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1 China's innovation challenge

An introduction

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1.1 Why a book on China's innovation challenge?

Over the past four decades, China has evolved from being largely isolated and irrelevant to the world economy to having the world's second-largest economy, and it is widely expected to have the largest economy in the near future.[1] In the process, China went from having a largely agricultural economy, with over 80 percent of population in the countryside, to becoming a major industrial economy, with less than 30 percent of population working in agriculture. Without repeating well-known historical details, the economic liberalization that began in 1978 was accompanied by a national policy that created surplus labor in the rural economy and unleashed a migration to the free-trade economic zones, which became hubs of low-cost, labor-intensive manufacturing for exports. In this respect, China followed the strategy of Japan after World War II, of South Korea under President Park Chung Hee, and of Taiwan under the Kuomintang. Exports were the source of national income that financed massive investment in infrastructure (roads, railroads, electric power, hydropower, flood control, nuclear power, airports, etc.), new cities, housing, and supporting supplier industries. China also attracted and encouraged unprecedented foreign direct investment (FDI) combined with policies that required sharing and transferring needed technologies. Even as exports increased, a new consumer society was being created that needed almost every imaginable amenity. As a result, it built a foundation for sophisticated industrial capabilities in mature industries that has given rise to globally competitive firms in areas such

[1] In October 2014, the International Monetary Fund (IMF) (2014) calculated that, in purchasing power parity terms, China had the world's largest economy.

as construction, high-speed rail, heavy engineering, shipbuilding, and steel making, to name a few important sectors.

Even as consumption increased, China also continued to benefit from very high savings rates. In 1981 (three years after the liberalization of the economy), the savings rate was about 20 percent of the gross domestic product (GDP). In 1988, it increased to 30 percent, and since 1988 it has averaged 40 percent. The high savings rate has been ascribed variously to the social, political, and financial uncertainties felt by households in China due to economic liberalization, the decreasing state ownership that reduced the government's participation in providing social welfare such as health care and pensions, and the one-child policy. Chinese people could no longer count on the government for social welfare, in particular retirement benefits. The need to save for retirement was also a direct consequence of the one-child policy, which places the burden of caring for aged parents on a single son or daughter. Chinese parents also were motivated to save so that their children could obtain a high-quality education, whether at home or abroad. A lack of certainty about property rights as well as the underdeveloped financial infrastructure and lack of investment options for building wealth also led Chinese to keep money in bank accounts.

Regardless of the reasons for the high savings rate, it enabled the Chinese government to underwrite enormous investments in infrastructure, housing, new cities, state-owned enterprises (SOEs), space programs, national defense, and the like. However, more recently the persistent high savings rate has prompted many economists to argue that it has slowed the growth of a consumer economy that would have the potential to shift the economic basis of the Chinese economy from an overreliance on exports and infrastructure investment to final consumption.

This breakneck growth has come at a very high human cost and includes the growth of a huge migrant population; family separation due to the need for parents to leave their children with grandparents so that they can pursue attractive jobs in regions other than the one of their residence; generations of families without access to social welfare, health care, or education;[2] and pollution of air, water, and soil on an

[2] Many migrants moving from the countryside to the cities or the new special economic zones were not legally entitled to social welfare, health care, and education benefits that, by statute, were only provided by the localities where

unimaginable scale. The scale of the economic transformation also resulted in the wasteful allocation of resources, manifested in overbuilding (roads that go to nowhere, new airports with little activity, idle factories, and empty buildings in new cities, etc.) as well as the arbitrary displacement of citizens from land by local and central governments – the last of which created an easy source of revenue as well as widespread corruption. Together or separately, all of these threaten the popular legitimacy of the Chinese Communist Party (CCP) and create an uncertainty that could affect continued economic growth and development.

