From "Made in China" to "Innovated in China": Necessity, Prospect, and Challenges

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From 1980–2015, China's economy grew at an average annual rate of 8.7 percent. During these 35 years, real per capita income increased by a cumulative rate of 1,759 percent, from $714 in 1980 to $13,277 in 2015 (based on the IMF's World Economic Outlook data, expressed in 2011 international purchasing power parity dollars). Apart from Equatorial Guinea, a country of less than a million people that literally struck oil, no other economy grew as much during the same period. China's growth performance is clearly spectacular and exceptional.

But China's economy has reached a crossroads. The annual growth rate has slowed to about 6–7 percent since 2014 and will likely moderate further. Part of the reason for the slowdown could be cyclical, a result of a relatively weak world economy. But a major part of the reason is structural and fundamental. China's economic growth of the previous three and a half decades was based on several key factors: a sequence of market-oriented institutional reforms, including openness to international trade and direct investment, combined with low wages and a favorable demographic structure. Chinese wages are now higher than a majority of non-OECD economies. For example, China's wages are almost three times as high as India, an economy with almost the same-sized labor force. The Chinese working-age cohort has been shrinking since 2012.

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The first section of this paper will review what factors have propelled China's economic growth in the past, and explain why they are unlikely to provide the same kind of boost going forward.

Future growth in China has to come mostly from the growth of labor productivity. Since China's investment-to-GDP ratio was already a remarkable 43.3 percent in 2015, it is hard to expect a high growth rate of productivity from continued physical investment. Indeed, Bai and Zhang (2014) estimated that the returns to investment have shown signs of decline since 2008. Some productivity increase could come from reducing resource misallocation (Hsieh and Klenow 2009), which could be accomplished by further reforms in the factor and product markets, including reforms of state-owned enterprises. However, the pace of reform in the future is unlikely to be as aggressive as in the past, partly because interest groups across China now have more means to block reforms than in the past and partly because the low-hanging fruit in the area of institutional reforms has been picked. Thus, productivity growth from this source also faces a limit.

Since the onset of the global financial crisis in 2008, the external demand for Chinese products has weakened, and wages in China have meanwhile increased faster than in almost all other major economies. A growth model based on exploiting the use of cheaper labor is no longer viable. While a strict family planning policy implemented since the early 1980s once produced an unnaturally low birth rate and therefore an unusually favorable dependence ratio for China, the same force has now produced relatively few people entering the labor force today relative to the new retirees, hence yielding an unusually unfavorable dependence ratio.

Facing rising labor costs and weak external demand, China's firms have to make a tough choice: in, out, up, or down. "In" is to move factories to inland areas where the wage is lower than coastal China. Given the pace of convergence within the country and the cost of logistics facing firms inland, this is at best a temporary strategy. "Out" means engaging in outbound direct investment, combining Chinese know-how with low wages in other countries. "Up" means innovation and upgrading, so that the firms no longer need to depend on low-paying unskilled labor. "Down" means closing the business; it is an option for individual firms, but not for the country as a whole. While a portfolio of these strategies will be employed by firms, a decisive factor for China's economic future is whether its firms can innovate and upgrade and how fast they can do so. In the next section, we focus on innovation and quality upgrading, and ask the question: Is China investing enough and wisely in research and development, and can it transition to a more innovative economy?

We study three questions in particular. First, how strong is China's national investment in research and development (R&D)? We do so by comparing the Chinese trajectory in recent years with international experiences.

Second, what is the growth of innovation by Chinese firms? To answer this question, we make use of data on patents from China State Intellectual Property Office (SIPO), the United States Patent and Trademark Office (USPTO), and World Intellectual Property Office (WIPO). We use the data on patents to compare China's rate of innovation as compared to other BRICS (that is, Brazil, Russia, India, and

South Africa) economies and high-income economies (such as the United States, Germany, Japan, and the Republic of Korea). We will use patent applications and patents granted by firms both at home and in the United States as proxies for innovative activities. China's performance on innovative activities as measured by patent data has been strong, especially in recent years, but China may well have some lessons to learn from India and in particular from the Republic of Korea. We will argue that rising wages and expanding markets are among the important drivers behind China's patent explosion.

Third, because the Chinese economy continues to have a nontrivial share of state-owned enterprises, we investigate possible resource misallocation in the innovation space. Although state-owned enterprises have received more subsidies from the government, their performance in innovation is lackluster compared to private enterprises. Furthermore, the elasticity of patent filing or patents granted with respect to expenditures on research and development is significantly higher for private sector firms than for state-owned enterprises. We interpret these data patterns as existence of misallocations in public fiscal resources. Interestingly, we find that China's state-owned enterprises often face higher realized tax burdens (the sum of corporate income tax and value-added tax as a share of sales or value added). To improve the efficiency of resource allocation, the direction of policy reforms should perhaps put weight on leveling the playing fields for firms across all ownership types with simultaneous reductions in discretionary subsidies and taxes.

Sources of China's Growth since 1980 and the Moderation of Growth since 2012

China's rapid growth in the past several decades has been driven by a combination of two sets of factors: a) market-oriented policy reforms to let market-determined output prices and factor prices replace administrative prices, to introduce and strengthen property rights, and to reduce barriers to international trade and investment; and b) economic fundamentals, including in particular a favorable demographic structure and a low initial level of labor cost. Here, we offer an overview of these factors and how they have evolved in the last 36 years.

The Chinese growth miracle started with the rural sector reform known as the "rural household responsibility system" in the early 1980s. Instead of collective farming and selling all output to a national procurement plan at a price set by the plan (usually substantially below the would-be market price), farmers were granted land user rights and allowed to sell what they produced in excess of the official quota at a market price. Agricultural production and rural incomes witnessed a dramatic increase in the ensuing years (Lin 1992). In a few years, hundreds of millions of farmers were released from their land and many started to work in factories, providing the nonfarm sector with a seemingly unlimited labor supply. In the 1980s, China's labor cost was among the lowest in developing countries, lower than in India and the Philippines and indeed lower than 114 out of 138 non-OECD

Table 1
Number of Registered Firms in China (1995–2014)

	Firm count at year end	Private (%)	State-owned firms (%)	Foreign (%)
1995	4,598,604	71	24	5
2000	5,875,706	76	19	5
2005	7,980,991	85	10	5
2010	11,150,201	90	5	5
2014	18,178,921	94	3	3
Annual growth rate (%)				
1995–2005	6	8	−3	5
2005–2014	10	11	−5	3
1995–2014	8	9	−4	4

Source: Tabulated by authors based on China Firm Registry Database.
Note: Firms ownership classification is based on the ownership information on firm registration. Foreign-invested firms include both fully foreign-owned and sino-foreign joint ventures. All firm ownership types other than "state" or "foreign" are grouped in "private."

economies. The vast majority of these workers were restricted to living in rural areas by the *hukou* system, with many working during the 1980s for township and village-owned enterprises, which were manufacturing firms located in rural areas. These enterprises provided a way for a reallocation of labor from low-productivity farm activities to higher-productivity manufacturing activities, at a time before restrictions on internal migrations were relaxed.

