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Assessing China's Efforts to Become an Innovation Society

A Progress Report

For many observers, while China may become a preferred global location for low value-added, commodity-based production, the United States' lead in high value-added, innovation-based production is secure. In this framing, China's emergence has led to the expansion of the global market allowing the U.S. and China to each specialize in their natural area of comparative advantage: China in commodity-based production and the United States in innovation. China, with its state-directed economy, weak intellectual property (IP) protection and limited entrepreneurship is best suited to assemble our I-Phones. America, with our superior entrepreneurial capabilities, design and market them.

While this view may have once accurately characterized both economies, it no longer does. Until the mid-2000s China actively encouraged foreign direct investment in assembly production through a vast array of incentives, many of them mercantilist in nature. But in 2006 that began to change. Chinese leaders decided that attracting commodity-based production facilities from multi-national corporations was no longer the principal goal. The path to prosperity and autonomy was now to be "indigenous innovation" (or in Chinese, zizhu chuagnxin) with Chinese firms the focus.[1] The seminal document advocating this shift was "*The Guidelines for the Implementation of the National Medium- and Long-term Program for Science and Technology Development (2006-2020).*" The so-called "MLP" sought to "create an environment for encouraging innovation independently, promote enterprises to become the main body of making technological innovation and strive to build an innovative-type country."[2] This was much more than a strategy to target some key areas where China had some preexisting capabilities. Rather, the MLP "must be made a national strategy that is implemented in all sectors, industries, and regions so as to drastically enhance the nation's competitiveness."[3] The MLP called on China to "master core technologies" in virtually every area Chinese state planners could imagine. Included were some 402 technologies, from intelligent automobiles to integrated circuits to high performance computers. Five years later it had met at least one its goals. For in 2011 China's announced that it had built the world's fastest supercomputer, taking that crown from the United States.

In short, China made a strategic decision to leapfrog its current development path to become a high-tech economy. The implications for the United States economy should be clear. The Chinese no longer want to dominate just cost-based commodity production and let us be the innovators, they want to also win in innovation-based economic competition, exactly what so many in the United States believe is America's "sweet spot" and natural comparative advantage.

While there is a broad consensus among experts on what China is trying to do, there is considerably less consensus over whether China will be successful and whether America should be concerned. Most China experts dismiss China's efforts, arguing essentially that unless China adopts the American model of innovation that it can never be truly innovative and never be a threat. But this ignores three key issues. First, even if Chinese-owned firms do not become innovation leaders, bringing "new to the world" innovations to the market, the Chinese economy may become an innovation leader if its policies result in foreign multi-nationals moving even more innovation-based activities to China. Second, even if Chinese firms won't lead in "new to the world" innovations, many appear to have the capability of being "fast followers", especially in engineering-based innovation where China is showing real strengths. Third, even if China does not succeed in transforming its economy to an innovation-based one, their rampant innovation-based mercantilist policies are already doing and will likely continue doing considerable harm to U.S. technology companies and to the U.S. innovation economy. The bottom line is that America ignores China's innovation policies and growing innovation capability at its own peril.

China would not be the first export-oriented Asian economy to embrace an industrial policy for technology markets that could significantly harm international competitors. Japan and Korea are the most conspicuous examples. In these predecessors, global market forces and determined policy responses by other countries slowly reversed the policy mix toward a slightly more open, market-oriented direction. But just as importantly, neither nation was anywhere near as large as China is (in terms of population) and therefore their mercantilist policies did less harm. Foreign firms could afford to not be in either nation (in fact in Japan, they were largely not wanted), meaning that neither nation could use market access as lever for coerced technology transfer. China is different. It is much bigger with a potential to be more disruptive to the global economy. Its fast growing market of over 1 billion consumers is just too tempting for multinationals to boycott over egregious Chinese mercantilist policies. And the leverage of the global economic community to encourage China to more in a more open, market-oriented direction is significantly less than it was with Korea and Japan. As such, China's potential rise as an innovation competitor to the U.S. economy promises to be one of the central challenges facing the U.S. economy over the next quarter of a century.