Since 1978, China has also made enormous investments in education, including higher education. In 1991, China's R&D investment was RMB 15.08 billion ($2.83 billion), or approximately 0.7 percent of GDP; in 2013, R&D investment increased to RMB 1.185 trillion ($191.44 billion), or approximately 2.01 percent of GDP. The increase in the share of GDP overall was fueled not only by the expansion of resources devoted to research but also by an economic growth rate of more than 8 percent annually over the period (World Bank 2015). As a result, in purchasing power parity terms, China has become the second-largest spender on R&D in the world and may have even surpassed the United States (OECD 2014). This is a clear indication of the Chinese government's commitment to increasing the economy's innovative capacity (State Council 2006; World Bank 2013). The critical issue is whether the massive investment in R&D, 74 percent of which comes from the corporate sector (OECD 2014: 292), can be converted into innovations that can increase the value added and the productivity of the Chinese economy.

Although there can be little doubt that, until now, the bulk of Chinese research has not been truly world class, the rapidity of the improvement in breadth and depth is unprecedented (Fu 2015). In terms of technological achievements, China is the first developing country to have a manned space program (BBC 2003), to possess the ability to design and build supercomputers, and to give rise to world-class telecommunications firms, to name only a few.

Since the publication of the seminal paper by Robert Solow (1957), the role of innovation in economic growth has become widely accepted

they were registered as residents. Of course, legal migrants were registered in their new cities and thus were entitled to receive these social benefits.

(Aghion, David, and Foray 2009; Kim and Nelson 2000; Landau and Rosenberg 1986; Nelson and Romer 1996).[3] Recognizing the importance of imitation in the early days of a country's attempts to build an advanced economy (Westney 1987), Ashby's (1956) Law of Requisite Variety underlines the importance of enabling innovation through either the acquisition of new technology or its indigenous development in the new ecosystem. In the early stages, much depends on enabling processes of "imitation" to create the basis for new capabilities (for a discussion of this at the organizational level, see Ansari, Fiss, and Zajac 2010). China has been very effective at adopting and imitating technologies through various means, from FDI, technology licensing, and judicious acquisitions abroad to outright copying. Success at acquiring and assimilating more advanced technologies or entering into higher value-added technological fields is greatly contingent on building the institutions and social conditions that provide the requisite absorptive capacity (Cohen and Levinthal 1990; Lewin, Massini, and Peeters 2009). In reality, there are many instances in which the attempted transplantation of practices and even far simpler physical assets such as machinery to unprepared regions has utterly failed because the necessary absorptive capacity did not exist or because the technological gap was too great (Lee, Chapter 5, in this volume). Thus, the transformation of any economy that aspires to drive growth through knowledge creation and innovation depends on previous investments in building human, organizational, and infrastructural assets so that it can encourage and harness innovation as an engine of economic growth and development.

The choice of Xi Jinping as president of China coincides with a widespread recognition that the economic policies that undergirded China's rapid growth likely have reached their limits. Two pillars of the economic miracle have reached diminishing returns or are near exhaustion. First, the migration of surplus labor from the rural economy to the cities and the industrial sectors is ending. Although less than 30 percent of the population still resides in rural areas, the bulk of this population cannot be mobilized due to age, poor health, and lack of education (see, e.g., Du, Park, and Wang 2005). Second, continuing the massive

[3] Of course, Karl Marx wrote extensively on the role of technology in the advance of the "productive forces," so it should be no surprise that the CCP advocates research. However, it is equally clear that before the liberalization begun by Deng Xiaoping in 1978, the Chinese innovation system was ineffective at best.

internal investment rate in infrastructure projects is not sustainable largely because the most productive projects have already been completed, resulting in diminishing returns (or even no returns at all). A case can be made that President Xi sees his mission as continuing and entrenching the hegemony of the CCP. This may be the key underlying reason for the sustained and intensive anti-corruption campaign being waged under the sole control of the CCP (with no involvement or participation by the public at large) and the urgency it feels to continue growth and avoid a "middle-income trap."