During the 1990s, the government launched reforms of the township and village enterprises and of the state-owned enterprise sector. Most township and village enterprises were privatized, de jure or de facto. By 2011, the township and village enterprise sector had almost disappeared, with employment plummeting from 129 million in 1995 to merely 6 million in 2011 (Xu and Zhang 2009). Among state-owned enterprises, which were overwhelmingly in urban areas, employment fell by about half from 113 million in 1995 to 67 million in 2011. The number of state-owned firms declined from 1,084,433 (or 24 percent of the total number of firms) in 1995 to 521,503 (or 3 percent of the total) in 2014 (according to our tabulations based on the China Firm Registry database in Table 1). The much larger drop in the number of state-owned enterprises than in their employment was part of a deliberate policy of "grasping the large and letting go of the small"—that is, privatizing small state-owned enterprises and consolidating bigger ones (Hsieh and Song 2015).

The reform was painful in the short run, in that tens of millions of urban workers had to leave their former state-owned employers. Remarkably, the country avoided a big spike in the unemployment rate. The key is that the de facto privatization was accompanied by aggressive reforms to lower entry barriers faced by private sector entrepreneurs. The inefficiency of the previously centrally planned, state-dominated economic system, together with very high barriers to entry, meant huge unexplored or underexplored profitable opportunities. As a result, almost all

of the lost jobs in township and village enterprises and state-owned enterprises were offset by new job opportunities in the dynamic private sector. As shown in Table 1, the number of private enterprises increased by nearly five-fold to about 17 million (18,178,921 × .94) in the period 1995–2014. By 2011, 193 million people worked in private enterprises (including self-employed) (CNBS 2012). This represents the largest de facto privatization program in world history in terms of the number of workers who move from state-sector to private sector employment, and one that was accomplished without massive unemployment.

Through this period, the growth in the Chinese economy has become driven overwhelmingly by the growth in the private sector aided by an expansion in the number of entrepreneurs. This pattern is especially true for the manufacturing sector, which has been growing faster than either the agricultural or service sectors. Indeed, Wei and Zhang (2011b) have documented two "70 percent rules" using manufacturing firm census data in 1994 and 2005: First, approximately 70 percent of the growth in industrial value added came from private sector firms between these two census years. Second, approximately 70 percent of private sector growth in value added came from growth in the count of new private sector firms (the extensive margin), while the remaining 30 percent came from growth of existing firms (the intensive margin).

China also carried out a number of other reforms intended to incentivize local governments to pursue growth-friendly policies. For example, under the fiscal arrangement introduced in the early 1980s, local governments and the central government follow a pre-determined revenue formula (though varying across regions as a function of local bargaining power), which stimulates the incentives of local officials to create a more business-friendly environment. More generally, in spite of the political centralization by the Communist Party, the country has implemented a system of fiscal and economic decentralization that grants local governments sufficient decision-making power—and more importantly incentives—to compete with each other. The local economic growth rate is used as a key performance indicator for the career advancement of officials. The delegation of economic policy authority to local governments, which have better knowledge of local information, and competition for investment and tax base among local governments in the Chinese style of federalism have provided a useful check on the temptation of local government officials to expropriate local firms. As a result, firms acquire some de facto security of property rights, even if the formal property rights institutions are problematic (Qian and Weingast 1997; Xu 2011).

China's government also set up numerous special economic zones and special development zones in the coastal provinces to attract foreign direct investment in the 1980s and 1990s. These zones help the government to meet two challenges. First, public funding for infrastructure was limited, especially in the early days of the reform era. The government was able to concentrate limited public funding to provide adequate roads, power supply, waste treatment and other infrastructure to the firms within the zones, even when it was not able to improve the infrastructure nationally at the same speed. Second, policy reforms within these zones were politically easier than doing the same things on a national scale. The success in these

zones in terms of economic growth, employment, and tax revenues in turn facilitated similar market-oriented reforms outside the zones. Foreign direct investment rose rapidly in China, especially since 1992, and these zones played an important role in attracting international firms. Foreign-invested firms were and continue to be an important channel for transfer of technology and management ideas from advanced economies to China.

China's integration with the global economy was accelerated after the country joined the World Trade Organization in December 2001. Foreign-invested firms have often accounted for half of the country's total exports. China's trade expanded fast: While China's GDP approximately doubled once every seven years, its export value in US dollar terms doubled once every four years. By 2004, China had come to be known as the World's Factory, a label describing not only the sheer volume of its cross-border trade, but also the breadth of its sector coverage (as discussed in Feenstra and Wei 2010). China's growth in both imports and exports, along with foreign investment coming to the country, is also an important channel for domestic firms to acquire technological knowhow.

While the deep cause of growth and development is institutional changes engendered by policy reforms and embrace of globalization, the proximate drivers of economic growth include improvement in productivity as a crucial component. The increase in productivity stems from innovations within sectors and the reallocation of resources (mainly workers) from lower-productivity to higher-productivity sectors, such as from the state sector to the private sector and from the agricultural sector to nonagricultural sectors (Zhu 2012). Sectoral productivity and structural change accounted for 42 and 17 percent of economic growth during 1978–1995 (Fan et al. 2003).

For three decades following the start of market-oriented reforms, China appeared to have an inexhaustible amount of "surplus labor" (which can be thought of as conceptually the same as low-productivity labor in rural areas). But signs of labor shortage started to emerge in the first decade of the 2000s. According to Cai and Du (2011) and Zhang, Yang, and Wang (2011), wages for unskilled workers showed double-digit growth starting in 2003–2004. The exact timing of a sharp increase in the wage rate of unskilled workers is subject to debate. Wang, Huang, Zhang, and Rozelle (2011) report a turning point as early as 2000. On the other hand, Knight, Deng, and Li (2011) and Golley and Meng (2011), for example, point out that barriers to internal migration, especially a rigid household registration system that prevents rural households from moving freely to urban areas, imply additional scope for rural-to-urban migration if and when the remaining barriers can be dismantled. In any case, China is a low-wage country no more.

Two features of demographic transition have also been a powerful driver of China's growth in the past three and a half decades. The first feature is a favorable dependency ratio. China's sharp decline in fertility rate has meant fewer young dependents to support for a given size of the working cohort. The fraction of prime-age people in total population rose steadily for three decades, creating an unusually large demographic dividend, which in turn contributed to economic growth (Cai and Wang 2008; Wei 2015).

The second feature of demography that affects growth is the gender ratio imbalance of the premarital cohort. This less-studied factor may have a quantitatively significant effect as well. The one-child policy has yielded an unintended consequence in distorting the sex ratio in favor of boys. As the one-child generation enters the marriageable age, young men face a very competitive marriage market. In order to attract potential brides, families with sons choose to work harder, save more, and take on more risks, including exhibiting a higher propensity to be entrepreneurs (Wei and Zhang 2011a, b; Chang and Zhang 2015; Wei, Zhang, and Liu forthcoming). It is estimated that increasing marriage market competition due to sex ratio imbalances has contributed to about two percentage points of economic growth per year (Wei and Zhang 2011b).

It is important to point out that the additional growth due to an unbalanced sex ratio is of an immiserizing type: social welfare is likely to have become lower even though the GDP growth accelerated. The logic is explained in Wei and Zhang (2011b): The extra work effort and extra risk-taking that produce a higher GDP growth rate are motivated by a desire to improve one's chance (or one's children's chance) of success in the marriage market. Yet the fraction of young men who will not get married in the aggregate is determined by the sex ratio, and not by the economy-wide work effort, risk-taking, or GDP growth rate. In this sense, the extra work effort and risk-taking are futile; households collectively would have been willing to give up this part of income growth in exchange for no sex ratio imbalance.

