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THE CHINA EFFECT ON GLOBAL INNOVATION

JULY 2015

RESEARCH BULLETIN

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JULY 2015

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THE CHINA EFFECT ON GLOBAL INNOVATION

How innovative is the Chinese economy? Does China have the innovative capacity to raise productivity, create more high value-added jobs, and achieve its economic aspirations? By traditional metrics, the answer would clearly be "yes"—China spent more than $200 billion on research and development in 2014, the second-largest investment by any country in absolute terms (and about 2 percent of GDP). Its universities graduate more than 1.2 million engineers each year—more than the next five countries combined. China also leads in patent applications, with more than 730,000 in 2013.

However, if we look at the actual impact of innovation—as measured by the success of companies in global markets—the picture is mixed.[1] In the industries where innovation requires original inventions or engineering breakthroughs, such as branded pharmaceuticals and autos, China has small shares of global markets. But in industries where innovation is about meeting unmet consumer needs or driving efficiencies in manufacturing—appliances and solar panels, for example—China is flourishing. China's massive consumer market and unmatched manufacturing ecosystem give it unique advantages in these sectors. Perhaps the most striking examples of this success are in e-commerce and consumer electronics, where companies such as Alibaba and Xiaomi are rapidly emerging as top global players.

This research, based on an impact-driven view of innovation, concludes that China does have the potential to become a global innovation leader. Although it has not yet seen the payoff, China has made the necessary investments in R&D and education to improve its performance in science- and engineering based industries. China's success in high-speed rail and telecommunications equipment prove that, under the right circumstances, Chinese companies can be global competitors in engineering-based industries. And, even now, in science-based industries such as biopharmaceuticals, Chinese companies are harnessing the scale and speed of the home market to become more nimble and stronger innovators.

With the right policies in place to support entrepreneurism, encourage market-based competition in more industries, and make China more attractive to top science talent, China can succeed in all forms of innovation. Timing will be critical: with slowing GDP growth, an aging population, and declining returns on massive fixed investments, China must find ways to raise productivity. Innovation is key to this sustainable growth path.

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[1] Innovation can be defined and analyzed in many different ways. One common approach is to assess novelty (imitation, invention, and innovation). Another approach is to assess the type of innovation activities (process, product, marketing, and organization innovation); see *Oslo Manual*, OECD, November 2005. Other researchers focus on the nature of innovation (disruptive vs. sustaining). For example, see Clayton Christensen, *The Innovator's Solution*, Harvard Business School Press, 2003. In this report, we use a broad definition of innovation that emphasizes impact, measured by the ability of companies to expand revenue and raise profits with new products and services, and improvements in design, manufacturing, or business models. For an overview of innovation literature, see *Innovation—A New Guide*, Jan Fagerberg, 2013.

China's innovation imperative

As we write this, China is in the midst of a challenging transition. A rapidly aging population, increasing debt, and declining returns on fixed asset investment place new burdens on the economy. Because of aging, the labor force is expected to peak this year and begin a long decline that could reduce its size by 16 percent by 2050. By 2030, China's dependency ratio—the percentage of the population that is not in the labor force (mostly the elderly and children)—will reach 47 percent. This is far sooner, in terms of GDP per capita, than in countries such as Japan or the United States. Even as its population is aging, China's wages are rising: average wages have risen by 11 percent a year for the past five years and are now more than 1.5 times higher than average wages in India and Vietnam.

At the same time, debt-financed investment is approaching a level of diminishing returns. China's debt-to-GDP ratio reached 282 percent of GDP in mid-2014, up from 158 percent in 2007, a ratio that is higher than that of such advanced economies as the United States and Germany. About a third of this new debt is concentrated in real estate and related industries.[2] With real estate markets overbuilt, this ratio is one reason that the return on fixed-asset investment in China is declining. The incremental capital-output ratio (ICOR), which shows how much capital is needed to generate a unit of GDP, was 3.4 on average from 1990 to 2010, but it has since risen to 5.4, meaning that it takes 60 percent more capital to generate a unit of GDP. On that trajectory, by 2030, China's ICOR could be 17 percent higher than the current ratio for the other BRIC countries (Russia, India, and Brazil) and near the current level of more advanced economies such as the United States and Korea.

Given these trends, we believe that innovation is essential to China's long-term sustainable growth. Over the past 30 years, much of China's economic growth has come from being an "innovation sponge," meaning it attempted to catch up with advanced economies by absorbing and adapting technology, best practices, and knowledge from overseas.[3] Chinese companies did this with foreign direct investment, purchases of equipment and companies, and joint ventures. As a result, China now ranks second in the world in knowledge-intensive flows—movement of knowledge-intensive goods and services and foreign direct investment.[4]

Now, innovation must play a larger role across all sectors of the Chinese economy. However, as Exhibit 1 illustrates, the contribution of innovation to growth (as measured by multifactor productivity) has declined in recent years.[5] From 1990 to 2010, multifactor productivity contributed between 40 and 48 percent of GDP growth. However, over the past five years, multifactor productivity has contributed just 30 percent of GDP growth, or about 2.4 percentage points of GDP growth per year, the lowest level in 35 years. To maintain GDP growth of 5.5 to 6.5 percent per year through 2025, China will need to generate 35 to 50 percent of GDP growth (two to three percentage points) from multifactor productivity.

Innovation will also be critically important to generate higher-value-added and higher-paying jobs. Continued urbanization is expected to bring 100 million more residents to large

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2 *Debt and (not much) deleveraging*, McKinsey Global Institute, February 2015.

3 Productivity matters for global growth as well. For further reading on the magnitude of the challenges and potential improvement opportunities, see *Global growth: Can productivity save the day in an aging world?* McKinsey Global Institute, January 2015.

4 *Global flows in a digital age: How trade, finance, people, and data connect the world economy*, McKinsey Global Institute, April 2014.

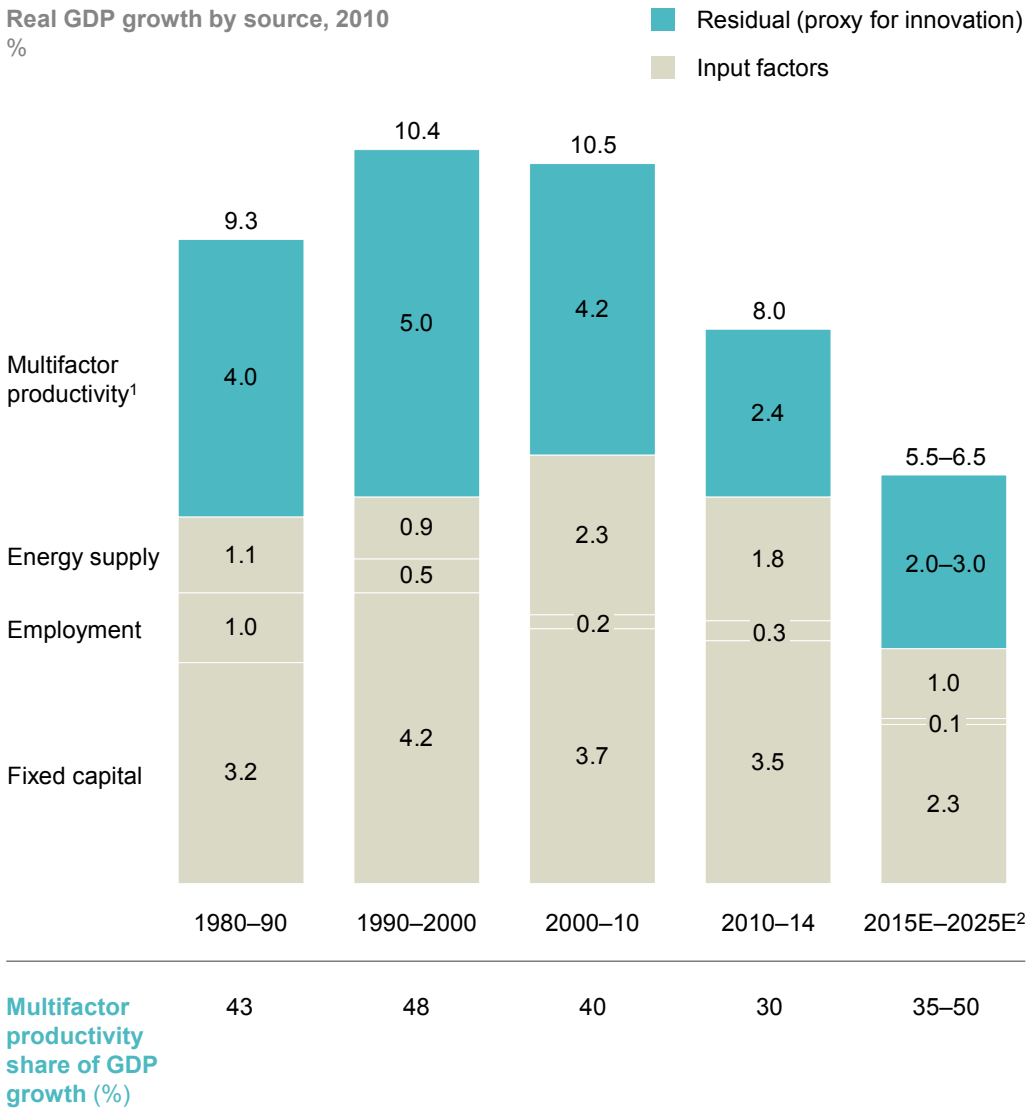
5 To measure the impact of innovation on a macroeconomic level, economists have long used multifactor productivity as a metric of innovation. Although there may be many reasons behind multifactor productivity gains, such as broad catch-up activities and efficiency gains in a developing economy, innovation is arguably the primary source behind long-term growth in multifactor productivity. See Bronwyn H. Hall, *Innovation and productivity*, National Bureau of Economic Research working paper number 17178, June 2011, and *The OECD innovation strategy*, Organisation for Economic Co-operation and Development, October 2010.