The dilemmas faced by Chinese policymakers are vexing. The CCP believes that its legitimacy depends, in large part, on delivering economic growth. For Xi, previously employed strategies to escape the "middle-income trap" entail a transition to more democratic institutions that would threaten the power of the CCP: in his view, the examples of such transitions in South Korea and Taiwan are unacceptable for China to follow.[4] Thus, since 1978, the adoption of market mechanisms for organizing economic activity has become acceptable particularly when integrated with government-driven economic or social initiatives, while political liberalization is viewed with much greater suspicion. Indeed, Justin Yifu Lin (Chapter 2 in this volume) advocates such a policy, combined with an emphasis on technological upgrading, which in combination are intended to increase the value-added output of Chinese industries. Similarly, the rise of companies such as Alibaba, Baidu, Netease, Sina, Sohu, Tencent, and Xiaomi have identified the digital service economy as a powerful new engine of economic growth.[5] Beijing, Hangzhou, Shanghai, and Shenzhen have vibrant startup ecosystems, indicating the possibility that China can

[4] Advocates of democratic forms of capitalism are reminded that throughout its more than 3,000 years of history and sixty-seven years of rule under the CCP, the Chinese people have only known and learned to survive centralized authority. A precipitous transition to a democratic form of social and political organization could be as chaotic as it was when the Communist Party of the Soviet Union collapsed in 1991 under Mikhail Gorbachev. The Chinese people have a long-term perspective and the fear of collapse and disunity is a motivating factor for supporting a strong central government.

[5] China has the most successful Internet startup ecosystem outside the United States. However, it is important to recognize that in many Internet-related industries, the Chinese government has closed its market to international competition.

succeed in building innovatory and entrepreneurial capabilities that could evolve into new powerful drivers of economic development.

It is clear that China aspires to – indeed, believes that it must – develop an innovative economy. Since 2005, China has aggressively increased its domestic expenditures on R&D at a compound annual growth rate of approximately 20 percent (from $55 billion in 2005 to $257.8 billion in 2013). However, as many people in the government recognize, China must eliminate the many institutional barriers to innovation and entrepreneurship that still exist, as well as transform its university-based science, technology, engineering, and mathematics (STEM) teaching and research (World Bank 2013).

1.2 Scholars differ in their views on China's prospects

Scholars, however, differ in their view of how easy or difficult it will be for China, with its one-party political system, to develop an indigenous model that will be successful in creating a knowledge- and innovation-based economy.

1.2.1 The optimistic view

The optimistic view is advanced in Chapter 2 by Lin. China has a rich history of invention, and there is no reason to believe that Chinese people inherently cannot be innovative. Before the rise of the West, China was the global leader in technology, having invented paper, printing, the compass, and gunpowder, among a plethora of other inventions, centuries earlier than they appeared in the West (Needham 1954). The admiration of European travelers such as Marco Polo for Chinese science and technology is evident from texts that circulated in the thirteenth, fourteenth, and fifteenth centuries (Adas 1989). However, as Gordon Redding (Chapter 3 in this volume) points out, these centuries of leadership were followed by many centuries of stagnation. Yet, as Lin argues, since the economic liberalization unleashed by Deng Xiaoping (the de facto leader, though without an official title as such) in 1978, the change has been dramatic. There is no doubt that China is capable of innovating (see, e.g., Breznitz and Murphree 2011). The question today is how innovative the Chinese can become, in contrast to the previous belief that China