Thus, from 1980 to 2011, China was experiencing a relatively low wage, a large workforce with a favorable dependency ratio, and an increasingly unbalanced sex ratio in the premarital cohort. But starting in 2012, China's age cohort of 15–60 started to shrink in absolute size. Policy changes to postpone the official retirement age or to encourage more female labor force participation will at best moderate the resulting decline in the workforce. Because the female labor force participation was very high under the central planning regime before the 1980s, higher than most non-Communist countries in the world, such as the United States, Japan, Germany, India, and Indonesia, the participation rate of women in the labor force has in fact come down over time. The recent relaxation of the family planning policy in November 2015 from the limit of one child per couple to two children per couple, while motivated by a desire to improve the demographic pattern for the economy, will make the dependency ratio worse for the next decade-and-a-half rather than better by adding to the number of children without altering the size of the workforce. After all, no couple can produce a 16-year old right away (Wei 2015). The sex ratio at birth started to become less unbalanced in 2009, and the contribution to growth from an unbalanced sex ratio will become weaker over time.[1]

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[1] Beside a moderation of growth since 2012, China has to deal with challenges associated with income inequality, regional disparity, environmental degradation, and corruption. For perspectives on these challenges, see Fan, Kanbur, Wei, and Zhang (2014).

Figure 1

**Contributions to GDP Growth of Physical Capital, Human Capital, and
Total Factor Productivity, 1979–2015**

(share)
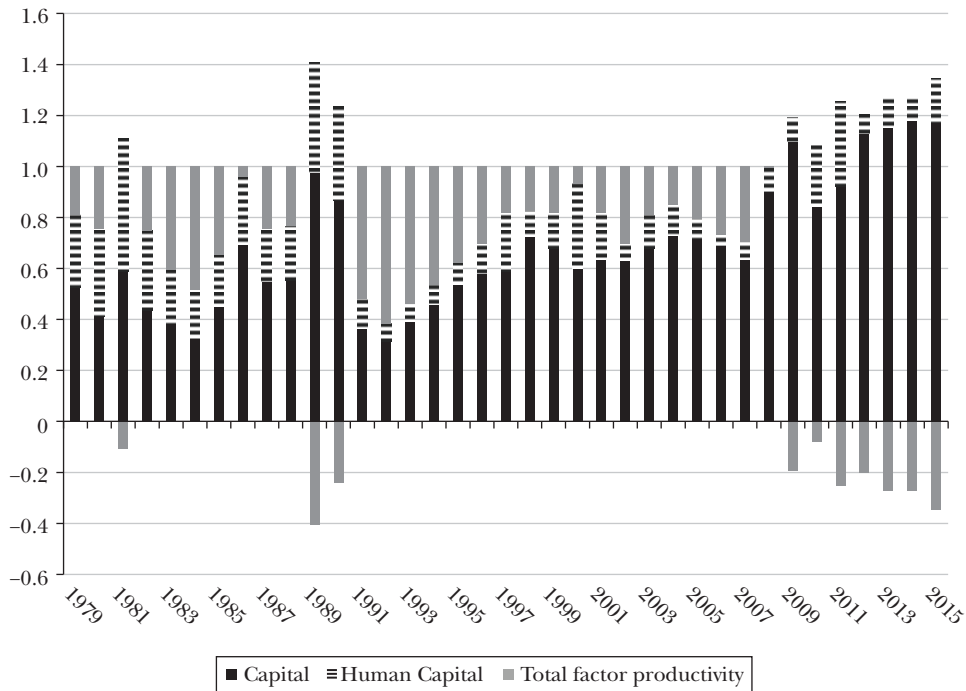
Source: Authors' calculations based on the methodology and data sources detailed in Online Appendix A.
Note: See Appendix for details of the estimation.

Evolution of Aggregate Productivity

To see how the growth of physical capital, human capital (workforce adjusted for average years of schooling), and total factor productivity each contributes to China's GDP growth, we perform a simple decomposition based on an aggregate production function approach.[2] Figure 1 summarizes the result. A few features are worth noting. First, investment in physical capital has always been important for China's growth, accounting for 67.9 percent on average throughout this period. The relative share of contribution from physical investment increased to 107 percent after 2009, which resulted from the government stimulus package in response to the global financial crisis. Second, the contribution from the growth of human capital has been positive, at 12.5 percent during 1999–2008 and 16 percent during 2009–2015.

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[2] The computation method and data sources are explained in online Appendix Part A, available with this paper at http://e-jep.org.

Because of the outsized role of physical investment in the Chinese economy, the contribution of human capital is smaller than what one typically finds from growth decomposition for an OECD economy. Third, the growth of total factor productivity was a major contributor to GDP growth before 2008, often accounting for 20 percent or more to the total growth. (An exception was the period of 1989–1991, a time of domestic political turbulence and international sanctions.)

Strikingly, the contributions from the growth of total factor productivity have turned persistently negative since 2009.[3] Upon reflection, this is perhaps not overly surprising. The Chinese government's response to the global financial crisis that started in 2008 was to encourage physical investment through an aggressive fiscal (and bank lending) program, but there were no ambitious structural reforms pursued during this period that could have raised aggregate efficiency, and yet GDP growth started to moderate after 2012—and this combination is a recipe for negative growth in total factor productivity.

The Chinese economy is at a crossroads. Structural factors in the form of less-favorable demographics and a higher cost of labor imply a lower potential growth rate. To achieve robust future growth, raising the growth of total factor productivity is a must.

One way to raise future productivity growth is to pursue more structural reforms. These include removing barriers to labor mobility from rural to urban areas (the *hukou* system) and leveling uneven access to bank loans by firms of different ownership. Another way to raise productivity growth is via innovation. Innovation can take the form of creating new products, new ways of using existing products, new designs, new processes for producing existing products that are more efficient and cost-effective, new ways of organizing business, and new ways of branding and marketing the products or services.

Can China transition from a world assembly line to an innovation powerhouse? It's easy to list reasons to be skeptical. There is no shortage of news stories of intellectual property rights violations by Chinese companies.[4] There is criticism that the Chinese school system puts too much weight on rote learning and not enough on creative and critical thinking. On the other hand, more optimistic examples are available, too. Tencent, the company that provides the popular communication tool, WeChat, which combines group chat, voice calls, video sharing, and financial exchanges, is generally regarded as among the most innovative internet companies in the world. Huawei, the telecom equipment producer, is said to take out more

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[3] The baseline calculation assumes a capital income share of 0.50. We vary the share from 0.4 and 0.55 and find that the broad pattern of the evolution of total factor productivity stays the same. Our finding is broadly consistent with Wu and Conference Board China Center (2014). For example, they reported negative total factor productivity from 2007 to 2012, while our estimate indicates such a decline from 2009 to 2014. One difference between their study and our growth decomposition is that they obtain a larger contribution from human capital, which may be related to the way the schooling adjustment is made.

[4] Fang, Lerner, and Wu (2016) provide evidence that regional variations in the strength of intellectual property rights protection in China are correlated with propensity to innovate for privatized formally state-owned firms.

patents a year than either Apple or Cisco. The world's first quantum satellite was launched by China in August 2016. To address whether such examples of innovation are exceptions or the norm, we offer a systematic look at the data in the next section.