Chinese cities by 2020, which will create a need for 10 million urban jobs every year, even as manufacturing employment drops.

To address these challenges, China will need to accelerate the evolution from innovation sponge to innovation leader, capable of driving more breakthroughs and competing in global markets. Making this transition will require a better understanding of how China innovates today, what its core strengths are, and which policies and business practices can build on the momentum of the past three decades. Policy makers are already acting to address some of these needs. The Internet+ program, for example, is intended to use the Internet as a catalyst for grassroots innovation and innovation in business processes.

Exhibit 1

Innovation (broadly defined) can contribute 2 to 3 percentage points of GDP growth in China by 2025, accounting for 35 to 50 percent of total GDP growth



1 Multifactor productivity defined as GDP growth minus input factors (energy, labor, capital). Multifactor productivity provides a broad, indirect measure of innovation on the economy.
2 McKinsey Global Institute estimate, based on regression of more than 100 variables and assuming no major shocks.
NOTE: Numbers may not sum due to rounding.

SOURCE: McKinsey Global Institute analysis

An archetype-based view of innovation across industries

To understand how China and Chinese companies can get better at innovation, we reviewed existing approaches that evaluate the innovative capacity of countries and firms. We found that most approaches do not provide actionable insights that decision makers in government and business can use to improve innovation. Many common approaches to innovation assessment use high-level rankings or indices based on metrics such as patents, R&D spending, and numbers of PhDs. These metrics may capture innovation capacity but do not measure successful innovation; countries may rank high on R&D spending and numbers of PhDs and patents, but these factors may not translate into high levels of innovation.

We use an alternate approach that looks at four archetypes of innovation, and identifies the factors needed for successful innovation in different types of industries. We began by looking at more than 30 industries to understand how innovation occurs in these industries, what the drivers of innovation are, and how innovation determines the success of firms. In our analysis, we looked at innovation of all kinds that have led to successful commercialization, from pure scientific discoveries and engineering breakthroughs to new business models and efficiency improvements. We identified four archetypes of innovation: science based, engineering based, customer focused, and efficiency driven. Depending on the industry, factors such as R&D intensity, understanding of customer needs, and capital/labor intensity are of greater or lesser importance (Exhibit 2).

- **Science-based innovation** involves the development of new products through the commercial application of basic research. Industries such as pharmaceuticals, biotechnology, and semiconductor design rely on scientific innovation and may spend 16 to 33 percent of revenue on R&D and devote 10 to 15 years of effort to bring an invention to market. Trade intensity in these sectors tends to be very high, which translates to higher competitive intensity for companies seeking to catch up with incumbents.

- **Engineering-based innovation** is about the design and engineering of new products through the integration of technologies from suppliers and partners. Industries that rely on engineering-based innovation include commercial aviation, auto manufacturing, and telecommunications equipment. These industries have moderate to high R&D intensity, typically spending 3 to 13 percent of sales on R&D, and can have product life cycles of five to ten years or longer.

- **Customer-focused innovation** involves solving consumer problems through innovations in products and business models. Industries in this category include Internet software and services, appliances, and household products. These industries are characterized by high marketing intensity (typically spending about 3 to 7 percent of sales on marketing) and short development cycles of less than a year or two. Because products and services in these industries tend to be tailored to local needs, industries often exhibit lower trade intensity than those dominated by other archetypes.

- **Efficiency-driven innovation** mostly involves process improvements to reduce cost, shorten production time, and enhance quality. In industries dominated by this archetype, companies compete on the basis of efficient use of resources. For this reason, efficiency-driven innovation is particularly relevant in capital- and labor-intensive industries, such as commodity chemicals, textiles, electrical equipment, and construction machinery.

Exhibit 2

The most important factors for innovation vary by industry

Low | Low/medium | Medium-high | High

Innovation archetype	Example sectors	R&D[1]	Capital[2]	Labor[3]	Marketing[4]	Trade intensity[5]	Source of innovation
Science-based	Semiconductor design	16	45	5	2	44	▪ Company research ▪ Academic research
	Biotechnology	33	28	3	2	41	
	Pharmaceuticals (branded)	15	27	3	5	41	
Engineering-based	Communications equipment	13	12	5	1	48	▪ Suppliers, technology partners ▪ Engineering know-how
	Auto manufacturing	4	29	1	3	41	
	Railroad equipment	3	23	3	2	22	
	Commercial aviation	4	17	5	<1	67	
Customer-focused	Internet software and services	13	25	3	5	n/a	▪ Consumer insights ▪ Identifying unmet needs
	Household products	2	27	n/a	7	38	
	Household appliances	2	16	6	3	40	
	Consumer electronics	6	17	7	4	70	
Efficiency-driven	Commodity chemicals	2	48	1	1	33	▪ Production know-how; scale
	Textiles	1	48	8	1	40	
	Electrical equipment	3	25	8	<1	45	
	Construction machinery	3	33	5	<1	42	

1 R&D expenses as a percentage of revenue.
2 Plant, property, and equipment divided by revenues.
3 Hours worked per $1,000 value added, in 2014 dollars.
4 Marketing expenses divided by revenues.
5 Exports divided by global production value, 2010–14 average.

SOURCE: McKinsey Corporate Performance Analysis Tool; IHS Economics & Country Risk; US Bureau of Labor Statistics; McKinsey Global Institute analysis

We recognize that an archetype model can be seen as overly simplistic and that there are limitations to fitting industries squarely into archetypes. In reality, multiple forms of innovation take place within a sector. For example, although innovation in the automotive sector depends heavily on engineering, competitive car companies must also master customer-focused innovation to keep up with consumer preferences and pursue efficiency-driven innovation in manufacturing to remain profitable. Nonetheless, we find that the innovation archetypes offer useful guidance to understand key drivers of innovation by sector and reveal insights that can lead to effective strategies for policy makers and business executives.

A major difference among the archetypes is the relative importance of invention and creation of original knowledge in company performance. In science- and engineering-based industries, invention is critical for success. As Exhibit 3 shows, company performance in pharmaceutical is linked strongly with the firm's ability to create high-quality knowledge, which we estimate through the average number of claims per patent. In engineering-intensive industries, such as telecommunications equipment, invention is also an important contributor to performance. However, invention is not strongly linked to success in customer-focused and efficiency-driven innovation, which relies on the ability of a firm to develop products to reach more customers or improve processes to drive down costs.

Where Chinese innovation is succeeding—and where it is not

In the absence of reliable direct measures of innovation impact in China (or in any other economy), we focus on firm-level performance metrics. Ultimately, the proof of successful innovation is the ability of companies to expand revenue and raise profits with new products and services and with improvements in design, manufacturing, or business models. Although the competitiveness of companies can be affected by non-innovation factors such as industry structure and factor costs, we believe innovation is a primary contributor to the growth of revenue and profit at the company level.[6]

To gauge the success of Chinese companies, we use a proprietary database of more than 20,000 publicly held companies to estimate the share of global revenue and profit captured by Chinese companies. Exhibit 4 illustrates the global revenue share of China-based companies in select industries indexed to China's share of global GDP (12 percent in 2013) to show where Chinese companies have a disproportionately high or low share of global revenue.[7] We used the same analysis to show the performance of US-based companies for comparison. Overall, Chinese companies show the greatest strengths in markets that require customer- and efficiency-driven innovation, and they have the most catching up to do in industries that rely on science- and engineering-based innovation.

[6] For further reading on innovation's impact on competitiveness, also see Michael Porter, "The competitive advantage of nations," *Harvard Business Review*, March–April 1990, and John Cantwell, "Innovation and competitiveness," in The Oxford Handbook of Innovation, Jan Fagerberg and David C. Mowery, eds., Oxford University Press, 2006.

[7] The exhibit shows revenue share rather than profit share. Our research found that Chinese firms tend to put revenue growth and scale ahead of maximizing returns on invested capital. This is based on MGI research on the shifting basis of global competition, scheduled for publication later in 2015.

Exhibit 3

Invention correlates with performance in science- and engineering-based industries, but not in customer-focused or efficiency-driven industries

Size of circle = Number of patents, 2010–14

Chinese player

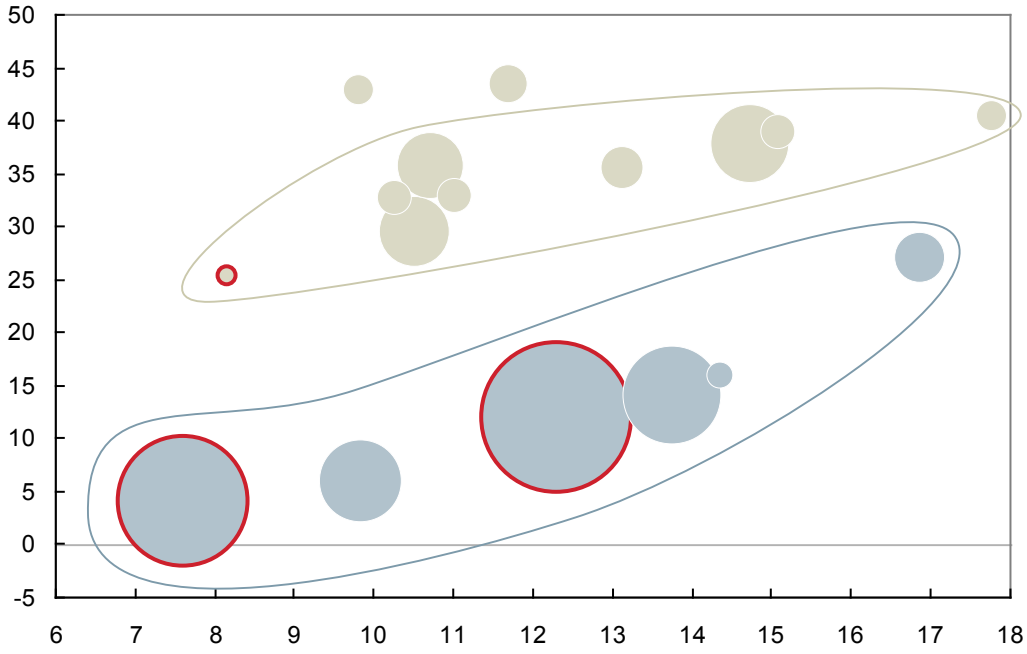
Invention and strong firm performance are highly correlated in science- and engineering-based industries