THE SHIFT TO INDIGENOUS INNOVATION

China's MLP signaled a distinct shift in China's economic policy. But lest one think that this goal was unique to the MLP, China's 11th five-year plan refined these industries and targeted sixteen "megaprojects." Three of the sixteen are deemed classified, but the other thirteen are:

- Core electronic components, high-end general use chips and basic software
- Large-scale integrated circuit manufacturing equipment and techniques
- New-generation broadband wireless mobile communication networks
- Advanced numeric-controlled machinery and basic manufacturing technology
- Large-scale oil and gas exploration
- Large advanced nuclear reactors
- Water pollution control and treatment
- Breeding new varieties of genetically modified organisms
- Pharmaceutical innovation and development
- Control and treatment of AIDS, hepatitis, and other major diseases
- Large aircraft, and
- High-definition earth observation system[4]

China's latest five-year plan (the 12th) narrowed this focus, but recommits to these goals stating, "It is necessary to comprehensively implement the state's long and mid-term programs for science and technology." In 2011, the Chinese government committed to "place the strengthening of indigenous innovative capability at the core of economic restructuring, growth model change, and national competitiveness enhancement ….Indigenous innovation refers to enhancing original innovation, integrated innovation, and re-innovation based on assimilation and absorption of imported technology, in order improve our national innovation capability."[5] The proposal for the plan goes on to stress:

> We should persist in the principle of independent innovation, making key strides, of supporting development, and of providing guidance in the future, increase commonality and capability on core technology breakthrough, and promote the transformation of sci-tech results into real productive force. There is a need to accelerate promoting the state's special major sci-tech projects and implement new knowledge-innovation and technology-innovation projects in an in-depth manner. We should closely integrate sci-tech progress with the optimization and upgrading of industrial structure and with the improvement of people's livelihood, enhance the capability of making original innovation, of integrating,

> introducing, digesting innovation, and score new breakthroughs in such areas as modern agriculture, equipment manufacturing, ecology, environmental protection, energy, resources, information network, new materials, security, and health, overcome a number of key core technologies such as core electronic components, very large scale integrated circuit, system software, new varieties of genetically modified foods, making of new drugs. We should enhance basic frontier technology research, and strive to occupy a high ground in future sci-tech competition in life sciences, marine, space, global science, and nanotechnology… We will give play to the state's leading and supporting role for special sci-tech projects, implement industrial innovation development projects, increase taxation and financial policy support, and help high technology industry to become big and strong.[6]

The plan identifies seven priority strategic emerging industries (SEIs), aiming to increase their contribution to GDP from their then current 2 percent level (2008) to 8 percent by 2015 and 15 percent by 2020. These are: 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. China's State Council first identified these industries in its "*Decision on Accelerating the Fostering and Development of New Strategic Industries*" announced in 2010. To reach this goal China will provide SEIs with preferential policies, incentives, and funds worth $1.5 trillion over the next five years.[7] For the United States to match China's commitment to their SEIs on a per-GDP basis it would have to pass the equivalent of an American Recovery and Reinvestment Act every year for five years and dedicate close to 100 percent of the funds to industry. The focus on SEIs appears to be emerging as the central organizing principle for Chinese indigenous innovation policy. The Chinese government is developing a wide range of documents to articulate detailed strategic plans for each sub-industry of the seven SEIs, with the first report focused on the Chinese medical device industry. The SEI efforts are likely to focus largely on state-owned enterprises, and use discriminatory policies including government and SOE procurement, priority patent review, tax incentives, R&D subsidies and a host of other policies to help support Chinese-owned companies in these industries.

