D spending by the country noted.



Source: Battelle, *R&D Magazine*, OECD, IMF, CIA
Adapted from the *2011 Global R&D Funding Forecast*, *R&D Magazine*, December 2010, www.rdmag.com.

Utility model patents facilitate low-budget forms of innovation

For products with a relatively short lifecycle such as electronics or communications devices, utility model protection offers Chinese firms an advantage because they can claim prior art more quickly than their foreign competitors who typically rely on formal invention patents. In essence, utility model patents facilitate low-budget forms of innovation (such as reverse engineering and incremental innovation), and hence are of great importance for smaller Chinese firms. One example of this type of successful low-cost innovations are no-name *shanzhai* (unlicensed) handsets that are estimated to have at least a 40 percent share of the Chinese handset market.[23]

What do we know about more demanding types of innovation? Disaggregated patent analysis for specific technologies and for specific companies indicate much more focused efforts to improve the quality of the domestically generated patent portfolios, and to be more selective and realistic in the choice of priorities. An example is Huawei, China's leading telecommunications equipment vendor that is now the third largest global supplier.

With 42,623 so-called patent cooperation treaty (PCT) applications (most of them submitted over the last few years), Huawei is now the second largest applicant at the World Intellectual Property Office (WIPO).[24] A broad portfolio of *essential patents* in important technologies (such as next-generation mobile communications and convergence of fixed and mobile networks) has established this company as a serious player in the development of architectural and radical innovations. Essential patents are frequently quoted in other patent filings, and hence shape technology trajectories. (Patents are also called essential when it is not possible to comply with an international standard without infringing those patents.)

Arguably of greatest importance is Huawei's focus on customer-centric innovation which implies that the service delivery platforms requested by the telecommunications operators define Huawei's choice of R&D priorities. This close interaction with the leading telecommunications operators is reflected in Huawei's global innovation network and provides assurance that key customers are willing to pay for Huawei's innovations.[25]

Other markers of innovation progress. Another indicator of China's rapidly improving innovation capacity is that China is now one of the four leading countries in science and technology publications, with particular strengths in materials science, analytical chemistry, rice genomics, and stem-cell biology.[26] Within materials science, China is especially strong in nanotechnology, ranking third (after the United States and Japan) in the number of nanotechnology publications, and the Chinese Academy of Science is ranked fourth for nano-science citations (after University of California, Berkeley; MIT; and IBM).

Additionally, China is ranked among the top five global R&D leaders in leading high-tech industries such as energy (both nuclear and renewable), satellite and spacecraft, commercial aircraft, automotive (especially electric cars), supercomputers, and life sciences (especially genetics), and it is rapidly catching up in high-speed rail, information and communications technology, and defense and security.

China now has the world's fastest supercomputer at the National Supercomputing Center in Tianjin that not only has greater computing capacity than the second-ranked US Department of Energy Oak Ridge National Laboratory, but it also consumes considerably less energy. The Tianjin supercomputer is an excellent example of architectural innovation—it uses existing component technology (i.e., energy-saving graphic processors supplied by Nvidia, a chip design company based in Santa Clara, California), but the Chinese engineers have changed the way these processors work together so that energy consumption is further reduced. In the context of defense and security, the test flight of China's next-generation stealth fighter in January 2011 "represents an important marker in the accelerating development of China's defense science, technology, and innovation capabilities."[27]

And yet, the gap persists. China's speed of upgrading its innovation capacity is impressive. But barriers to innovation in China remain substantial, ranging from severe quality problems in education to plagiarism in science, and barriers to entrepreneurship and private R&D investment. Moreover, as the following indicators demonstrate, China still has a long way to go to close the innovation gap with America, as well with the European Union and Japan. Even if one would make the heroic assumption that the United States and China would keep investing at the current rates, it would "take China 20 years to reach the US level. But that may be unlikely. China has many other demands on its capital, while the US R&D growth is currently at unusually low levels. Moreover, wages in China…keep rising, which will eventually reduce… [China's] cost advantages in the performance of R&D."[28]

Leading Chinese firms continue to trail global US industry leaders—there are no Chinese companies among the top 20 global R&D spenders

The following 2010 data on R&D investments in the information technology industry document that leading Chinese firms continue to trail global US industry leaders. There are no Chinese companies among the top 20 global R&D spenders, where Microsoft leads with $9.010 billion, followed by Nokia ($8.240 billion), Samsung ($6.002 billion), IBM ($5.820 billion), Intel ($5.653 billion), and Cisco ($5.208 billion). China's Huawei and ZTE are way behind with $2.030 billion and $845,000 2010 R&D investments, respectively.[29]