Pharmaceuticals

Communications equipment

EBITDA margin, 2010–14

%



Average claims per patent, 2010–14[1]

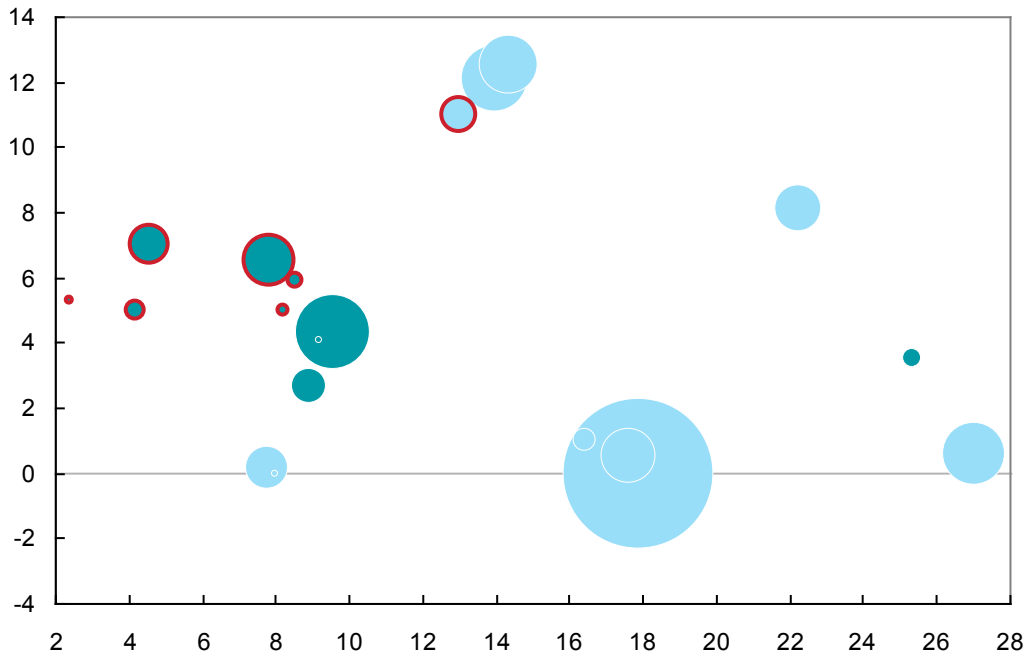
However, invention is less important in customer-focused and efficiency-driven industries

Smartphone[2]

Solar[3]

Market share, 2014

%



Average claims per patent, 2010–14[1]

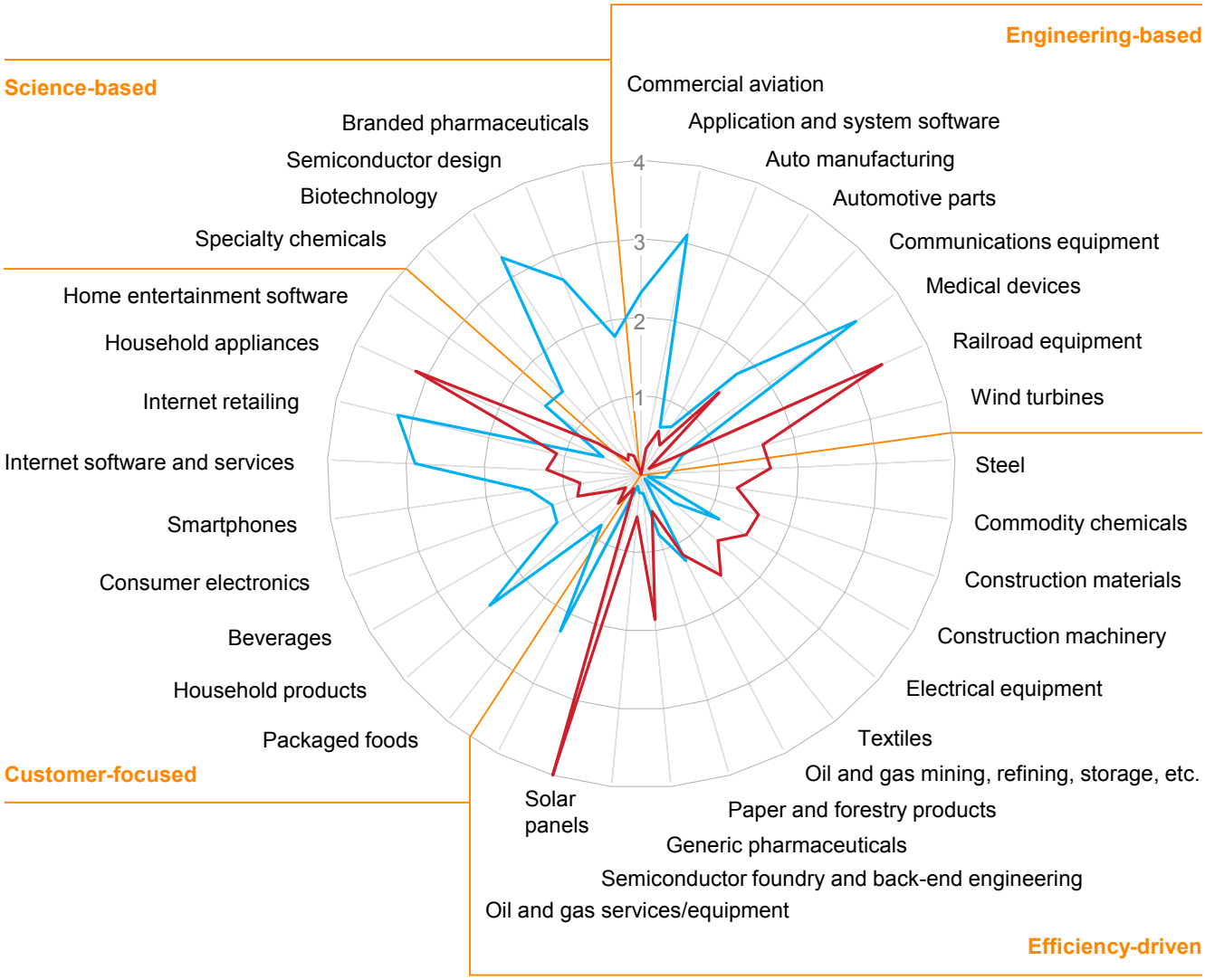
1 A patent application may include multiple claims describing specific inventions; a high number of claims per patent is a sign of patent strength.
2 Share of Chinese market.
3 Share of global market in megawatts.

SOURCE: Innography; McKinsey Corporate Performance Analysis Tool; Strategy Analytics; McKinsey Global Institute analysis

Exhibit 4

China has established strength in efficiency-driven and customer-focused innovation but continues to lag in science- and engineering-based innovation

Country performance ratio relative to fair share, 2013
Index: 1 = Fair share[1]



1 Country performance is based on data from 20,000 public companies. Performance ratio equals a country's share of global revenue divided by its share of global GDP in 2013, indexed to a "fair share," which is the share of industry revenues that each country would be expected to have based on its share of global GDP.

SOURCE: IDC; McKinsey Corporate Performance Analysis Tool; annual reports; World Industry Service; IHS Economics & Country Risk; iSuppli; McKinsey Global Institute analysis

Customer-focused innovation: China's commercialization advantage

The power of China's massive and dynamic consumer market to rapidly commercialize new products and services should not be underestimated. It provides a model not only for success in China, but also across the developing world.