It is hard to quantify with precision the relative contributions to total factor productivity growth from different sources. From the *China Statistical Yearbook on Science and Technology*, we compute and compare investment made by firms in the survey in (a) importing and digesting foreign technologies, (b) buying and digesting technologies from other domestic firms, and (c) developing their own in-house technological improvement. In 2000, the survey firms collectively spent nearly 20 percent of their technology improvement budget on importing and digesting foreign technology, about 2 percent on buying technologies from other domestic sources, and 78 percent on developing their own in-house technological improvement. Over time, the share of the first item declines, whereas the last two items expand. By 2014, the survey firms collectively spent 11 percent of their technological improvement budget on importing and digesting international technologies, about 5 percent on buying technologies from domestic sources, and the remaining 84 percent on developing their own in-house technological advancement, with the last two categories showing a significant increase over the shares in 2000 (see online Appendix Figure A1). These numbers indicate in an indirect way the improvement in the domestic innovation capacity in China's manufacturing sector.

Research and Development: Investment and People

Innovative leaders at both the corporate and national levels tend to invest heavily in research and development. The United States, Japan, and Germany, the largest three rich economies, invested more than 2.7 percent of their GDP in research and development in 2014, which is almost 50 percent more than an average OECD country (about 1.9 percent in 2014), and about three times as much as most developing countries. If China makes the transition to a more innovative economy, it needs to make a commitment to research and investment spending as well.

In 1991, when systematic data on this subject started to be collected, China invested 0.7 percent of GDP in research and development. This was much lower than technological leaders like the United States, Japan, and Germany, but not out of line with big developing economies such as India, Brazil, or South Africa. Indeed, because China's competitiveness at this time was based on exploiting its vast cheap labor and making use of technologies developed elsewhere, domestic research and development and innovation were not an imperative at this time.

A comparison of research and development spending between China and other economies is provided in Figure 2. For all countries in the world other than China, we plot research and development expenditure as a share of GDP in the latest possible year (which is 2014 for most countries). Clearly, higher-income countries tend to have a higher ratio of research and development spending to GDP. For China, we plot the same ratio using corresponding data for China from 1995 to

Figure 2
Research and Development Intensity Comparison
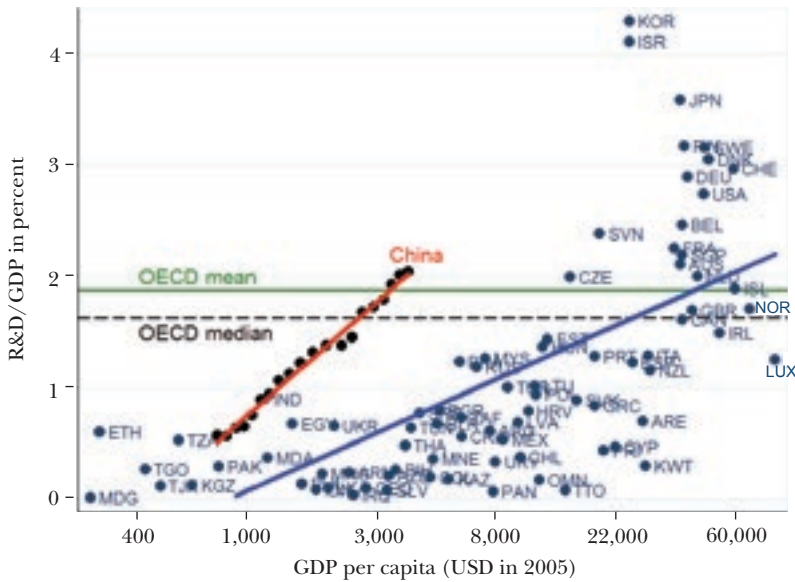
Source: World Bank, OECD database (https://data.oecd.org/rd/gross-domestic-spending-on-r-d.htm).
Note: Data for China are from 1995 to 2014, and data for all other countries are for 2014 or the latest year available.

2014. By 2010, China had reached the median value of research and development as a share of GDP. By 2012, its spending had caught up with the OECD average (at 1.88 percent of GDP in that year) even though China's income level was still less than one-fifth of the OECD average. By 2014, China's research and development spending had reached 2.05 percent of GDP. From an aggregate R&D spending viewpoint, China is an overachiever.

Another indicator of innovation effort is the share of researchers in the population. In 1996, China had 443 researchers per million people. In comparison, the shares for the United States, Japan, and Korea were 3,122, 4,947, and 2,211 per million, respectively. The Chinese ratio in 1996 was comparable to Brazil (420 per million in 2000) and better than India (153 per million in 1996), though much lower than Russia (3,796 per million in 1996). By 2014, the share in China had grown to 1,113 researchers per million population.[5] Because China's research and development expenditure has grown faster than the number of researchers, research and development expenditure *per researcher* has grown over time as well.

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[5] For more cross-country comparisons, see online Appendix Figure A2, available with this paper at http://e-jep.org.

Table 2
Patent Applications and Patents Granted (1995–2014)

	Number of patent applications at China's State Intellectual Property Office (SIPO)	Number of patents granted by China's SIPO	Distribution of patents granted by type of patents (3)			Share of patents granted to applicants from outside China (%)	Number of patents granted by foreign patent offices to China-based applicants
			Invention (%)	*Utility model (%)*	*Design (%)*		
Year	*(1)*	*(2)*				*(4)*	*(5)*
1995	83,045	45,064	8	68	25	8	75
2000	170,682	105,345	12	52	36	10	88
2005	476,264	214,003	25	37	38	20	398
2010	1,222,286	814,825	17	42	41	9	2,587
2014	2,361,243	1,302,687	18	54	28	7	10,603
Annual growth rate in different periods (%)							
1995–2005	19	17	31	10	22	28	18
2005–2014	19	22	18	27	18	9	44
1995–2014	19	19	25	18	20	18	30

Source: Authors' tabulation based on data from China's State Intellectual Property Office's webpage (http://www.sipo.g ov.cn/tjxx/) for columns 1–4 and the World Intellectual Property Office for Column 5.

The Pace of Innovation as Measured by Growth in Patents

Not all dimensions of innovation are equally well measured. The output of innovation can take the form of patents, commercial secrets, improvement in business processes or business models, and others. Innovation can also take place in areas outside the commercial space, such as culture. Since innovation in the form of patents is relatively well measured, we will pay special attention to patents by firms. Our conjecture is that innovation across all dimensions is positively correlated.[6]

The number of Chinese patents has exploded. Table 2 presents some summary statistics. The number of patent applications filed in China's State Intellectual Property Office (SIPO) rocketed from 83,045 in 1995 to more than 2.3 million in 2014, at an annual growth rate of 19 percent (column 1). In 2011, China overtook the United States as the country with the most patent filings in the world that year (based on data from WIPO).

What explains the explosion of Chinese patents? Could it be easy approval or low-quality patents? Some straightforward comparisons across countries suggest not.

One simple metric for judging ease of patent approval is the ratio of the number of patents granted in year t to the number of patent applications in year $t-1$, which we will call the patent approval rate. Based on data from the World Intellectual Property Organization, the patent approval rate in China in recent years is 30–40

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[6] A simple regression of firm-level total factor productivity (estimated using the Olley–Pakes method based on data from the Annual Survey of Manufacturing Firms) on the cumulative number of patents yields a positive slope coefficient. In other words, firm-level total factor productivity and the stock of patents are positively correlated. Fang, He, and Li (2016) also show a positive association between firm-level total factor productivity and patent count. They interpret this as patent innovation raising productivity; such an interpretation would need an instrumental variable approach to back it up.