This shift to indigenous innovation can also be seen in policies toward specific industries. For example, the Chinese have targeted aviation and hope to become self-sufficient through Chinese firms. COMAC, the state-owned Chinese commercial aircraft company, benefits from a wide array of mercantilist policies in order to foster the development of a narrow-body aircraft to compete with Boeing and Airbus.[8] COMAC's stated goal is clear: get as much foreign aviation technology as possible while seeking to develop its own "independent intellectual property rights."[9] COMAC "will commit to national and international cooperation based on the 'airframe suppliers' model to share risks and benefits, and build a system of both national and international suppliers for trunk lines, and eventually establish relatively complete service and industrial chains in the commercial airplane business."[10] In other words, the goal is to partner with some foreign suppliers to produce all kinds of airplanes, from commuter jets to wide-body, long-haul jets and to eventually produce all the supply chain inputs, including engines and advanced avionics in China through Chinese-owned companies.

In other words, China not only wants to maintain current advantages in its low value-added manufacturing (including through its refusal to allow the renminbi to appreciate other than a few percent a year) but also to gain new competitive advantage in a wide array of technology-intensive products it now imports. China's strategy for globalization is to win in almost all of the industries through its new goal of indigenous innovation. As hard as it may be for adherents of Western neoclassical economics to grasp, China doesn't want to make some things and buy others; they want to make virtually everything, especially advanced technology products and services. The result could very well be the continuation of the trend of the last

decade when the U.S. manufacturing output experienced an unprecedented decline of 11 percent at a time the overall economy grew by around 13 percent.[11]

CHINESE POLICIES AND PROGRESS TOWARD INNOVATION

China is backing up its intentions to lead in innovation through a wide array of policies. These can be classified into two types: what ITIF has termed "good" and "bad" in our report "*The Good, the Bad, the Ugly (and Self-Destructive) of Innovation Policies.*" In that report we developed a typology of nations' innovation policies, classifying them as to whether they help or hurt the country implementing them and help or hurt the rest of the world. "Good" policies helped both the nation and the world and include measures such as boosting government support for basic science and STEM education. "Bad" policies help the country (at least in the near to moderate term) but hurt the world and include practices such as intellectual property theft, standards manipulation and forced technology transfer. China is aggressively implementing both kinds of policies.

"Good" Policies"

In terms of "good" policies, China has made considerable progress. This is especially true with respect to support for science and the education of scientists and engineers, where we see dramatic progress.

- Over the past decade, Chinese R&D expenditures increased by 21 percent a year while R&D intensity (R&D to GDP ratio) increased 179 percent from 1999 to 2008.[12]
- Business R&D intensity (R&D to GDP ratio) now surpasses EU-15 levels.[13] In other words, there is more R&D investment in China as a share of its GDP than in the EU-15 countries (e.g. France, Spain, United Kingdom, etc.)
- As a result, China ranks second to the United States in total investment in R&D.
- First university degrees in natural science and engineering increased from 280,000 in 2000 to 1 million in 2008.
- China produces more engineering bachelors' degrees than Japan, South Korea, United States, Taiwan, France and Germany combined, and almost twice as many doctorates of engineering as the United States.[14]
- The number of science and engineering researchers in China doubled between 2000 and 2009.
- China ranks second behind the United States in the output of scientific and technical scholarly journal articles.

"Bad" Policies

The Chinese are not content with gradually building up their innovation capabilities, they want to jump start these, in part through bold and robust national investments, but also through a vast array of unfair, innovation mercantilist policies. ITIF documented many of these policies I n its report "*Enough is Enough: Confronting Chinese Innovation Mercantilism.*" Some are briefly described here.

Government procurement focused on forced technology transfer. In 2007 China rolled out its "indigenous innovation product accreditation" scheme—a list of products invented and produced in China that would receive preferences in Chinese government procurement.[15] To be eligible for preferences, products would have

to contain Chinese proprietary intellectual property rights. The central government stated that it would "delink" product catalogues and innovation and tell the provinces to do so as well, but it appears unlikely that this will actually happen in practice. What will change is that the discrimination will be done surreptitiously.