China's size advantage enables rapid commercialization

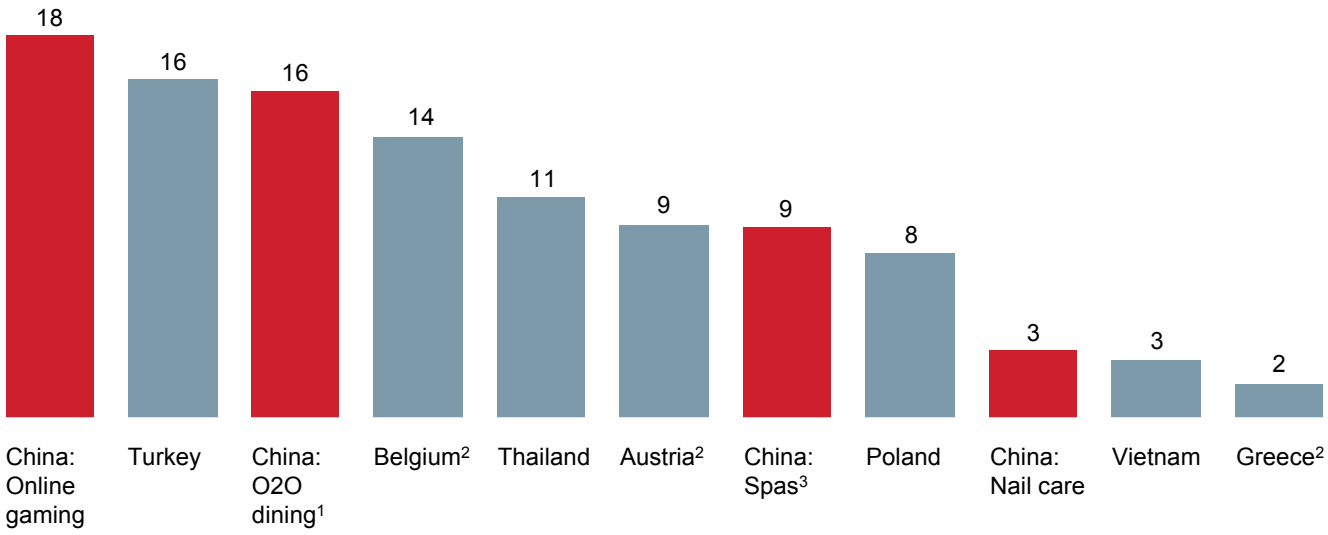
Some of China's greatest successes have come in industries that require customer-focused innovation. As measured by share of global revenue, Chinese firms are growing rapidly across sectors such as household appliances, in which they now account for 39 percent of global revenue, Internet software (15 percent), and smartphones (10 percent). In these sectors, most of the growth is driven by sales in local markets. Indeed, only in household appliances and consumer electronics do exports exceed 10 percent of sales. So, largely based on the size of the Chinese consumer market, appliance makers such as Haier and Internet companies such as Baidu, Alibaba, and Tencent have become world leaders in their fields.

The success of Chinese companies in these industries illustrates some of the advantages that Chinese companies have in customer-focused innovation. Chief among these is the massive Chinese consumer market. China has become the world's largest market for smartphones, personal computers, air conditioners, refrigerators, microwaves, and home laundry appliances. Indeed, the Chinese market is so large that in many segments domestic leaders are, by definition, global market leaders. And niche markets in China, such as online gaming and beauty spas, are bigger than major industries such as autos in other economies (Exhibit 5).

Exhibit 5

A niche in China can be larger than a major industry in another economy

Niche markets in China vs. passenger vehicle markets in other economies, 2014
$ billion



1 Online-to-offline dining, or online restaurant reservations and food delivery ordered online.
2 MGI estimates.
3 Including facial and body treatments, and facial product sales through spa channels.

SOURCE: 2014 China Gaming Industry Report; International Organization of Motor Vehicle Manufacturers; iResearch; Turkish Statistics Institute; International Council on Clean Transportation Pocketbook 2014; press search; McKinsey Global Institute analysis

The Chinese consumer market is not only large but also dynamic and fast-moving. Disposable income has risen by 10 percent per year in real terms over the past decade and, since 2000, more than 85 million households have joined the new mainstream consuming class (defined as households with disposable income of 106,000 to 229,000 RMB [$17,080 to $36,900]). Some 106 million more households are expected to join the new mainstream consuming class by 2020.[8] In this large and growing consumer market, innovations can be scaled up and commercialized rapidly. WeChat, a Chinese social media platform, garnered 100 million members in just 1.2 years—compared with 4.5 years for Facebook. Chinese consumers also seem to be more willing than other consumers to participate in the innovation process by acting as perpetual beta testers. Consumer-facing companies routinely launch new models and continue to refine them based on market feedback. In 2014, for example, Xiaomi updated its smartphone operating system 52 times. Improving broadband and logistics networks also helps Internet content and retailing companies reach consumers efficiently.

Markets that rely on customer-focused innovation tend to have low barriers to entry, which is illustrated by the wave of Chinese entrepreneurs in Internet services, games, and e-commerce. In a 2013 job placement report, 12 percent of Peking University graduates said they had launched a company or were self-employed, compared to 4 percent in 2005. Venture investing has tripled, rising from $5.4 billion in 2010 to $16.9 billion in 2014.

Consumer-facing companies innovate through commercialization

Over the past three decades, Chinese companies have learned to adapt products from around the world to the needs of a rapidly urbanizing nation and have become very agile—moving goods into production quickly, then tweaking designs afterward to better address consumer needs. A new generation of entrepreneurs is solving consumer problems and developing new business models, often in uniquely Chinese ways. Makers of consumer goods are changing their approaches to address the rising expectations of China's expanding middle class and moving beyond the "good enough" products of the past.

- **Solving consumer problems.** One of the biggest challenges facing Chinese consumers is the country's highly fragmented retail industry, which severely limits choice for consumers in all but the largest cities. Chinese entrepreneurs have built a world-leading e-commerce industry to address this problem. From its start in 1999, Alibaba has grown into the world's largest online marketplace, based on the value of merchandise sold in its online stores ($394 billion in fiscal year 2014).[9] Alibaba's innovations include Alipay, a payments system, and Ali Finance, which provides financing for small-scale suppliers that are not served by the traditional banking system. Baidu, the leading Chinese search-engine service, saw a need to improve delivery of health care. Its Doctor Baidu app recommends the best available physicians in the local area, based on the consumer's description of symptoms. The app can also schedule appointments with doctors online. Within six months of its launch, Doctor Baidu expanded to six provinces, covering a total population of 340 million. With additional artificial intelligence programming, Baidu aims to turn Doctor Baidu into a virtual "family doctor," filling additional unmet needs.

[8] Yuval Atsmon and Max Magni, "Meet the Chinese consumer of 2020," *McKinsey Quarterly*, March 2012.

[9] See *China's e-commerce revolution: Online shopping as a catalyst for growth*, McKinsey Global Institute, March 2013.

- **Rethinking business models.** Nowhere have Chinese entrepreneurs shown a greater flair for innovation than in Internet-based businesses. In many cases, they have done so by inventing business models. For example, in most parts of the world, online businesses generate 60 to 90 percent of their revenue from advertising. However, in China, advertising is not as large a source of revenue—China's advertising industry is only about one-quarter the size of the US industry—and Chinese companies have been forced to create new business models to monetize web traffic. Tencent generates 90 percent of its revenue from online games, sales of virtual items on social platforms, and e-commerce. Average revenue per user in 2014 was $16, $6 more than Facebook, according to 2014 annual reports. YY.com, a video-based social communication platform, has built diverse revenue streams, including a virtual currency. In 2014, YY.com generated 57 percent of revenue from music and entertainment through sales of virtual goods such as virtual roses that viewers purchase to give to performers on the platform. Performers can redeem the virtual goods for cash and top performers can earn more than RMB 20,000 a month, seven times what the average factory worker earns.[10]

- **From "good enough" to "cheaper and better."** For years, customer-focused innovation in China meant creating "good enough" products, which cost about half of what multinationals charged and delivered about 80 percent of the quality. Good-enough products still work for lower-income consumers, but in an increasingly affluent China, innovators must create "cheaper and better" products to win new mainstream customers. Four-year-old Xiaomi, a Beijing-based smartphone maker, has become one of the world's most successful startups with products such as the Mi4. Xiaomi phones typically cost half as much as top-of-the-line products from other global brands, yet offer comparable or better hardware features. Business model innovations such as online-only sales and risk sharing with suppliers help Xiaomi offer its products at a low price. Xiaomi is now the largest smartphone player (by shipments) in China, with more than 12 percent market share in 2014, and is entering foreign markets.

Efficiency-driven innovation: The advantages of China's manufacturing ecosystem strength

In large part, manufacturing innovation is about rapidly climbing the learning curve in new manufacturing processes and finding ways to make additional improvements. Successful innovators are also highly pragmatic and flexible. As China has become a global manufacturing leader, it has created a vast ecosystem of suppliers, workers, service companies, and logistics providers. This ecosystem makes it possible for Chinese companies and companies from all over the world to produce virtually any kind of product efficiently and refine production processes in China.

[10] Tomio Geron, "YY.com; China's unique real-time voice and video service with a virtual goods twist," *Forbes*, June 11, 2012.