Table 3

Number of Patents Granted by the US Patent and Trademark Office (USPTO) to International Corporate Applicants

Year	China	Brazil	India	Russia	South Africa	Germany	Japan	Republic of Korea
1995	62	63	37	98	123	6,600	21,764	1,161
2000	119	98	131	183	111	10,234	31,296	3,314
2005	402	77	384	148	87	9,011	30,341	4,352
2010	2,657	175	1,098	272	116	12,363	44,814	11,671
2014	7,236	334	2,987	445	152	16,550	53,849	16,469
Annual growth rate in different periods (%)								
1995–2005	21	2	26	4	−3	3	3	14
2005–2014	38	18	26	13	6	7	7	16
1995–2014	28	9	26	8	1	5	5	15

Note: Computed by authors based on data from the United States Patent and Trademark Office (USPTO).

percent, which is essentially in the middle of the approval rates across countries. For example, the Chinese approval rate is higher than those in India and Brazil, which are close to 20 percent, but lower than those in the United States and Korea, which are in the range of 50–60 percent. Therefore, the Chinese patent approval ratio does not seem to be unusually high.

Among the three types of patents (invention, utility model, and design), the fraction of approved invention patents, arguably the most technically intensive category, rose from 8 percent in 1995 to 18 percent in 2014 (column 2 of Table 2). In 2005, patents granted to foreign applicants accounted for more than 20 percent of China's total approved patents, but dropped to 7 percent in 2014, suggesting an increasing role of indigenous innovations in the Chinese economy since 2005. As Table 2 shows, both total Chinese patents filing and approvals show a rapid growth.[7]

One way to consider the quality of Chinese patents is to examine patents applied by and granted to Chinese firms in other countries. As noted earlier, the rate of patents approved by China's patent office grew at an annual rate of 19 percent from 1995 to 2014. During that period, the number of patents granted to Chinese applicants by patent offices in developed countries was rising even faster at 30 percent per year (see last column in Table 2).

Of particular interest is a comparison of the number of patents granted by the US Patent and Trademark Office (USPTO) to Chinese firms with those to firms from other countries. As shown in Table 3, the number of patents granted by the USPTO to Chinese corporate applicants rose from 62 in 1995 to 7,236 in 2014. The annual growth rate was 21 percent in the first half of the period (1995–2005) but accelerated

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[7] The online Appendix available with this paper at http://e-jep.org includes more detail on patent data. For example, Appendix Tables A2 and A3 provide more detail on Chinese patent filings and approvals, while Appendix Figure 3 provides more details on cross-country comparisons of patent approval rates.

Figure 3
Patents Granted in US Patent and Trademark Office (USPTO) to Different Countries
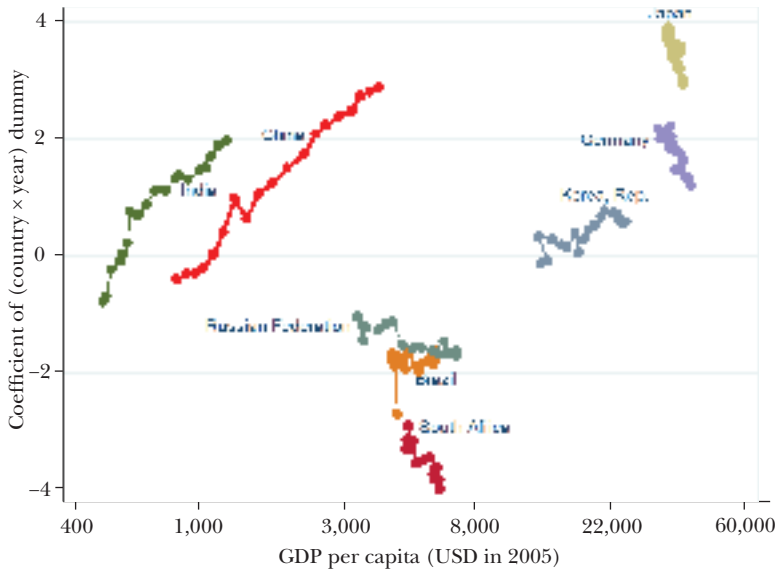
Source: Authors using data from World Intellectual Property Office (WIPO).
Note: Conditional plot by controlling for population, population squared, and country and year fixed effects. One can interpret the coefficients indicated on the y-axis as showing how a given country does relative to the average international experience based on its population size.

to 38 percent a year during the latter half of the period (2005–2014). Of the comparison countries—Brazil, Russia, India, South Africa, German, Japan, and Korea—only India had a similar rate of growth in corporate patents in the United States.

Two natural adjustments are to consider a country's population size and income level. To this end, we run cross-country regressions with log number of patents granted to applicants from various comparison countries by the US Patent and Trademark Office as the dependent variable. As explanatory variables, we use the log of population, squared log of population, and country times year (country × year) fixed effects. Figure 3 plots the estimated coefficients for the interaction term between county and year fixed effects for selected counties. These coefficients can be interpreted as how a given country does relative to the average international experience based on its population size. China shows steady gains in patents even with these adjustments. Of the comparison countries, India also shows gains over time after these adjustments, but Japan, Germany, the Republic of Korea, the Russian Federation, Brazil, and South Africa do not. Overall, Chinese firms collectively do better in their patent count than what the country's population size and income level would have suggested.[8]

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[8]Details of the regressions are available in an online Appendix available with this paper at http://e-jep.org. See Appendix Table A5.

One can also look at foreign citations of Chinese patents (granted by China's State Intellectual Property Office). The count of foreign citations of Chinese invention patents grew at the rate of 33 percent a year during 1995–2005, but accelerated to 51 percent a year from 2005 to 2014. The growth of citations of Chinese utility model patents is similar, at 36 percent per year during 1995–2014. After adjusting for population size and income, Chinese firms perform well.[9] This pattern is consistent with international recognition of rising scientific and innovative ideas out of China.

Overall, not only has the number of Chinese patents exploded, but a variety of comparisons suggest that Chinese patent quality also exhibits a real and robust improvement over time that is quite favorable relative to international experience. There is no reason to be pessimistic about the intrinsic ability for Chinese firms to innovate.

Patterns of Innovation Growth

By looking at patterns of patents across different categories of industries, we can gain insight into some of the factors as potential drivers of innovation, including the rise in relevant market size, industrial competition, market size, and change in relative prices (such as rising wages). We merge the Chinese patent database with the Annual Survey of Industrial Enterprises in China (ASIEC). The ASIEC database covers all the state-owned enterprises and private firms with sales exceeding 5 million yuan from 1998 to 2009, including ownership information.[10] The patent database contains all patents granted by China's State Intellectual Property Office between 1985 and 2012. One pattern that emerges is that state-owned enterprises in general perform worse than private firms in generating patents. During the period 1998–2009, the number of patents granted to private firms in China grew by 35 percent per year, overtaking the number of patents given to state-owned and foreign firms by a comfortable margin. The drop in the share of patents by state-owned enterprises is partly due to the shrinkage of that sector, as described earlier. In 1998, state-owned enterprises accounted for 30 percent of total firms in the ASIEC database, while they dropped to 2 percent by 2009. Clearly, private firms have become the engine of innovation in China.