Market Access Tied to Forced Transfer Technology: In the *Catalogue for the Guidance of Foreign Investment Industries (2007)* joint ventures with foreign firms have to be approved, and technology transfer agreements reached within joint venture contracts must also be submitted for approval. The guidelines encourage transfer of technology.[16] Sometimes this process takes the form of mandatory licensing of technology. Sometimes this is in the form of requirements to establish R&D facilities where the technology often "goes out the back door" in the form of Chinese researchers who leave to take the technology to Chinese firms.

Weak and Discriminatory Patent System: The global patent system means that companies that file inventions first have protection from copying. The Chinese patent system is designed to get around this restriction. Under the Chinese patent system, it is extremely easy for a Chinese firm to be granted "utility model and design patents" (as distinct from invention patents that are more akin to U.S. patents). In 2009 these "junk patents" constituted approximately three-quarters of Chinese patents issued to Chinese-owned firms.[17] This weak patent system makes it easy for Chinese firms to countersue in response to infringement suits by foreign competitors. In addition, until the Chinese government rescinded its indigenous innovation product catalogues, it intended to "give support to enterprises that develop the technology and products listed in the catalogue in the application for a patent."[18] In other words, it would have been easier to get a patent if the firm filed to protect a technology the government has identified.

IP Theft: The U.S. International Trade Commission estimates that—in 2009 alone—Chinese theft of U.S. intellectual property cost almost one million U.S. jobs and caused $48 billion in U.S. economic losses.[19] Many in China even view piracy as simply a different kind of business model. There's the make/buy IP business model, and the "steal IP" business model. Both are seen as legitimate. In an article in the *Journal of Science and Technology Policy in China,* edited by the Chinese Academy of Sciences, Sheng Zhu and Yongjiang Shi write about how the cell phone "cluster" in Shenzhen called Shanzhai is "turning to the Shanzhai ethos, starting with producing counterfeited mobile phones to rebel against the expensive world-leading brands…. The Shanzhai idea of rebellion has evolved into a desire to take on global corporations by producing copies of the world leading brands."[20] The view is that this kind of rebellion is almost "Robin Hood-like" as it provides cell phones for the masses at the expense of the greedy, rich Apples, Nokias, and LGs of the world. The authors go on to note how those in central government "tend to tacit consent the phenomenon."[21]

Domestic Technology Standards: China uses home-grown standards as a way to gain competitive and hopefully monopolistic advantage. As the MLP stated, "The state should establish a platform to service standards, support and speed up the transformation of advanced foreign standards into domestic standards, and give key support to enterprises that promote the formation of technological standards with ourselves as the dominant factor through re-innovation." The 12th Five-Year Plan proposed to "encourage the adoption and promotion of technical standards with indigenous intellectual property rights."[22] These non-tariff barrier tools are becoming a more central part of China's mercantilist strategy. As China scholar Dieter Ernst points out, the Standards Administration of China justifies its nationalistic and protectionist standards strategy on the grounds that "China's accession commitments to the WTO have substantially reduced the use of most other trade restrictions such as tariffs, import quotas, and licensing requirements."[23] As a result, China lags significantly behind other economies in developing a pro-innovation standards policy. According to the WTO, in 2007, around 14.5 percent of national standards, 15 percent of professional standards, and 19

percent of local standards in China were mandatory.[24] Moreover, voluntary standards can become mandatory if they are referenced in mandatory conformity assessment procedures. In 2007, only 46.5 percent of Chinese national standards were equivalent to international standards.

These "bad" mercantilist policies are all designed to ensure that the Chinese economy produces significantly more technology-based products and imports significantly fewer. For example, through the SEI initiative, China is working to ensure that 30 percent of domestic semiconductor demand is met with Chinese designed and produced semiconductors by 2015, and that 80 percent of flat panel displays consumed in China be produced domestically by 2015. It is creating a domestic Chinese "IT could" based on Chinese technology and IP. Brute force and massive subsidies may not be as elegant or efficient as an entrepreneur working in a garage in Silicon Valley, but they can still be effective.