China's manufacturing ecosystem strength

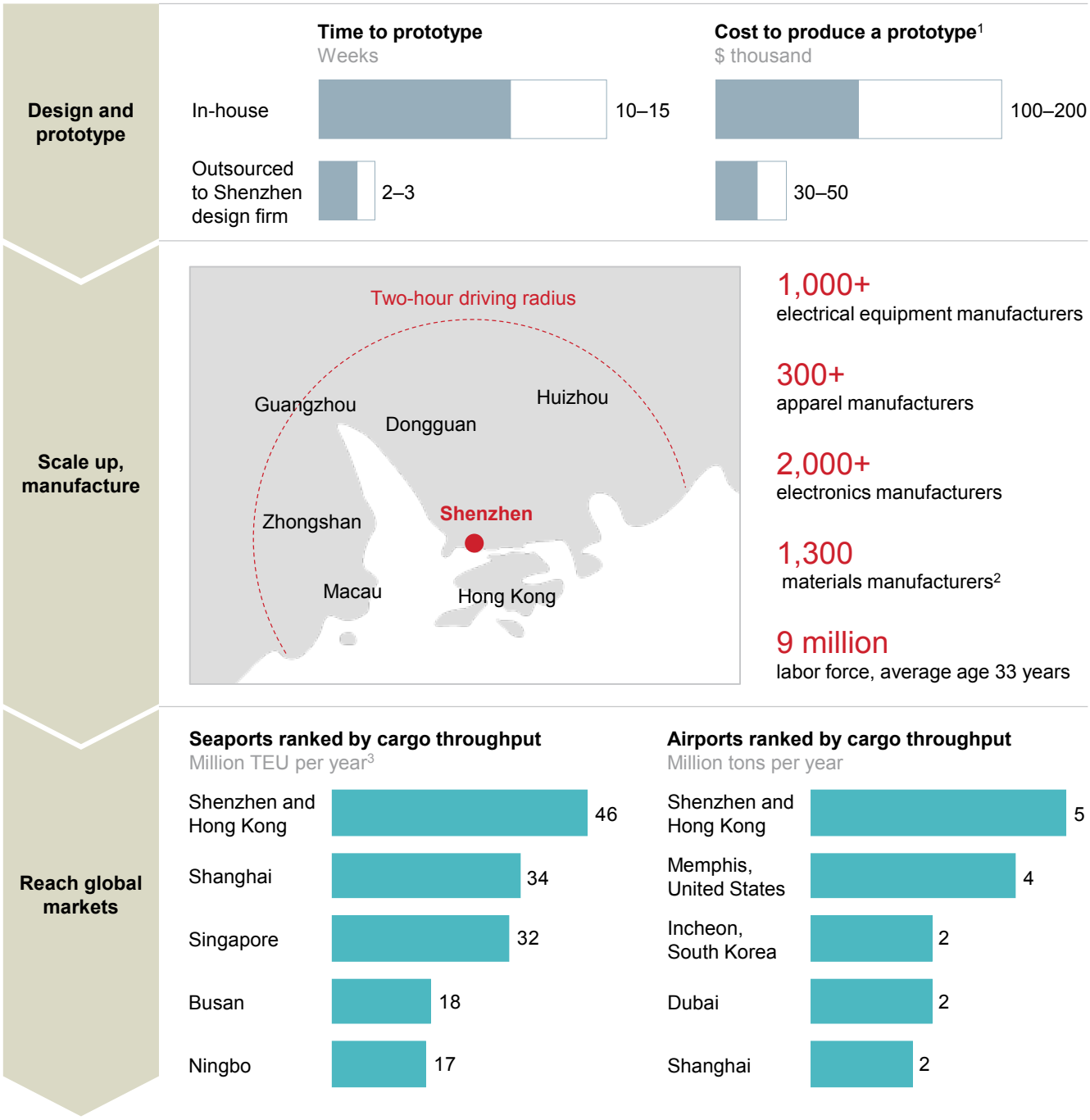
China's strength in efficiency-driven innovation has allowed it to consolidate its position as a preeminent global manufacturing hub and is helping Chinese manufacturers rise in the industry value chain. China was once an exporter of low-value-added goods, such as toys, textiles, and furniture, and a contract assembler for foreign firms. While China remains strong in input-intensive sectors such as solar panels (with 51 percent of global revenue), textiles (20 percent) and commodity chemicals (15 percent), it is increasingly competitive in more sophisticated, knowledge-intensive sectors such as construction machinery (19 percent) and electrical equipment (16 percent). Indeed, from 2004 to 2014, China's share of global manufacturing value added (measured as the net output of the manufacturing sector) tripled, from 8 percent to 25 percent.

Much of China's manufacturing success can be attributed to its extensive manufacturing ecosystem—a deep network of suppliers, a large skilled labor force, and a well-developed logistics infrastructure. This ecosystem has helped Chinese manufacturers drive process innovation, and the sector continues to benefit from the economy's unique scale advantage. China's extensive supplier base allows companies to respond quickly to changing customer needs with new or lower-cost components and quick turnaround of additional supply. China has more than 140,000 machinery suppliers, 75,000 companies in communications and equipment industries, and 104,000 companies in the transportation equipment sector. This is over five times the size of the supplier base in Japan.

Similarly, China's large and flexible manufacturing workforce enables companies to scale up production at speeds that are hard to match elsewhere. China has 150 million manufacturing workers, compared with 14 million in the United States, 9 million in Japan, and 4 million in Korea. Its manufacturing workforce is three times the entire working-age population of Vietnam, a rising force in low-cost manufacturing. The ecosystem includes a modern transportation infrastructure—highways, railroads, and airports—that link Chinese factories efficiently to sources of global demand. For example, newly built railroads now allow manufacturers in the central Chinese city of Zhengzhou to reach consumers in Europe in 16 days, compared with 38 days via the sea route used before. Exhibit 6 shows the benefits of the manufacturing ecosystem in Shenzhen, where companies can save time and costs in developing prototypes, tap into a large supplier base, and move products into global markets quickly.

Exhibit 6

Shenzhen has a strong ecosystem advantage in manufacturing



1 Low-tech electronics example.
2 Chemicals, rubber, minerals, metals, textiles.
3 Twenty-foot equivalent unit, a measure of cargo ship capacity.

SOURCE: Shenzhen Statistical Yearbook 2014; Drewry Container Market; Airport Council International; McKinsey Global Institute analysis

How manufacturing companies innovate through rapid learning and operational flexibility

China's strong ecosystem helps innovative companies rapidly scale up production and climb the learning curve. Manufacturing companies have also developed a flexible, pragmatic approach to innovation in production processes, using semi-automation systems and agile manufacturing.

- **Rapid scaling and learning.** The cost of solar panels has fallen by half in the past three years. While much of this price reduction was driven by structural overcapacity in the market, Chinese firms were also able to wring efficiencies out of their manufacturing processes by applying scale economies and lessons about production processes. For example, they have been able to reduce the amount of silicon needed in wafers and the amount of silver needed for connections. Companies have also introduced new production efficiencies in advanced glass, coatings, and films. The scale of Chinese factories—as much as four times larger than US solar plants—helps to drive process improvements across the value chain. Scale and supply-chain advantages give Chinese players an estimated 22 cents per watt advantage over their foreign peers, or about a 15 to 20 percent edge in total cost per watt, according to an MIT study.[11]

- **Semi-automation.** China is already the largest buyer of robots in the world, but many Chinese manufacturers have found that at this point they can be more productive using semi-automation strategies rather than complete automation. Chint, an electrical equipment producer based in Zhejiang, installed four fully automated production lines in addition to manual lines with thousands of workstations. The company discovered that it cost four times as much to maintain the automated machinery as it cost to pay the workers that the automated machinery had replaced. Chint also found that humans were much more efficient for small batches and customized orders. The company analyzed every automated procedure and reassigned those that could be done better by humans to manual lines. It saved $600,000 in equipment investment for every production line and gained flexibility. The move also reduced waste, because unlike in the automated process where an imperfect part would be discarded, on the manual lines, workers often could adjust a part and put it back into production.[12]

- **Agile manufacturing.** Speed and agility are becoming increasingly important in global manufacturing. Everstar and Red Collar are traditional apparel manufacturers that are transforming themselves into modern custom clothing suppliers that let customers design their own garments. Everstar's e-commerce portal offers DIY design tools that are accessible by computer or smartphone. Investments in 3-D scanning and laser cutting enable swift production of customized designs (as quickly as 30 minutes after an order is received), and Everstar has boosted production capacity by 30 percent while cutting needed labor by 50 percent. The company also built a fast logistics platform that promises 72-hour turnaround on custom orders. Based in Guangdong, its factory is within easy reach of more than 2,000 textile, apparel, and accessories manufacturers. In 2014, Everstar produced 1.8 million pieces of apparel and had $20 million in sales.

[11] Alan C. Goodrich et al., "Assessing the drivers of regional trends in solar PV manufacturing," *Energy & Environmental Science*, issue 10, October 2013.

[12] Eden Yin and Peter J. Williamson, "Rethinking innovation for a recovery," *Ivey Business Journal*, May 2011.

Engineering-based innovation: Digesting and innovating

Engineering-based innovation involves the complex integration of numerous components and technologies. Success is part art and part science, requiring accumulated know-how from learning by doing, experimentation, and trial and error. In China, government action has been a catalyst for accelerating learning by creating massive local demand and instituting regulations that require technology transfer from overseas partners.

China has had mixed success in engineering-based innovation

Progress in Chinese engineering-based innovation is moving at different speeds in different markets. China's best performers have been in "B2G" (business-to-government) markets, where companies filling government orders have learned through the "acquisition, assimilation, and improvement" of overseas technology.[13] This formula has been used most successfully in high-speed rail, where China now has 41 percent of the global market, as well as in wind power (20 percent), and communications equipment (18 percent).

In the case of high-speed rail, the Chinese Ministry of Railways launched a RMB 3 billion program in 2008 to develop a new generation of high-speed trains. As part of this plan, the Ministry of Railways contracted with overseas manufacturers to transfer technology and manufacturing know-how. Just as important, it has created conditions for continuous learning and innovation. Since 2008, China's high-speed rail market has grown by 70 percent a year, accounting for 86 percent of global growth. The act of commercialization has also allowed firms to improve their "delivery capacity"—the ability to understand project requirements, turn them into detailed product specifications and work plans, and deliver the output on time. Delivery capacity is critical for commercializing engineering-based innovations. One result: in 2010, the China South Locomotive & Rolling Stock Corporation introduced the CRH380A, China's first local locomotive design capable of reaching speeds of 380 kilometers per hour.

This formula has been applied in other industries, including wind power. After announcing its Wind Power Concession program in 2003, China ordered 3,350 megawatts of capacity, significantly accelerating the country's development of wind power (Exhibit 7). Since then, the industry has been growing by 62 percent per year, or three times the rate of the global market. Overseas manufacturers were also invited to participate, but with mandated minimum local content of 70 percent.