Market size has been regarded as a key driver of innovation in the literature (Acemoglu and Linn 2004). In other words, firms aiming at larger global markets should be more innovative. In past decades, the Chinese economy has become

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[9] We perform cross-country regressions similar to those described in Figure 3 with the forward citation of Chinese firms' patents by all patent applicants in the United States as the dependent variable. The online Appendix Table A5 provides more detail on the extent of forward citation across countries regression analysis, and Appendix Figure A4 shows the coefficients on the interaction term between country and year fixed effects against log income. Overall, relative to a country's population size and income level, the Chinese firms do well in terms of forward citations of their patents. See also Xie and Zhang (2015) for an analysis of the growth of patents in China.

[10] While ASIEC data for 2010–2014 seem to be available on the gray market, the quality appears suspect. To be conservative, we do not use these data in this paper.

increasingly integrated with the world economy, in particular since China joined the World Trade Organization in 2001. In this data, exporting firms in China are indeed more innovative than nonexporting firms.

Since 2003, real wages in China have grown by more than 10 percent a year. Some reckon that China has passed the so-called "Lewis turning point," which means that an era of ultra-low-wage production is over (for example, Zhang, Yang, and Wang 2011). While patents are rising for both capital- and labor-intensive firms, the fraction of patents granted to labor-intensive firms increased from 55 percent in 1998 to 66 percent in 2009. Rising labor costs may have induced labor-intensive sectors to come up with more innovations to substitute for labor.[11]

We can connect the discussions on total factor productivity and on innovation. We separate all firms in the ASIEC sample into those with no patents during 1998–2007, those with a cumulative patent count of 1–4 patents during the same period, and those with a cumulative count of more than 4 patents. We compute the growth of total factor productivity for each individual firm. We find that firm-level productivity tends to grow faster in the group that engages in more innovation. This suggests that to reverse China's negative levels of total factor productivity, it would be helpful for China to facilitate conditions that expand both the number of firms that engage in innovative activities and the intensity of innovation per innovating firm.

Misallocation of Innovation Resources

The innovation gap between China and leading advanced economies such as the United States, Japan, and even Korea is still wide. On the list of 2015 Thomson Reuters' Top 100 Global Innovators, Japanese and US firms lead the way, while no single Chinese firm makes the list. More systematic data confirms the continued gap in innovation (Shen, Wang, and Whalley 2015). The numbers of US patents received by either Japanese, German, or Korean firms are still more than twice as many as those obtained by Chinese firms in spite of their smaller population size (as shown earlier in Table 3). Part of the gap reflects different stages of development: as we have shown, both investment in R&D and innovation measured by patent count are strongly positively related to GDP per capita. However, another contributor to the gap could be resource misallocation in the innovation space. We turn to this topic next.

Following China's reforms in the late 1990s, the share of state-owned enterprises in total firms dropped significantly from 24 percent in 1995 to 3 percent in 2014, as discussed earlier. However, most of the surviving state-owned enterprises are relatively big, and are in upstream industries or strategically important sectors

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[11] The descriptions in these paragraphs are based on bivariate correlations, and as such are, of course, only suggestive. In order to evaluate the relative importance of these factors' contributions to firm innovations in a more rigorous manner, we run multivariate regressions using a hybrid binomial estimation method proposed by Allison (2005). The details are available in the online Appendix, Part B, available with this paper at http://e-jep.org (see Appendix Tables A7–A11). Overall, the findings confirm the importance of rising labor cost.

(Hsieh and Song 2015). They are typically subject to less competition than private enterprises. Thus, China's state-owned firms both absorb nontrivial resources, including government subsidies, and still command nontrivial political weights. Part of China's move to becoming an innovative economy must be to improve the efficiency of resource allocation between state-owned and private firms. China's state-owned firms continue to receive considerable financial support from the government, including access to low-cost bank loans and research and development subsidies. In the aftermath of both the 1997 Asian financial crisis and the 2008 global financial crisis, the Chinese government launched stimulus packages which often involved credit expansion and which disproportionately went to state-owned enterprises. The more favorable policies and injection of massive stimulus funds have reduced the returns to capital of state-owned enterprises since 2008 (Bai and Zhang 2014), caused a decline in their total factor productivity (Wu 2013), and provided a lifeline for inefficient zombie firms (Tan, Huang, and Woo 2016). The returns to capital of state-owned enterprises are much lower than their private counterparts (Hsieh and Song 2015). Moreover, state-owned enterprises lagged behind private firms in total factor productivity (Brandt 2015). These patterns suggest a misallocation of government support between state-owned and private enterprises. Government subsidies for research and development can promote firm innovations in China (as reviewed in Boeing 2016 and confirmed by our own firm-level regressions). Government subsides can be defended on the ground that research and development by firms generate positive externalities. Indeed, most advanced countries subsidize research and development as well. The question is not whether subsidies can be justified at all, but rather whether China's allocation of such subsidies is consistent with economic efficiency.

Based on simple averages, it would appear that a greater fraction of state-controlled firms are innovative (that is, they have patents) than domestic private sector firms. Indeed, some state-controlled firms receive many patents in a year. But the simple averages are misleading both because state-controlled firms are much larger on average (and larger firms tend to invest more in research and development), and because they tend to receive more subsidies from various levels of the government. Subsidies from local governments to local government-controlled firms are especially noteworthy.

We examine firm-level data for evidence of effectiveness of research and development spending in generating innovations. Based on firms in the ASIEC sample during 2005–2007, for every 10 million yuan of firm-level investment in research and development, domestic private- sector firms and foreign-invested firms generate 6.5 and 7.6 patents, respectively. In comparison, the same investment by state-owned firms yields a more meager 2.2 patents. We may obtain a more informative picture by sorting firms by size and ownership. In Figure 4, on the horizontal axis, all Chinese firms are sorted into ten size deciles based on the sum of the sales during the period, with the first decile being the smallest and the 10th being the largest. Within each size decile, firms are then sorted by ownership. "State" refers to all firms in which the state (either the central or the local governments) have controlling shares (50 percent or

Figure 4

Patent Count per Million Yuan of R&D Investment as a Function of Ownership and Size
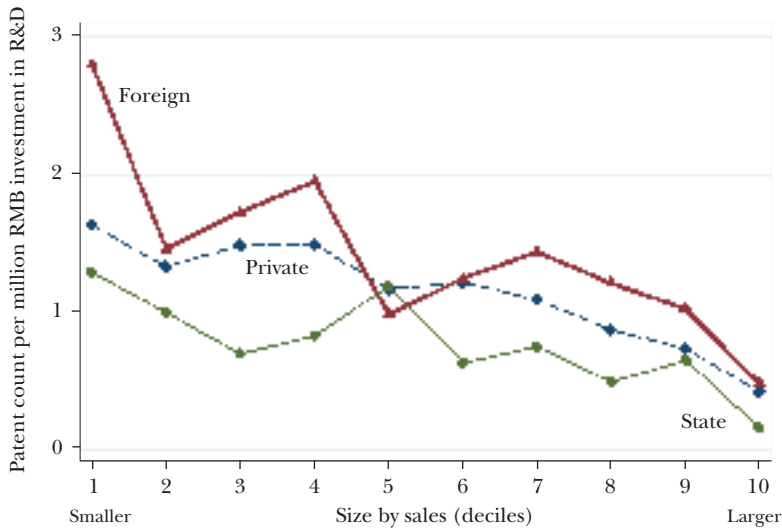
Source: Data from Annual Surveys of Above-Scale Manufacturing Firms, 2005–2007.
Notes: We used a 2005–2007 sample. Firms are first sorted by size (sales) deciles, and, within each size decile, are subdivided into three ownership groups: "State" refers to firms for which the state (central or local governments) has 50 percent share or more; "Foreign" refers to firms for which foreign entities have at least 10 percent of the share and the state has less than 50 percent share; "Private" includes all other firms. Firms that report positive patents but no R&D spending (or spending of less than 100 yuan) are excluded.

more); "foreign" refers to all firms in which foreign entities, including investors from Taiwan, Hong Kong, or Macao, have a 10 percent share or more but the state has no more than 50 percent of the shares. All other firms are in the "private" category.