Furthermore, ownership of the worldwide stock of intellectual property remains highly concentrated. Of the roughly 6.7 million patents in force in 2008, residents of Japan (with a stock of 1.85 million patents) and the United States (1.35 million patents) owned around 48 percent of the total. China (with a stock of 134,000 patents) owned just 2 percent of the total. In addition, 95 percent of these China-owned patents are in force in China only.[30] The persistent dominance of the established innovation centers in the United States and other industrialized countries is documented by the following indicators: all 15 leading companies with the best record on patent citations are based in the United States (9 in the IT industry); and more than 80 percent of the 700 largest R&D spenders come from only five countries (United States dominates, followed by Japan, Germany, United Kingdom, and France).

Finally, while China has substantially improved the relative strength and depth of its innovation system, the figure on page 6 provides a graphic reminder of the steep challenge that China is facing in the future.

America's Challenge

The United States is still way ahead in overall innovation capacity, and fears of China's threat are exaggerated. US policy debates should instead focus on a more fundamental question: How can we build on existing strengths to upgrade America's innovation system?

There is little doubt that places like Silicon Valley and Route 128, US hotbeds of innovation, remain among the best places to be for high-risk, knowledge-intensive innovation activities. This is because such locations typically include a broad portfolio of support services—including legal, finance, and property development—that facilitate rapid adjustments of business models to changing requirements of markets and technology. These are also privileged places to collect strategic market intelligence from the most demanding lead users. Additional strengths of the US innovation system include (1) the presence of the world's leading research universities, (2) an unrivaled exposure to leading-edge management practices for R&D projects, and (3) a high mobility of knowledge workers that facilitates quick and relatively hassle-free knowledge diffusion.

However, there is also a growing recognition that "the United States cannot sit idly by and merely observe the rise of new technology powers. Instead, [the US government] must help shape the institutions and networks that promote and support science and technology in a globalized world."[31] The United States needs a "new national innovation strategy" to cope with the challenge of China's innovation policy from a position of strength.[32] Both the US government and the private sector need to join forces and develop a national strategy to enhance the country's innovative capacity and to create well-paying jobs in research, product development, and engineering.

This upgrade is necessary so that American firms can reap ample opportunities for cooperation with China. Chinese firms will continue to need access to American innovations across a broad spectrum of industries and services. China's innovation push thus will create new markets for American firms, provided they stay ahead on the innovation curve.

China's innovation push will create new markets for American firms, provided they stay ahead on the innovation curve

Many reports have identified key priority areas that need change.[33] This includes overdue improvements in the US education system, so that students are encouraged to study science and technology and to acquire complementary management, interpretative, cross-cultural, and other "soft" capabilities.[34] Equally important is a realignment of fiscal incentives to spur early-stage investments in new technologies like low-carbon energy, and reforms in the financial system to improve allocation of capital and create space for patent innovation funds.

According to William Brody—then president of Johns Hopkins University and cochair of the US Council on Competitiveness's National Innovation Initiative—the United States is facing a serious challenge: "We are losing our collective will to fund basic research…[which] has failed to demonstrate a return on investment that satisfies the ravenous appetite of financial markets for short-term earnings growth."[35] After the global financial crisis of 2008, there is an even greater need for policies that facilitate the supply of patient innovation investment funding.

Yet, barriers to and disincentives for innovation in the United States remain aplenty. For instance, a major challenge to the US innovation system is that federally funded R&D has been under tremendous pressure since the November 2010 midterm elections, while a severe fiscal crisis forces states and local governments to drastically reduce their R&D funding. This matters as US companies are increasingly relying on the federal government and on universities and federal laboratories for their innovations.[36]

In addition, as US companies need to please their investors and their ever increasing return-on-investment requirements, they are prone to offshore not only manufacturing but also engineering, new product development, and research. Following this purely financial logic, American companies tend to sign short-sighted agreements in China that are harmful over the long term in order to generate sales during the current or next quarter.

China's innovation policy and its considerable achievements should serve as a wake-up call for America to mobilize the combined forces of private industry and government to upgrade its own innovation system. "The only sane course at the end of the day is: Wake up, pull together your public and private resources, and compete. Don't demonize or underestimate or overestimate your competitor."[37] As "the US has very little leverage over Chinese government policy, it makes more sense for the US to think about what its own response should be than to expend lots of energy trying to change Chinese policy."[38]

The real threat for America are self-destructive forces of an economic system that has relied excessively on presumably self-regulating markets. Corrective action needs to start now, but there is still time to adjust policies and corporate strategies to the new challenges of an increasingly multipolar global knowledge economy.