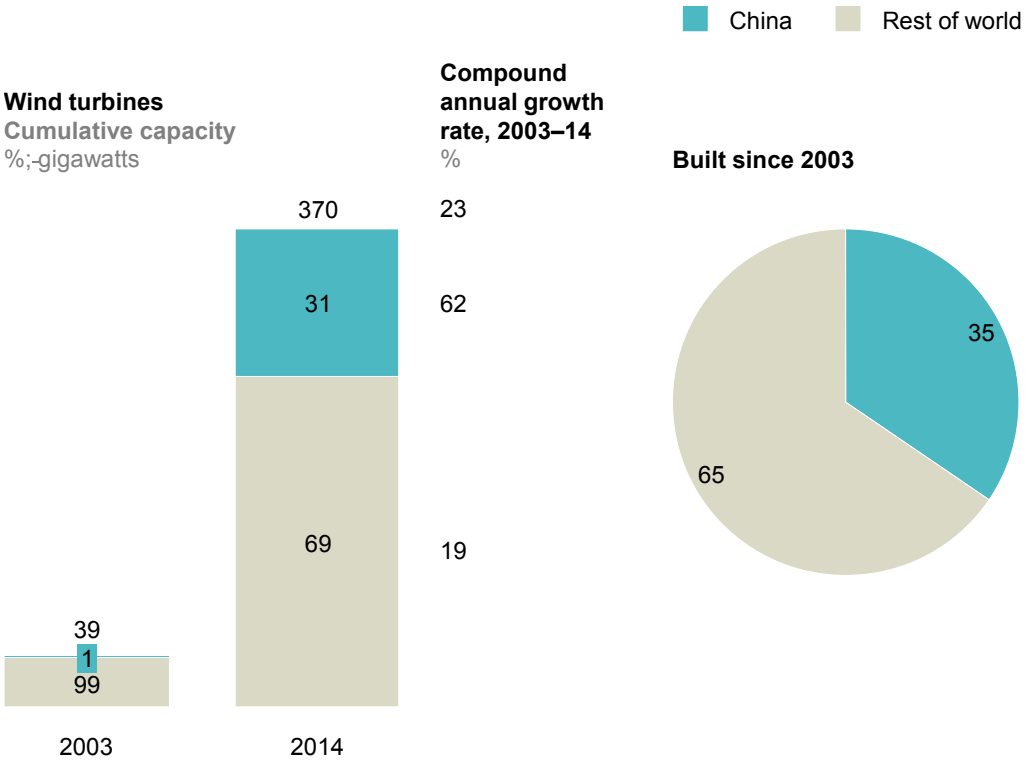
In industries where China is further behind, such as autos and medical devices, Chinese companies have had fewer opportunities to climb the learning curve. For example, in the automotive sector, where China has 7 percent of global revenue, Chinese state-owned enterprises operate joint ventures with major overseas car manufacturers, an arrangement that offers limited the opportunity to improve local capabilities. Instead of providing local engineers with the chance to learn end-to-end product design, joint ventures often use existing designs from foreign partners, depriving Chinese workers of valuable experience. In addition, many local car manufacturers have engaged foreign firms for high-value-added design.[14]

[13] Peng Ru et al., "Behind the development of technology: The transition of innovation modes in China's wind turbine manufacturing industry," *Energy Policy*, April 2012.

[14] *Chinese autos, part 1: The quest for global competitiveness—technology, competence, ambition and politics*, Sanford C. Bernstein & Co., 2013.

Exhibit 7

How government policies supported innovation in wind turbines and high-speed rail



SOURCE: Global Wind Energy Council; Chinese Wind Energy Association; International Union of Railways; China Statistical Yearbook; National Railway Administration; McKinsey Global Institute analysis

Innovators in engineering-driven industries have learned from multiple sources

Long-term, stable government demand has provided unique opportunities for local companies to build delivery capacity in the past three decades. Throughout this process, Chinese innovators have pursued learning opportunities from all possible sources, to build their engineering know-how.

- **Learning from foreign partners and "re-innovating."** China became the world's top player in high-speed trains in just six years through a "digest and innovate" strategy—starting by learning from foreign partners, then mastering the technology. Initially, trains were imported or built under technology transfer agreements, but Chinese companies had bigger ambitions. The China South Locomotive and Rolling Stock Corporation developed a "1 to 3 ratio" approach: for every dollar spent on technology transfer, the company would invest three dollars to learn and apply the technology. Once they had the knowledge to do so, Chinese engineers pursued innovations to meet local requirements. For example, to operate in difficult places such as the route from Ha'erbin to Dalian in the frigid northeast, engineers developed a special cabin for snowy conditions and water leakage protection technology to deal with rapid temperature changes. China has already built more than 16,000 kilometers of high-speed rail lines, and Chinese companies are now in discussions with 28 countries for export deals.

- **Developing end-to-end knowledge.** In the 1990s, executives at Huawei, a Shenzhen-based telecom equipment company, made the strategic decision to develop their own designs, because they believed that foreign partners would not share cutting-edge technology. Its first in-house projects were for basic switching components, and the learning curve was steep: the first product encountered quality issues, and the company had to imbed engineering teams at customer sites to manage fixes. This experience helped Huawei accumulate knowledge while earning the trust of customers. Because they worked such long hours, Huawei developers kept mattresses in their offices. Today, Huawei is the global leader in telecommunications equipment (with 16 percent share of markets in which they operate) and dedicates 14 percent of revenue to R&D. Huawei products are sold across Europe and the company has set up 19 joint innovation centers with European customers.

- **Leveraging supply-chain partners.** The unmanned-aircraft (drone) industry had high barriers to entry, since most customers were military users and only a few suppliers had the required technology. DJI, a Shenzhen-based technology company, identified a niche in civilian drones and, more importantly, realized that it could build them inexpensively by tapping the manufacturing ecosystem. DJI designed mass-market models and drew on the engineering and manufacturing expertise of supply-chain partners in the Shenzhen industrial ecosystem to get them to market. The company itself focused on core technologies where it could differentiate, including an operating system that improved controllability. It gave away a software development kit, which allowed developers and programmers to introduce new applications such as 3D mapping and live video streaming on the DJI platform. DJI has quickly grown to become the global market leader, accounting for about 70 percent of small civilian drones. The company has grown from 300 to 3,500 employees over the past two years, including 1,000 in R&D. DJI has filed hundreds of patents and is aggressively pursuing suspected patent infringers.[15]

[15] *The Economist*, "Commercial drones: up," April 11, 2015; "DJI innovation—behind the overnight success," *People's Daily*, May 6, 2015.

Science-based innovation: Still catching up, but also trying novel Chinese approaches

Science-based innovation—inventing truly new products or techniques—is what many people consider the purest form of innovation. Science-based innovation not only leads to the highest levels of economic value but also can have profound impact on people (new lifesaving drugs, for example). China has made science-based innovation a top priority and has invested in building the institutions and capabilities needed for discovery and invention. So far, these investments have not translated into innovation leadership, but they have created a strong foundation. Meanwhile, in the industries that depend on science-based innovation, Chinese companies are forging their own path—taking advantage of Chinese scale and speed to conduct drug trials, for example.

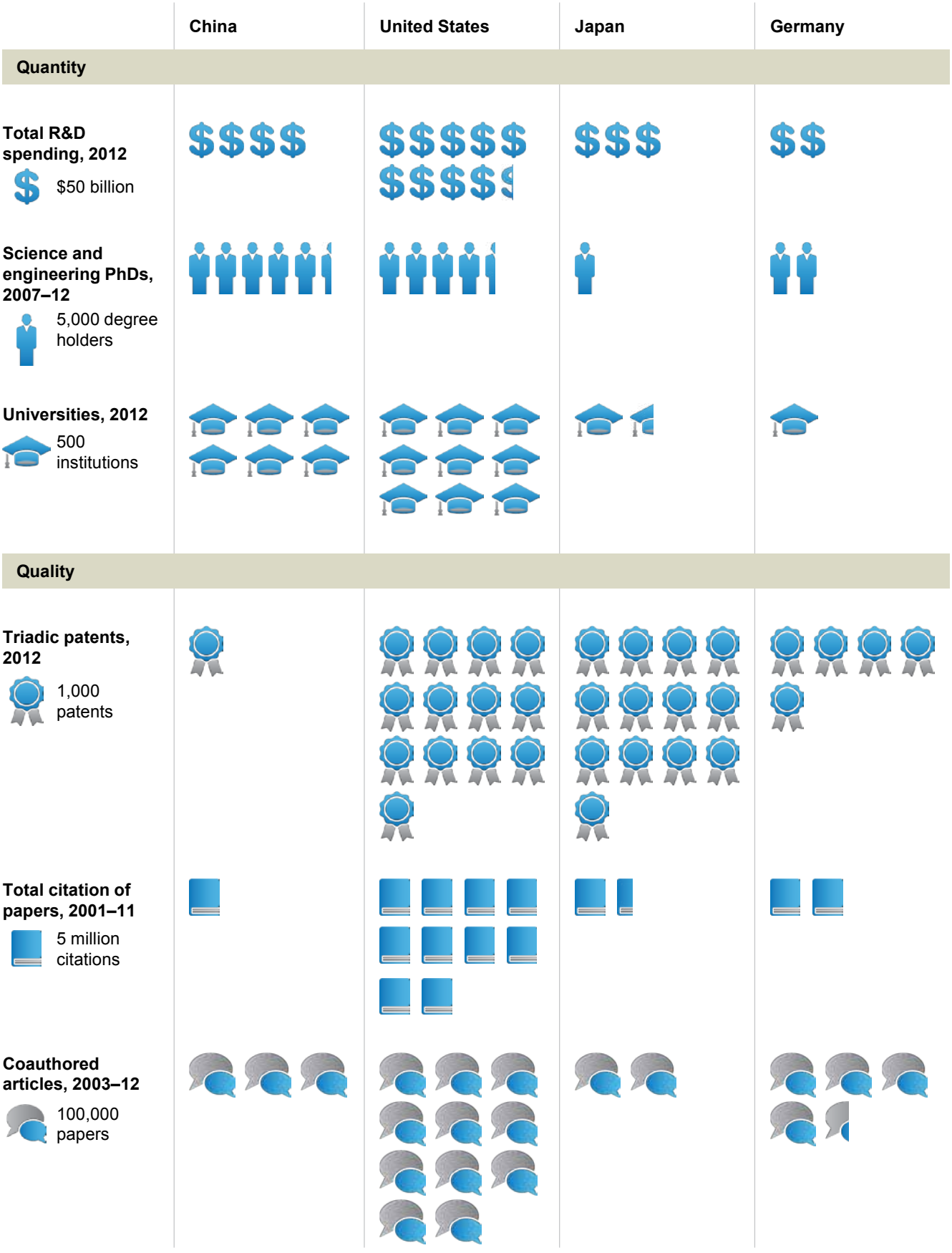
Still investing in capacity to catch up

In the three industries we analyze that depend on science-based innovation, China is not yet a top global competitor. It has less than 1 percent share of global revenue in branded pharmaceuticals, 3 percent in biotech, and 3 percent in semiconductor design. In these markets, Chinese firms still tend to focus on lower-value-added products and strategies, such as making generic pharmaceuticals. This record reflects both how long it takes to build science-based innovation capacity and how much catching up China still has to do, despite its large investments in R&D. In fact, there are no Chinese companies with strong brand names in science-based innovation.