Table 4 presents statistics on domestically granted patents by firm ownership and size during 2005–2007 when all relevant data are available. In most of the size categories, domestic private sector firms and foreign-invested firms invest more in research and development and generate more patents than their state-owned counterparts.

Inspecting Figure 4 and Table 4, several patterns are especially noteworthy. First, the returns to research and development spending—as measured by the number of patents per million yuan of research and development spending on the vertical axis—tend to decline with firm size. Because large firms tend to spend more on research and development, this pattern is consistent with the idea that diminishing returns apply to investment in innovation. Second, across most size deciles, we see that foreign-invested firms and domestic private sector firms tend to have higher returns to investment in research and development. Third, we do not observe a connection between firm subsidies (relative to sales) and effectiveness at converting research and spending into innovative outcome as measured by patents. Instead, we

Table 4

Patents, Research and Development Expenditure, and Subsidies by Firm Type and Size

	Firm type	*Size by sales quantile*				
		0–20%	*20–40%*	*40–60%*	*60–80%*	*80–100%*
Number of patents	Private	1,107	2,630	4,003	7,585	64,586
	Foreign	226	579	876	3,031	44,178
	State	46	87	177	351	9,116
R&D expenditure (million RMBs)	Private	769	1,763	3,335	7,933	143,848
	Foreign	122	312	760	2,333	86,946
	State	41	112	210	595	51,172
(Subsidies/sales) × 100	Private	0.22	0.25	0.25	0.24	0.31
	Foreign	0.13	0.11	0.11	0.11	0.11
	State	0.84	0.86	0.71	0.74	0.27

Source: Authors' calculation based on Annual Surveys of Above-Scale Manufacturing Firms, 2005–2007.
Note: We used a 2005–2007 sample; divided into 5 groups by sales; and drop observations that invest less than 100 Yuan but have positive patents. "Foreign" refers to firms for which foreign entities have at least 10 percent of the share and the state has less than 50 percent share. "Private" includes all other firms.

see that state-controlled firms tend to have much higher subsidies (relative to sales) than either domestic private firms or foreign-invested firms. Interestingly, because small and medium state-owned firms are mostly owned by local governments, they receive more subsidies from the local governments than large state-owned firms.

König, Song, Storesletten, and Zilibotti (paper in progress) argue that, in theory, the most productive firms should pursue innovation and less-productive firms should just imitate. Against this theoretical benchmark and also compared to the data patterns in Taiwan, they find that less-productive firms in China engage in too much research and development spending—and the more-productive firms may not do enough. Based on their calibrations, if the R&D misallocation can be reduced (so that the association between productivity and R&D spending resembles that in Taiwan), the aggregate productivity growth in Chinese manufacturing during 2001–2007 could have grown by about one-third to one-half.

In sum, there is prima facie evidence that the pattern of subsidies across China's firms represents resource misallocation. China's economy-wide innovative outcomes would have been higher if the subsidies were more evenly spread across firm ownership.[12] The sensible policy reforms would be to provide subsidies only

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[12] The Appendix available online with this paper at http://e-jep.org offers some exploratory regressions that tend to confirm the intuition in the text. In particular, we regress patent count on firm R&D expenditure by controlling for firm sales, firm fixed effects, and year fixed effects. In order to evaluate whether private firms and state-owned enterprises have different elasticity regarding R&D expenditure, we interact firm ownership with R&D expenditure in the regressions. The interaction term between the state-owned enterprise dummy and R&D variable is statistically negative, indicating that the elasticity of

in cases where the social returns exceed private returns (such as certain innovative activities) without regard to firm ownership.

Conclusions

China's past success in economic growth means that its real manufacturing wage has increased by about 14-fold from 1980 to 2015. In addition, China's shrinking workforce since 2012 has added to the wage pressure. By necessity, China has to move to a growth model that is based more on innovation and productivity increase than in the past.

Can China rise to the challenge? One sometimes hears an argument for the "middle-income trap hypothesis," which claims that only in exceptional cases can a middle-income country ever manage to become an innovative high-income economy. Indeed, the challenges facing China have often been expressed in the context of a possible middle-income trap by both the government of the country and some scholars (for example, OECD 2013; Ma 2016). Han and Wei (2015) do not find support for an unconditional notion of the middle-income trap hypothesis, using both a transition matrix analysis and a nonparametric analysis (by regression trees). Nonetheless, they identify certain conditions under which growth in a middle-income country could stagnate or even regress.

We have argued that Chinese firms have demonstrated a capacity to become more innovative in response to wage pressure and global opportunities. The data on Chinese patents, both from a quantity and a quality perspective, appear encouraging enough that we should not be that pessimistic about China's prospects for a successful transition to a more innovation-based growth model.

If China finds effective ways to embrace a shift to a more innovative economy, it can realize faster its dream of moving into the high-income club. The government subsidies tend to favor state-owned firms, and yet both domestic private sector firms and foreign-invested firms are more effective in converting investment in R&D to innovation outcomes as measured by patents. One meaningful step along those lines would be for China to reduce its apparent misallocation of innovation resources by leveling the playing field for firms of all ownership types, limiting the government's discretion in subsidies for research and development, and assuring that private sector firms have a fair chance at receiving those subsidies. This will be a helpful structural reform that will complement the reforms in stronger protection of intellectual property rights and in the education system.

patents granted with respect to R&D expenditures is significantly higher for private firms than for SOEs. This finding is consistent with the view that state-owned enterprises have not spent R&D resources as efficiently as private firms.

References

Acemoglu, Daron, and Joshua Linn. 2004. "Market Size in Innovation: Theory and Evidence from the Pharmaceutical Industry." *Quarterly Journal of Economics* 119(3): 1049–90.

Allison, Paul D. 2005. *Fixed Effects Regression Methods for Longitudinal Data Using SAS.* Cary, NC: SAS Institute.

Autor, David H., Frank Levy, and Richard J. Murnane. 2003. "The Skill Content of Recent Technological Change: An Empirical Exploration." *Quarterly Journal of Economics* 118(4): 1279–1333.

Bai, Chong-en, and Qiong Zhang. 2014. "Zhongguo de Ziben Huibaolv Jiqi Yingxiang Yinsu Fenxi (Returns to Capital and Their Determinants in China)." *World Economy* [in Chinese] 10: 2–30.

Boeing, Philipp. 2016. "The Allocation and Effectiveness of China's R&D Subsidies: Evidence from Listed Firms." *Research Policy* 45(9): 1774–89.