Notes

[1] Important sources of innovation theory include J. Schumpeter, *Business Cycles: A Theoretical, Historical, and Statistical Analysis of the Capitalist Process*, 2 vols. (New York: McGraw-Hill, 1939); P.F. Drucker, *Innovation and Entrepreneurship: Practice and Principles* (Oxford: Butterworth-Heineman, 1985); R.R. Nelson and S.G. Winter*, An Evolutionary Theory of Economic Change* (Cambridge, MA: The Belknap Press, 1982); W.B. Arthur, *The Nature of Technology: What It Is and How It Evolves* (New York: Free Press, 2009).

[2] D. Ernst, "The New Mobility of Knowledge: Digital Information Systems and Global Flagship Networks," in *Digital Formations: IT and New Architectures in the Global Realm*, ed. R. Latham and S. Sassen (Princeton, NJ: Princeton University Press, 2005).

[3] This taxonomy of innovation was originally developed by R.M. Henderson and K.B. Clark in "Architectural Innovation: The Reconfiguration of Existing Systems and the Failure of Established Firms," *Administrative Science Quarterly* (March 1990) 9–30. For an application of this taxonomy to the study of Asian innovation strategies, see D. Ernst, *A New Geography of Knowledge in the Electronics Industry? Asia's Role in Global Innovation Networks*, Policy Studies, no. 54 (Honolulu: East-West Center, 2009).

[4] Demetrios Marantis, Deputy US Trade Representative, quoted in Doug Palmer, "UPDATE 2-China Trade Behavior Imperils Ties —USTR," Reuters, July 15, 2010, http://www.reuters.com/assets/print?aid=USN1520929420100715.

[5] J. McGregor, *China's Drive for "Indigenous Innovation": A Web of Industrial Policies*, report commissioned by US Chamber of Commerce (2010), 4, http://www.uschamber.com/reports/chinas-drive-indigenous-innovation-web-industrial-policies.

[6] This has culminated in the published study *China: Intellectual Property Infringement, Indigenous Innovation Policies, and Frameworks for Measuring the Effects on the US Economy*, Investigation No. 332-514, USITC Publication 4199 (Washington, DC: US International Trade Commission, November 2010).

[7] Testimony by Jeremi Waterman, Senior Director, Greater China at the US Chamber of Commerce before the US International Trade Commission hearing *China: Intellectual Property Infringement, Indigenous Innovation Policies, and Frameworks for Measuring the Effects on the US Economy*, Investigations No. 332-514 and 332-519, June 15, 2010.

[8] Wen Jiabao, Speech at the National Science and Technology Conference, Beijing, January 9, 2006. Quoted in *China Daily*, January 10, 2006.

[9] For an American perspective, see W. Baumol, *The Free-Market Innovation Machine: Analyzing the Growth Miracle of Capitalism* (Princeton, NJ: Princeton University Press, 2004). How globalization shapes China's innovation policy is analyzed in E. Steinfeld, *Playing Our Game: Why China's Economic Rise Doesn't Threaten the West* (Oxford: Oxford University Press, 2010).

[10] For a detailed analysis, see D. Ernst, *Indigenous Innovation and Globalization: The Challenge for China's Standardization Strategy*, a forthcoming IGCC Occasional Paper copublished by the University of California Institute on Global Conflict and Cooperation (IGCC) and the East-West Center, especially chapter four.

[11] Quoted in "Immelt Confident of Solid Sales Growth for GE's China Ventures," *Financial Times*, January 21, 2011.

[12] Liu Xielin, "Path-Following or Leapfrogging in Catching-Up: The Case of Chinese Telecommunications Equipment Industry," CIRCLE Electronic Working Paper Series, no. 2007/01 (Lund, Sweden: Lund University, 2007), 23, http://www.circle.lu.se/publications.

[13] Anne Stevenson-Yang and Ken DeWoskin, "China Destroys the IP Paradigm," *Far Eastern Economic Review* (March 2005), 10.

[14] Battelle, *2010 Global R&D Funding Forecast* (R&D Magazine, December 2009), 23, http://www.battelle.org/aboutus/rd/2010.pdf.

[15] Battelle, *2011 Global R&D Funding Forecast* (R&D Magazine, December 2010), 28, http://www.battelle.org/aboutus/rd/2011.pdf.

[16] Battelle, *2010 Global R&D Funding Forecast*, 28.