China's science push has not paid off yet, largely because the quality of output from the science innovation system does not match the quantity of funding and scale of effort (Exhibit 8). In 2013, China graduated 28,700 PhDs in science and engineering, the largest number in the world. Chinese researchers published 440,000 science papers in 2013, the second most of any country. However, the papers are cited half as frequently as papers published by US researchers, and the number of papers coauthored with foreign academics is roughly half of the level in US, Japanese, and South Korean research. In 2012, China filed only 998 triadic patents, which are patents filed in the United States and Japan, and with the European Patent Office. Triadic filing is usually considered an indication of high patent quality. During the same period, US and Japanese companies filed ten times as many triadic patents. And while China has become a top spender on R&D, only 5 percent of its investment goes to basic research, compared with 19 percent in the United States.

Exhibit 8

China has invested heavily in science-based innovation but has not seen commensurate results



SOURCE: UNESCO Institute of Statistics; 2014 Global R&D Funding Forecast Report, Battelle; China National Bureau of Statistics; Report on the Survey on Research and Development (2013); Essential Science Indicators, National Endowment for Science, Technology and the Arts; World Market Monitor; McKinsey Global Institute analysis

In science-based innovation, companies are exploiting Chinese advantages in scale and speed, and building their own talent pools

Important advances in science come from insights drawn from an accumulation of knowledge and may take many years of basic research, followed by more years of commercialization. However, Chinese innovators are not waiting. They are trying to do things differently by leveraging China's scale and speed advantages in scientific research and filling talent gaps. They are attempting to defy convention about how to do science. If they succeed, they may offer lessons for companies around the world that depend on science-based innovation.

- **Using scale advantage.** BGI, a Shenzhen-based biotech company, is wielding scale to innovate in two ways: hiring more than 2,000 PhDs and tapping China's enormous population for genomic data. The company recognized that gene sequencing is less about breakthroughs at the laboratory bench and more about computing power and data mining, and it now owns about 50 percent of the world's genome sequencing capacity. This enables the firm to do sequencing on an unprecedented scale. BGI has also ventured into cloning, producing 500 cloned pigs a year, which makes it the world's biggest center for animal cloning. BGI expects new therapies and technologies to come from its vast genomics data and related technologies.[16]

- **Accelerating scientific discovery.** BeiGene, a biopharma company, is showing that Chinese companies can excel in science-based innovation. It has used speed and a focus on accuracy to get four cancer drugs into clinical trials within the past 18 months. Typical drug development goes through preclinical testing, which involves testing on animals, and then into clinical testing if preclinical testing is successful. Many drugs fail in the clinical phase, and BeiGene is addressing the problem by creating a proprietary testing model. It has built its own bank of human cancer samples, which enables BeiGene to approximate testing with human subjects during the preclinical phase. This increases success rates in the clinical phase and speeds up the drug development timeline.

- **Growing a talent pool.** A shortage of qualified talent is often cited as a barrier to science and technological innovation in China. Neusoft, a Chinese leader in health-care technology and IT services, is getting around this barrier by creating a talent pool for itself, its business partners, and the broader health-care technology ecosystem. The company has set up three universities and schools for biomedical and information engineering, with a total current enrollment of 29,000. Since the first school opened in 2001, Neusoft and its business partners have hired hundreds of graduates every year. Graduate-level researchers at the schools have also helped Neusoft's R&D efforts, contributing to such innovations as a cloud health-care platform and visual recognition software for computer-assisted driving.

[16] Henny Sender, "Chinese innovation: BGI's code for success," *Financial Times*, February 15, 2015.

Extending the success of Chinese innovation with supportive policies and company actions

Based on our assessment of how Chinese businesses innovate today and the strong capabilities for innovation that exist or are being developed, we believe that China has the potential to become a global innovation leader. Chinese corporations and a growing community of entrepreneurs have taken advantage of China's massive market to rapidly scale up new products and services, and to use consumer feedback for continuous innovation. China's manufacturing ecosystem continues to break ground in efficiency-driven innovation and China has demonstrated the ability to learn engineering-based innovation in sectors such as high-speed rail and telecommunications equipment. Proper policy supports and bolder innovation strategies by companies can build on today's successes and maximize China's innovation potential.

How policy makers can support innovation in China now

Government has supported innovation through both pragmatic economic development policies and investment in science and technology to build important foundational capabilities. Market-oriented reforms have contributed to today's innovation success in China by creating a huge consuming class and a competitive manufacturing sector. Continued reforms, particularly in state-owned enterprises, can help enable more innovation. For China to achieve global leadership across the four innovation archetypes in the next ten years, policy makers should modify innovation-specific policies. Government can empower entrepreneurs and let markets work; raise the innovation bar by being a demanding customer; use metrics that capture the impact of innovation; and foster strong regional innovation clusters.

Empowering entrepreneurs and letting markets work

One of the most important tasks for government is to create the right conditions for entrepreneurs to thrive. This is particularly important in fast-moving consumer markets such as Internet businesses. The Chinese government has already announced programs to support new-business accelerators and incubators, and has earmarked $6.5 billion for a government-backed startup fund. While access to early-stage financing is critical for entrepreneurs, as an investor, government should be careful to avoid picking winners (and losers) or crowding out private financing. The government of Singapore has addressed these concerns by co-investing with independent venture investors rather than investing directly. Under its Spring Startup Enterprise Development Scheme, the government matches private investment in companies dollar for dollar, thus helping companies scale faster while lowering risk for investors.

Governments can encourage innovation by cutting red tape. For example, the drug approval process in China can take seven to eight years longer than in the United States, which is one reason Chinese companies focus almost exclusively on generics. To make doing business easier, Australia launched a 90-day "Simplify" project to reduce red tape. Several government organizations hosted sessions with industry representatives and elicited more than 500 ideas to eliminate bureaucratic hurdles for businesses. A Simplify team—consisting of ten current government employees and ten recently retired senior executives—developed additional recommendations.[17]

[17] Government of South Australia, Office for the Public Sector, "Simplify—the government's red tape reduction initiative."

Government also can support innovation through quality and safety standards that build consumer trust and confidence in new goods and services. In the United States, for example, Underwriters Laboratories, a government-approved testing company, performs safety-related certification, validation, and testing. Established in 1894, UL helped enable public acceptance of electricity by assuring consumers that wiring and electrical devices such as lamps and appliances were safe.

Finally, continuing reforms in sectors where state-owned enterprises dominate can help expand market-based competition and innovation. Many state-owned enterprises do not have enough incentive to innovate, given the captive local market and a lack of commitment to long-range strategy because of the short tenure of rotating leadership. One way to address this innovation gap is through exposure to global competition, as seen in private company success cases. Huawei, for example, strengthened its innovation capabilities by competing against global players and collaborating closely with its global customers.

Government can accomplish much as a demanding customer

Government's role as a customer can be effective when applied in the early stages of technology development, helping to spur learning and rapid scaling, as China has demonstrated in high-speed rail and wind power. However, it can also impede innovation if government purchases become guaranteed markets for domestic champions. Policy makers can avoid this by making sure that government is a demanding customer, continuously raising technical requirements and insisting on competition. For example, the UK Department of Health and the National Health Service have used procurement competitions to redesign hospital equipment. One contest focused on ways to counteract hospital-borne infections, resulting in a method for reducing ventilator-associated pneumonia, a common problem in intensive care units.

Using metrics that capture the impact of innovation

Developing accurate measures of innovation is a challenge for many countries. Like other nations, China has set ambitious goals for easily quantified activities, such as R&D spending and patent applications. However, these measures have not fully translated into high-quality innovation output. For example, in the National Patent Development Strategy (2011–2020), Chinese policy makers set a goal of two million patents by 2015. The goal was met—and surpassed—ahead of schedule. However, more than 60 percent of patent applications in 2014 were utility and design patents, which typically do not represent significant innovation. To better encourage innovation, policy makers need to look beyond traditional measures such as R&D spending. In the United States, the National Science Foundation launched the Science of Science and Innovation Policy program to help policy makers assess the impact and efficiency of R&D investments. The program recently launched a cross-agency database in which R&D investments can be linked to social outcomes such as health and environmental impacts, workforce impacts such as student mobility and employment, and economic outcomes such as company startups.[18]

[18] www.scienceofsciencepolicy.net/content/star-metrics

Strengthening China's innovation clusters

Industries tend to cluster in geographic proximity, which can help drive innovation by facilitating collaboration among entrepreneurs, research institutions, and investors. Strong clusters are the birthplaces of successful innovation and many governments around the world have tried to create the next Silicon Valley. However, top-down, policy-driven approaches have largely failed; the entrepreneurial culture, academic and business ecosystems, and the critical mass of talent that created Silicon Valley cannot be conjured by policy action.[19]

China's innovation clusters are concentrated in large cities and have distinct specialties. Beijing is well known for the technology hub concentrated in the Zhongguancun area, which is home to both established technology companies and many startups. Shanghai is becoming a hub for life sciences and engineering, leveraging its strength in global trade and access to the Yangtze River Delta manufacturing base. Shenzhen's manufacturing ecosystem makes it a center of efficiency-driven innovation.