Brandt, Loren. 2015. "Policy Perspectives from the Bottom Up: What Do Firm-Level Data Tell Us China Needs to Do?" Paper presented at the Asia Economic Policy Conference on "Policy Challenges in a Diverging Global Economy," Federal Reserve Bank of San Francisco, November, 19–20. In *Policy Challenges in a Diverging Global Economy* edited by Reuven Glick and Mark M. Spiegel, 282–302. Available at http://www.frbsf.org/economic-research/events/2015/november/2015-asia-economic-policy-conference/.

Cai, Fang, and Yang Du. 2011. "Wage Increases, Wage Convergence, and the Lewis Turning Point in China." *China Economic Review* 22(4): 601–610.

Cai, Fang, and Meiyan Wang. 2008. "A Counterfactual Analysis on Unlimited Surplus Labor in Rural China." *China & World Economy* 16(1): 51–65.

Chang, Simon, and Xiaobo Zhang. 2015. "Mating Competition and Entrepreneurship." *Journal of Economic Behavior & Organization* 116(C): 292–309.

China National Bureau of Statistics (CNBS). 2012. *China Statistical Yearbook.* Beijing: China Statistical Press.

Feng, Shiliang. 2014. "Factor Allocation and Economic Growth in China: Analysis across Regions and Sectors from 1978 to 2012." Dissertation, Peking University. [In Chinese.]

Fan, Shenggen, Ravi Kanbur, Shang-Jin Wei, and Xiaobo Zhang. 2014. *The Oxford Companion to the Economics of China.* Oxford University Press.

Fan, Shenggen, Xiaobo Zhang, and Sherman Robinson. 2003. "Structural Change and Economic Growth in China." *Review of Development Economics* 7(3): 360–77.

Fang, Jing, Hui He, and Nan Li. 2016. "China's Rising IQ (Innovation Quotient) and Growth: Firm-level Evidence." Unpublished paper, IMF.

Fang, Lily, Josh Lerner, and Chaopeng Wu. 2016. "Intellectual Property Rights Protection, Ownership, and Innovation: Evidence from China." Unpublished paper, INSEAD, Harvard University, and Xiamen University.

Feenstra, Robert C., and Shang-Jin Wei. 2010. *China's Growing Role in World Trade.* University of Chicago Press.

Golley, Jane, and Xin Meng. 2011. "Has China Run Out of Surplus Labour?" *China Economic Review* 22(4): 555–72.

Han, Xuehui, and Shang-Jin Wei. 2015. "Re-examining the Middle Income Trap Hypothesis (MITH): What to Reject and What to Revive?" CEPR Discussion Paper 10989.

Hsieh, Chang-Tai, and Peter J. Klenow. 2009. "Misallocation and Manufacturing TFP in China and India." *Quarterly Journal of Economics* 124(4): 1403–48.

Hsieh, Chang-Tai, and Zheng (Michael) Song. 2015. "Grasp the Large, Let Go of the Small: The Transformation of the State Sector in China." *Brookings Papers on Economic Activity* 50(1): 295–366.

Knight, John, Quheng Deng, and Shi Li. 2011. "The Puzzle of Migrant Labour Shortage and Rural Labour Surplus in China." *China Economic Review* 22(4): 585–600.

König, Michael, Zheng M. Song, Kjetil Storesletten, and Fabrizio Zilibotti. In progress. *"From Imitation to Innovation: Where is All that Chinese R&D Going?"*

Li, Bin. 2011. "Comparative Analysis of Estimates on Capital Stock of China" [in Chinese]. *Journal of Quantitative & Technical Economics* [in Chinese] (12): 21–36.

Lin, Justin Yifu. 1992. "Rural Reforms and Agricultural Growth in China." *American Economic Review* 82(1): 34–51.

Ma, Damien. 2016. "Can China Avoid the Middle Income Trap?" *Foreign Policy*, March 12.

OECD. 2013. *The People's Republic of China—Avoiding the Middle-Income Trap: Policies for Sustained and Inclusive Growth.* September. Paris: OECD.

Qian, Yingyi, and Barry R. Weingast. 1997. "Federalism as a Commitment to Preserving Market Incentives." *Journal of Economic Perspectives* 11(4): 83–92.

Qu, Yue, Fang Cai, and Xiaobo Zhang. 2013. "Has the Flying Geese Paradigm Occurred in China?" *China Economist* 8(6): 18–31.

Shen, Keting, Jing Wang, and John Whalley. 2015. "Measuring Changes in the Bilateral Technology Gaps between China, India and the U.S. 1979–2008." NBER Working Paper 21657.

Tan, Yuyan, Yiping Huang, and Wing Thye Woo. 2016. "Zombie Firms and the Crowding-Out of Private Investment in China." *Asian Economic Papers* 15(3).

Wang, Xiaobing, Jikun Huang, Linxiu Zhang, and Scott Rozelle. 2011. "The Rise of Migration and the Fall of Self-employment in Rural China's Labor Market." *China Economic Review* 22(4): 573–84.

Wei, Shang-Jin. 2015. "Freer Choice, Lower Growth, and Higher Welfare: Recent Changes in China's Population Control Policy and the Impact on Its Economy." Keynote (Dinner) Address at the Asia Economic Policy Conference "Policy Challenges in a Diverging Global Economy," Federal Reserve Bank of San Francisco, November 19–20. In *Policy Challenges in a Diverging Global Economy,* edited by Reuven Glick and Mark M. Spiegel, 129–46. Available at http://www.frbsf.org/economic-research/events/2015/november/2015-asia-economic-policy-conference/.

Wei, Shang-Jin, and Xiaobo Zhang. 2011a. "The Competitive Saving Motive: Evidence from Rising Sex Ratios and Savings in China." *Journal of Political Economy* 119(3): 511–64.

Wei, Shang-Jin, and Xiaobo Zhang. 2011b. "Sex Ratios, Entrepreneurship and Economic Growth in the People's Republic of China." NBER Working Paper 16800.

Wei, Shang-Jin, Xiaobo Zhang, and Yin Liu. Forthcoming. "Home Ownership as Status Competition: Some Theory and Evidence." *Journal of Development Economics.*

World Intellectual Property Organization (WIPO). 2012. *World Intellectual Property Indicators.* Geneva: WIPO.

Wu, Harry X. 2013. "Measuring and Interpreting Total Factor Productivity in Chinese Industry" [in Chinese]. *Comparative Studies* [in Chinese] 69(6). http://magazine.caixin.com/2013/cs_69/.

Wu, Harry X., and Conference Board China Center. 2014. "China's Growth and Productivity Performance Debate Revisited: Accounting for China's Sources of Growth with a New Data Set." Economics Program Working Paper no. 04-01, Conference Board. https://www.conference-board.org/pdf_free/workingpapers/EPWP1401.pdf.

Xie, Zhuan, and Xiaobo Zhang. 2015. "The Patterns of Patents in China." *China Economic Journal* 8(2): 122–42.

Xu, Chenggang. 2011. "The Fundamental Institutions of China's Reforms and Development." *Journal of Economic Literature* 49(4): 1076–1151.

Xu, Chenggang, and Xiaobo Zhang. 2009. "The Evolution of Chinese Entrepreneurial Firms: Township-Village Enterprises Revisited." IFPRI Discussion Paper 854, International Food Policy Research Institute.

Zhang, Xiaobo, Jin Yang, and Shenglin Wang. 2011. "China Has Reached the Lewis Turning Point." *China Economic Review* 22(4): 542–54.

Zhu, Xiaodong. 2012. "Understanding China's Growth: Past, Present, and Future." *Journal of Economic Perspectives* 26(4): 103–124.