[17] National Science Board, "Global Higher Education and Workforce Trends," in *Science and Engineering Indicators 2010*, NSB 10-01 (Arlington, VA: National Science Foundation, 2010), http://www.nsf.gov/statistics/seind10/c0/c0s4.htm.

[18] E.Y. Zhou and B. Stembridge, *Patented in China: The Present and Future State of Innovation in China* (Thomson Reuters, 2010) 3, http://ip.thomsonreuters.com/chinapatents2010/China_Report_0810.pdf.

[19] WIPO, *World Intellectual Property Indicators, 2010 Edition* (Geneva: World Intellectual Property Organization, 2010).

[20] Quoted in "Innovation in China: Patents, Yes; Ideas, Maybe," *Economist* (October 14, 2010), 79.

[21] McGregor, *China's Drive*, 27.

[22] H. Odagiri, A. Goto, A. Sunami, and R.R. Nelson, eds., *Intellectual Property Rights, Development and Catch-Up* (Oxford: Oxford University Press, 2010).

[23] Literally "mountain village" or "mountain stronghold," the term *shanzhai* (山寨机) refers to the mountain stockades of regional warlords or bandits, far away from official control.

[24] The Patent Cooperation Treaty (PCT) provides a unified procedure for filing patent applications with WIPO to protect inventions in each of its contracting states.

[25] Huawei's global innovation network includes, in addition to six R&D centers in China, five major overseas R&D centers in the US (including Plano, Texas, and San Jose, California), Sweden (Kista, Stockholm), Moscow, and the United Kingdom (as part of British Telecom's list of eight preferred suppliers for the overhaul of its fixed-line phone network). The company chose these R&D locations to be close to major global centers of excellence and to learn from incumbent industry leaders: Plano, Texas, is one of the leading US telecommunications clusters centered on Motorola; Kista, Stockholm, plays the same role for Ericsson and, to some degree, Nokia; and the link to British Telecom was Huawei's entry ticket into the exclusive club of leading global telecommunications operators. For details, see D. Ernst, *A New Geography of Knowledge in the Electronics Industry? Asia's Role in Global Innovation Networks*, Policy Studies, no. 54 (Honolulu: East-West Center, 2009).

[26] Thomson Reuters Web of Knowledge can be accessed at http://wokinfo.com.

[27] Tai Ming Cheung, *The J-20 Fighter Aircraft and the State of China's Defense Science, Technology, and Innovation Capabilities*, SITC Policy Brief, no.17 (San Diego, CA: University of California Institute of Global Conflict and Cooperation, January 2011).

[28] Battelle, *2010 Global R&D Funding Forecast*, 24.

[29] Note however that these two Chinese companies are in the group of companies with the fastest R&D growth in 2000–2009: Huawei (+29 percent growth) and ZTE (+24 percent).

[30] WIPO, *World Intellectual Property Indicators 2010*.

[31] A. Segal, *Advantage: How American Innovation Can Overcome the Asian Challenge* (New York: W.W. Norton & Company, 2011), 14.

[32] For an early outline of this recommended strategy, see D. Ernst, *Innovation Offshoring: Asia's Emerging Role in Global Innovation Networks*, East-West Center Special Reports, no. 10 (Honolulu: East-West Center, 2006), 2, http://www.eastwestcenter.org/pubs/2006.

[33] See, for instance, Committee on Prospering in the Global Economy of the 21st Century: An Agenda for American Science and Technology; National Academy of Sciences; National Academy of Engineering; and Institute of Medicine, *Rising above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future* (Washington, DC: National Academies Press, 2007); http://www.nap.edu/catalog.php?record_id=11463; and National Science Board, *Science and Engineering Indicators 2010*.

[34] R.K. Lester and M.J. Piore, *Innovation—The Missing Dimension* (Cambridge, MA: Harvard University Press, 2004).

[35] As quoted in *Financial Times*, August 19, 2005.

[36] F. Block and M.R. Keller, "Where Do Innovations Come From? Transformations in the U.S. Economy, 1970–2006," in *State of Innovation. The U.S. Government's Role in Technology Development*, ed. F. Block and M.R. Keller (Boulder, CO: Paradigm Publishers, 2011).

[37] Email to the author, dated March 16, 2011, from Thomas Hout, former partner, Boston Consulting Group and Adjunct Senior Lecturer, Fletcher School at Tufts University.

[38] Email to the author, dated March 15, 2011, from Andrew Batson, Research Director, GaveKal Dragonomics, Beijing, and former China correspondent of the *Asia Wall Street Journal*.

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