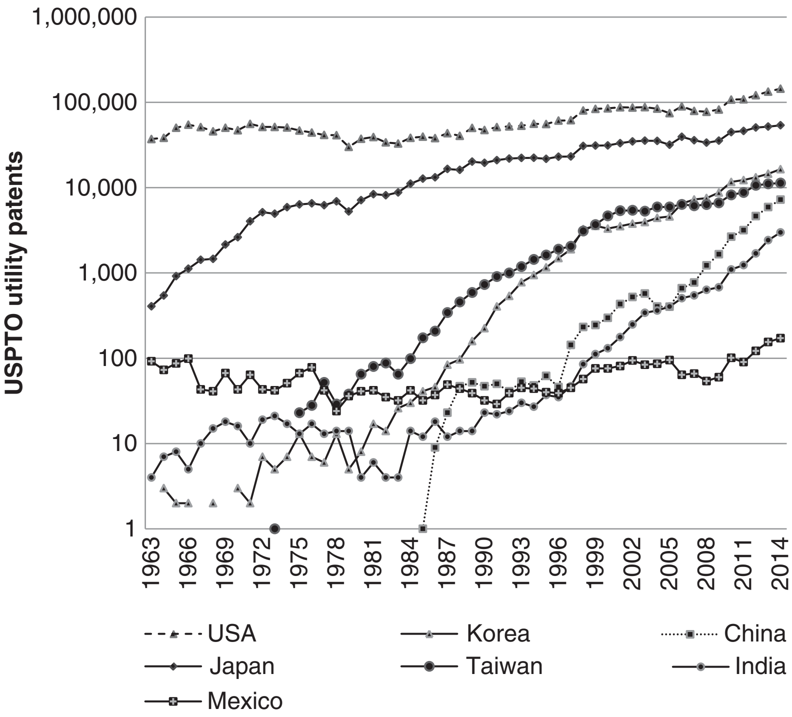

Figure 1.1 USPTO utility patents granted for selected countries (1963–2014)
Source: USPTO, various years.

could not possibly be innovative. To put it even more succinctly, how far can China go?

Innovativeness can be measured in a wide variety of ways. One of the most common measures is patenting (for a detailed discussion, see Cheng and Huang, Chapter 7, in this volume). As Figure 1.1 indicates, the number of Chinese patents registered with the United States Patent and Trademark Office (USPTO) has increased dramatically and is following a pattern similar to the one by Japan in the 1960s and Taiwan and Korea beginning in the 1980s. Whether this pattern will continue for China is uncertain, but it provides evidence for the optimists that China's innovative capacity is increasing dramatically.

China recognizes the imperative of developing and building a new growth model centered on innovation. Most recently, this national priority has been reaffirmed by Premier Li (2015), who has called for greater efforts to encourage innovation in science and technology, stating that innovation is the “golden key” to China’s development. He stressed the need for breakthroughs in important technologies, for more people to start science and technology-based businesses to transform their talent into productivity, and for China to create a fair and open environment for these firms by removing “obstacles that hold back startups and innovation.”

Upgrading of universities. The first modern Western-style universities were established in the 1890s. After 1911, when the Qing dynasty was overthrown, the new republican government under the Nationalist Party (Kuomintang) made scientific learning one of its priorities and sent Chinese students to both the United States and Japan (Hayhoe 1989). Yet, by any measure, Chinese universities were hopelessly behind the global frontier. In 1949, when the CCP won the civil war against the Nationalists, Chinese universities were in shambles. Immediately upon taking power, the CCP adopted the Common Program, which declared that natural science should be placed at the service of industrial, agricultural, and national defense construction (Hayhoe 1989) and, presumably, any technologies developed should be transferred to the productive sectors of the economy.

After it rose to power, the CCP adopted the Soviet model of economic development, with the Chinese Academy of Sciences specializing in basic research, while various research institutes were tasked with applied research and universities were relegated to teaching (Liu and White 2001). The Cultural Revolution of 1966–1976 disrupted education across the board, especially at Chinese universities and research institutions. As a number of chapters in this volume point out, in 1978, in the aftermath of the end of the Cultural Revolution two years earlier and China’s opening up spearheaded by Deng, it was recognized that scientifically and technologically China badly lagged behind not only the United States, Europe, and Japan but, increasingly, some of its Asian neighbors, dubbed “the Asian Tigers.” In the years that followed, a plethora of new policies were introduced to encourage “socialism with Chinese characteristics” (i.e., blending socialism with markets) and improve China’s global scientific and technological standing.