Policy makers can strengthen the innovative capacity of these clusters by encouraging cross-cluster collaboration. For example, innovative data analytics software from Beijing might be used in a health monitoring wristband manufactured in Shenzhen. The band could then be used by life sciences companies in Shanghai to monitor patients in clinical trials to accelerate drug discovery.

To make each of China's innovation clusters more globally competitive, policy makers can focus on the quality-of-life issues that are critical for attracting top talent, especially for science- and engineering-based innovation. Today, Chinese clusters rate poorly on "soft" quality-of-life metrics such as air quality, housing options, and traffic (See Box 1, "How Chinese clusters compete globally").

How companies can use Chinese innovation to enhance global competitiveness

Both domestic companies and global companies operating in China can benefit from the Chinese innovation model. The results can be used by both types of companies to compete in China and around the world. Both groups of companies also can make bigger bets on China's innovation potential and take advantage of the speed of innovation in China. In addition, global players operating in China can deal with local competition through multiple approaches: beat, buy, or join (collaborate with) them.

Making bigger bets on China's innovation potential

Foreign companies have established more than 1,200 R&D centers in China, but most focus on commercial opportunities for the local market rather than pursuing innovations that they can use globally. This is partly due to concerns over intellectual property, but it also reflects an outdated bias about the capabilities of Chinese innovation talent.

Nearly a decade ago, Microsoft took a different tack. It expanded the responsibilities of the Beijing-based Microsoft Asia-Pacific Research and Development Group in 2006, and the group's mission became "Innovation in China, innovation for the world." Today, more than 3,000 scientists and engineers, including some transferred from Microsoft headquarters, are assigned to such frontier research topics as natural user interfaces, next-generation multimedia, and data-intensive computing. They recently developed "Xiaoice," a language-recognition engine that uses artificial intelligence algorithms to understand human language and engage in conversation. The first version understands Chinese, and Microsoft is adapting it to other markets. China-based R&D can help other global players, especially as they pursue growth opportunities in developing economies, where innovations that lead to commercial success in the United States or Europe may not be appropriate.

[19] Vivek Wedhwa, "Silicon Valley can't be copied," *MIT Technology Review*, July 3, 2013.

Box 1: How Chinese clusters compete globally

Most of the Chinese cities listed in Exhibit 9 have invested heavily in producing as many patents as possible, but China has had less success in commercialization of innovation, particularly in cities outside of Beijing. In 2014, 38 Beijing-based companies issued initial public offerings, roughly comparable with Silicon Valley (35), Tokyo (55), New York (25), and London (34). However, only 13 companies based in Shanghai went public, 14 in Shenzhen, and three in Guangzhou.

All four Chinese cities compare poorly with global peers on the quality-of-life factors that can play a critical role in attracting the best innovation talent. On metrics such as housing costs, traffic, and pollution, Chinese cities underperform. Air pollution is three to seven times worse than in peer cities around the world, which industry leaders say is contributes to emigration by scientific talent. Diversity, often a driver for creative ideas, is low, too. In Silicon Valley, 36 percent of the population is foreign born and 44 percent of technology and engineering startups founded between 2006 and 2012 had at least one immigrant founder.[1] In most of China's innovation cluster cities, the figure is much lower—less than 1 percent of the population.

[1] *2014 Silicon Valley Index*, Silicon Valley Community Foundation, February 2014; *America's New Immigrant Entrepreneurs: Then and Now*, Kauffman Foundation, October 2012.

Exhibit 9

Chinese cities have produced many patent applications but need to improve quality-of-life factors that attract top talent

Low Medium High

	Innovation activity			Quality-of-life factors			
	Patent applications						
	Per year, 2011[1]	Compound annual growth rate, 2006–11[2] %	IPOs, 2014[3]	Air quality index[4]	Diversity % foreign-born	Traffic inefficiency[5]	Property price/ income[6]
Silicon Valley	6,912	1.8	35	29	36	179[7]	29
Boston	3,553	-0.4	18	45	27	89	~10
Paris	748	4.1	6	35	13	101	31
Tokyo	12,041	9.9	55	100	2	132	34
London	679	0.6	34	50	31	275	47
New York	3,698	-4.6	25	60	37	108	37
Seoul	3,379	11.6	11	90	3	84	26
Beijing	2,634	31.5	38	210	1	202	52
Shanghai	1,439	22,2	13	100	1	192	40
Shenzhen	7,892	30.6	14	90	0.3	192[8]	39
Guangzhou	1,106	26.6	3	80	0.2	192[8]	31

1 Patents filed under the Patent Cooperation Treaty, OECD.
2 Global compound annual growth rate over this period is ~4.3%.
3 By city of issuing company; covers 128 global stock exchanges, including AIM, Amsterdam, Catalist, Fakuoka, Hong Kong, Jasdaq, KOSDAQ, London, Nagoya, Nasdaq, New York, Sapporo Ambitious, Singapore, Taiwan OTC, Tokyo. Tokyo MOTHERS, Toronto, and Toronto Venture Exchange.
4 Sampled from AQICN, May and June 2015. 0–100 is good to moderate, 101–150 is unhealthy for sensitive groups, 151 and above is unhealthy. Does not account for seasonal changes; for example, Beijing's air quality is known to be much better during the summer.
5 The Inefficiency Index estimates inefficiencies in the traffic; high inefficiencies means more driving and longer commute times. Global distribution is characterized by a median of ~130 and average of 140 with a long tail. Medium here is defined as average +/- 0.5 standard deviation.
6 Average price of a 90-square-meter property divided by average after-tax disposable income in local market.
7 Uses San Francisco as proxy; likely an overestimate. As benchmark, Sacramento (in Northern California but not in Silicon Valley) has an inefficiency index of 97.36.
8 Estimated using commute time comparison with Shanghai.

SOURCE: OECD; World Intellectual Property Organization; Dealogic; Air Quality Index Organization; Chinese Statistical Yearbooks by city; Numbeo; literature search; McKinsey Global Institute analysis

Similarly, Chinese companies can use their innovation skills to conquer export markets. As growth in their home market begins to slow, Chinese companies will have to find more export sales. The innovation experience they have gained in serving the rapidly urbanizing Chinese consumer market can help these companies tailor products for the fast-growing markets of Asia, Africa, and Latin America.

Achieving—and maintaining—"China speed"

China's biggest contribution to innovation may well be showing how it can be done far more rapidly. Large companies tend to have long and costly product development cycles, requiring multiple sign-offs at various stage gates that can delay a product launch by months or even years. Chinese innovators act much more quickly, sourcing new ideas from customers and employees, taking bold bets, and quickly scaling up when something works. Developers at Xiaomi, for example, regularly post proposed features for smartphone software on an online forum. Consumers vote for their favorite ideas, and the company adds popular ones to the product development system, sometimes within a week. The result: Xiaomi has more competitive products and more loyal customers. At Alibaba, employees compete to get their innovative ideas developed. It received 270 project proposal in 2011 and green-lighted ten.

Global players can benefit by emulating China's streamlined and rapid innovation approaches. At the same time, Chinese innovators will need to think about how they can remain nimble as they grow.

Dealing with local competition: Beat them, buy them, or join them

Local innovators tend to have several advantages, including better local insights and agile processes that enable rapid responses to market needs. Global players can succeed in innovating for the Chinese market by beating local competitors, buying them, or joining them.

- **Beat them.** Over the past decade, foreign brands have accounted for over 70 percent of the Chinese passenger-vehicle market. To keep their lead, foreign companies not only have maintained quality and brand advantages but also have tailored products to local market needs. Audi, for example, recognized a need for long-wheelbase models in China, where luxury car buyers often have drivers and models with spacious back seat areas are in demand. To meet this need, in 2000 Audi began offering a long-wheelbase version of its flagship A6 model and then added the option on its compact A4 line. The move helped Audi achieve leadership in the Chinese luxury segment. In 2014, the company sold 575,100 units in China, a third of its global sales.

- **Buy them.** Often it is not practical for a large global player to reinvent products or processes to address the needs of a single market, even one as large as China. In such cases, global players may be better off buying a local competitor. Philips, a Dutch consumer and health-care products company, bought Povos, a Chinese rice-cooker company, to fill a hole in its product line and tap into a local source of innovation. SEB, a French appliance maker, bought Supor, a Chinese cookware company, for similar reasons.

- **Join them.** When it is difficult to compete, companies can collaborate with local players, by forming joint ventures or simply using Chinese competitors. Amazon, for example, launched its online retail business in China in 2004. By 2014, it had captured less than 3 percent of the market. While maintaining its own online store, Amazon has also signed up with Alibaba, the dominant online platform (with 80 percent share), opening a store on Tmall, Alibaba's business-to-consumer platform.

By better understanding the way innovation works across industry sectors, Chinese business leaders, academics, and policy makers can effectively focus efforts to promote innovation. They can build on the success of today's innovators and create policies that can promote innovation in the four archetypical sectors we analyze. China can continue to evolve into a more mature, productive, and innovation-based economy and may even provide a model for effective innovation approaches around the world.[20]

[20] This paper is a preview of an in-depth study of innovation in China that will appear later in 2015. The full report will provide greater detail, as well as additional analysis of China's potential to innovate successfully in more fields in the next ten years and the possible global impact of the Chinese innovation model.

McKinsey Global Institute
July 2015

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