Innovation Results

China's emphasis on science, technology and innovation has paid off, at least in terms of some innovation indicators. ITIF's *Atlantic Century* report ranks nations on sixteen variables related to innovation and competitiveness, including corporate and government R&D funding, scientists and engineers, new business formation, productivity growth, and others. It also compares nations on overall combined scores in 2011 and in the early 2000s to compare rates of progress. China ranked first among 44 nations on its rate of progress since the early 2000s. In contrast, the United States ranked second to last, ahead of only Italy. Georgia Tech's *2008 High-Tech Indicators* study, found that China improved its technological standing by 9 points (on a scale of 100), moving the nation ahead of the United States in technological capability for the first time. In a survey conducted by Battelle of 713 researchers from around the world on what nations lead in ten different technology areas, China was in the top five nations on all ten areas, and ranked as high as second on agriculture and food production, commercial aerospace and military/aerospace.[25] We can see further evidence of China's progress in a number of indicators:

- China's global share of high technology manufacturing value added increased from 3 percent in 1998 to 19 percent in 2010.[26]
- China's trade balance in high technology goods increased from approximately zero in 1998 to around $155 billion in 2010.[27]
- China's total patent volume rose at an annual rate of 26.1 percent from 2003 to 2009.
- China now has as many offshore R&D operations of U.S. multinational firms as does Europe.[28]
- By 2008, the U.S. share of global machine tool production had fallen to 5 percent (half its share in the 1970s), as China's share rose to 35 percent.
- China's market share of global printed circuit board has grown from 7 percent in 1999 to over 31 percent in 2008.
- In 2007, 40 percent of the semiconductor fabrication plants under construction in the world were located in China, with just 8 percent being built in the United States.
- China became the world's leading producer of solar panels in 2009, the leading producer of wind turbines in 2010, and intends to become the world's largest manufacturer of lithium ion batteries sometime between 2015 and 2020

Why Do So Many in the United States Dismiss China's Innovation Capabilities?
Despite all that China is doing to compete and win in innovation-based production, the consensus view in Washington is that China poses no real threat to the U.S. innovation-based economy. This compliancy comes from several sources.

First, over the past half-century, the United States has developed an attitude that we always have and always will lead at innovation. This has fostered an entitlement mentality which assumes that other nations can never really "touch us" when it comes to innovation. Economist Irwin Stelzer declares, "America remains the source of most of the world's innovations and the home of most of its great entrepreneurs."[29] RAND confidently affirms that "Despite perceptions that the nation is losing its competitive edge, the United States remains the dominant leader in science and technology worldwide."[30] But to paraphrase the warning on investment prospectuses, past performance is no guarantee of future performance.

Second, one reason America is supposedly destined to lead on innovation is because purportedly only the "Washington economic model" can produce real innovation. Under this model policies that promote open trade, free markets, free speech, rule of law, strong intellectual property protection, and support basic "factor conditions" such as investments in science and education, are not only the keys to innovation, they are the only way to generate innovation. Other models based on more interventionist policies by definition cannot succeed. And according this view, since China follows a "Beijing consensus" model, not a "Washington consensus" model, it simply will never develop an innovation economy. As Adam Segal, a Senior Fellow at the Council on Foreign Relations writes in his book *Advantage: How American Innovation Can Overcome the Asian Challenge*, "without respect for rule of law and IP rights, as well as a culture of individual initiative and openness, these steps will not produce the intended results."[31]

He goes on to write, "History shows that it will be difficult to build a truly innovative economy while tightly controlling information." For Segal and other defenders of the Washington consensus America's cultural values of individualism, social mobility, entrepreneurship, and limited barriers to market access will provide a significant advantage over China, even if the latter invests massive amounts in innovation and enacts rampant innovation mercantilist policies.

Segal is not alone. Chrystia Freeland, an editor for Thomson Reuters, writes in a *Washington Post* editorial that: "China is an object lesson in the threat that centralized, authoritarian states pose to revolutionary technological development."[32] She goes on to laud the American model: "The American political economy has many flaws—collapsing infrastructure, a hollowed-out middle class. But America has one great virtue that no other country has yet to replicate: When it comes to innovation and its translation into things people want, America is unbeatable." If Freeland defines "unbeatable" as having been beaten by forty-two other nations, in the rate of progress on innovation-based competitiveness in the last decade), then yes we are "unbeatable."