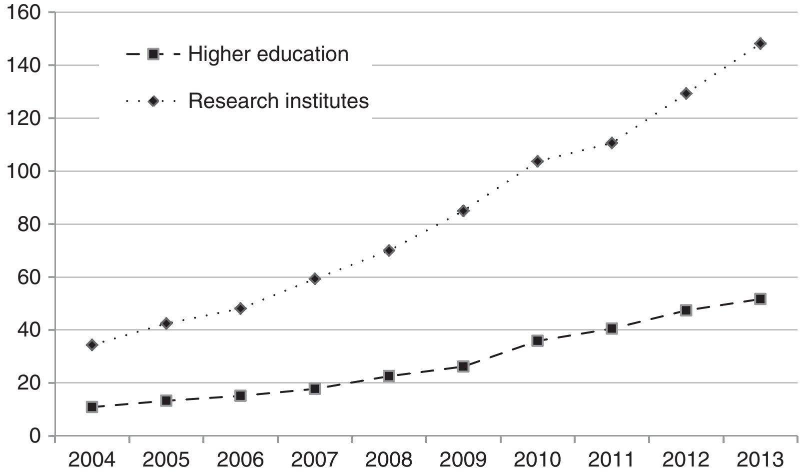

Figure 1.2 Chinese government funding for R&D in universities and research institutes (in billions of yuan) (2004–2013)
Sources: Chen, Patton, and Kenney, 2015; Ministry of Science and Technology of the People's Republic of China, 2005–2014.

In 1978, the third plenary session of the eleventh CCP Central Committee concluded that the connection between academic research and industrial needs was weak, and new policies were introduced to encourage Chinese research institutions to address social and economic development (Chen and Kenney 2007). In the early 1980s, because of a severe national budget crisis, university budgets were cut dramatically. However, in the 1990s, research funding for top universities increased dramatically, in the overall environment of expanding university and research institute R&D funding, particularly through the 985 Project, which began in 1998, and massively increased research funding for selected groups of universities, with the goal of moving them into the ranks of top-tier elite global research universities (on recent growth, see Figure 1.2).[6] This is also reflected in the pursuit of sixteen huge national science and engineering projects identified by the State Council in 2006. Each of them addresses major technologies deemed to be of strategic importance for the Chinese economy, national defense, and overall competitiveness. From 2004 to 2013,

6 For a discussion of the impacts of the 985 Project on university research publications, see Zhang, Patton, and Kenney (2013).

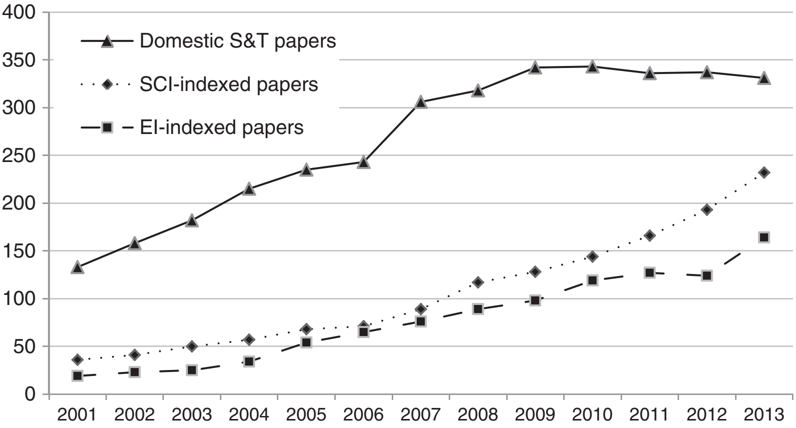

Figure 1.3 Domestic S&T papers by higher education, and Chinese S&T papers published in international journals and indexed by SCI and EI (in thousands of papers) (2001–2013)
Sources: Chen, Patton, and Kenney, 2015; Ministry of Science and Technology of the People's Republic of China, various years.

both university and research institute R&D expenditures increased at a compound annual rate of 18.9 percent and 20.55 percent, respectively – in nine years, R&D funding roughly quintupled.

The growth in research funding was reflected in an increase in Chinese academic publications. The growth in publications is documented in Figure 1.3. Domestic publications increased dramatically until 2009 but then leveled off, in large measure because the Chinese government changed policy to encourage publication in leading international journals. This can be seen in the fact that publications listed in the Science Citation Index (SCI) and Engineering Index (EI) continued to increase. On the assumption that international journals have a more rigorous peer-review process, this growth in citations is an indication that Chinese R&D capacity has increased in quantity and also in scientific relevance.

As Menita Liu Cheng and Can Huang show in Chapter 7, the number of university patents has increased dramatically. However, many of these patents have been criticized as being of little or no value. Much of the increased patenting activity is in response to government pressure for "results" and to incentives that reward volume, not scientific or technical significance. The weakness of university