One of many problems with these sanguine views is that they too narrowly define innovation to include "first to the world" new products, services and business models. To be sure this is an important component of an innovation economy and on this score, China is lagging. At this time, China lacks an innovation system that would enable it to produce large numbers of "new to the world" innovations, in products, services, processes or business models. The elements of such a model include risk taking entrepreneurs, a robust venture funding industry, top quality technology managers, and robust regional learning systems where information and innovations flow easily between various players. The major investments they made to model Silicon Valley have so far not been very successful, turning into largely real estate plays.

Chinese patent filings illustrate the challenges. According to the OECD, in 2008 there were only 473 triadic patent filings (patents signifying more fundamental innovations) from China versus 14,399 from the US, 14,525 from Europe, and 13,446 from Japan. Data for patent grants in 2010 by individual offices present a similar picture. Patent offices outside China have granted only 1 per cent of patents to China. Half of these patents were granted to subsidiaries of foreign multinationals.

But it is important to recognize that Chinese officials are well aware of these weaknesses and are aggressively working to remedy them. China, for example, has made huge strides on building a world-class university and research lab system in the past three decades.

More importantly, "new to the world" is only one component of an innovation economy. Another component is *innovation adaptation*, defined as taking complex production system that are relatively well defined and building products and related processes. This is a major activity of engineering and development centers of multinational enterprises. It also is common among Chinese entrepreneurs, including the use of reverse engineering and copying of international products and processes. And this is where' China's real strength in innovation lies, in what can be called engineering-based innovation.

We see this in a number of statistics. In terms of science and engineering journal articles, China is only slightly ahead of Japan and considerably behind the United States. But when looking just at engineering articles, China is about double of Japan and only about 20 percent less than the United States.[33] Its higher education system is focused principally in engineering, with 30 percent of all first time degrees in engineering, and 60 percent of science and engineering degrees. In contrast, the equivalent percentages in the United States are 4 percent and 14 percent.[34] This means that China is well positioned to win in producing advanced technology products, even if it doesn't innovate them in the first place.

Chinas strong engineering talent pool combined with its vast array of mercantilist policies means that China attracts foreign multinational innovation and technology activities. Even if China only becomes a vibrant high-tech, "branch plant" economy with multi-national firms establishing laboratories and advanced production facilities there and does not produce a significant number of Chinese owned innovation-based multinationals, the damage to the U.S. economy will be significant as America loses advanced technology production jobs and establishments.

Finally, even if Chinese policies do not succeed at creating an innovative Chinese economy, the mercantilist portion of their policies do real damage the U.S. economy by reducing U.S. corporate profits, lowering productivity and innovation, increasing the U.S. trade deficit and reducing higher wage U.S. jobs.

Conclusion

It is difficult for many American economic and trade experts to fully grasp the implications of what China is doing. To these experts, economic policy is about enhancing consumer welfare by enabling markets to efficiently allocate goods and services in well-defined, legally protected markets. Borrowing from Ricardo's writings on free trade, if a nation's natural comparative advantage is in wine (e.g. in China's case, commodity production and assembly) then it should export wine to pay for its textile imports. If the Chinese government is misguided enough to subsidize their high-tech exports, the thinking goes, not only with this backfire since government can't change comparative advantage, but American consumers are the better off for it.

Many American trade and economic policy experts refuse to acknowledge that Chinese economic policy is based on a fundamentally different conception than America's of economic welfare and of how to achieve it.

Because of this, when they see what they believe to be market distorting, welfare-reducing "innovation policies" from the Chinese government, they believe that China not yet learned the merits of the superior and correct rules-based system. But the reality is that China appears to have has little interest in adopting the Washington consensus approach to economic policy. They don't want to make just "wine" they want to make 747 jet airplanes. And if they continue their current "good" and "bad" innovation polices they are likely to do so.

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