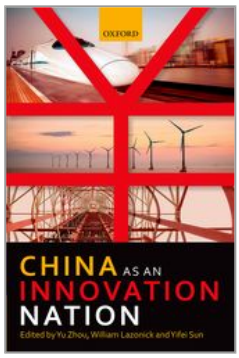

China as an Innovation Nation
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Introduction

China's Transformation to an Innovation Nation

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Abstract and Keywords

The transformation of China in the last three decades has largely been based on massive investments in human knowledge and physical infrastructure. Now, the only way for China to sustain its growth is by becoming an "innovation nation," with innovation being defined as the process that generates a higher quality, lower cost product than was previously available. Is China already an innovative nation or is it in the process of becoming one? The introductory chapter conceptualizes the theory of an innovation nation and the lessons from Japan and Untied States. It integrates the findings from the chapters of this book and outlines the key governance, employment, and investment institutions that China must build for the transition to innovation nation status

to occur, with a focus on the challenges facing China and its innovative strategies in the era of global production systems.

Keywords: innovation, industrial sectors, industrial districts, global production networks, state, indigenous innovation, strategic control, organization integration, financial commitment, institutions

China’s Rapid Growth

In the last three decades, China has transformed itself from one of the poorest countries to the world’s second largest economy. In the process, hundreds of millions of people have left behind lives in poverty. Especially over the past decade, and at an accelerating rate, a Chinese middle class has emerged.

Much of China’s growth since the late 1970s has been based on massive investments in human knowledge and physical infrastructure. In 1980, 33.1 percent of the population had no schooling; in 2010 only 6.6 percent did. Meanwhile the average years of schooling among this population increased from 3.87 to 7.12 (Barro and Lee 2000). The Chinese government has invested in road, rail, and air transportation networks, a national telecommunications system, new sources of energy, and massive amounts of industrial materials such as steel, all of which have underpinned China’s industrialization process.[1]

In the end, however, all of these national investments in physical and human capital cannot be sustained unless business enterprises make use of them to produce goods and services that buyers need or want at prices that they are able or willing to pay. The business enterprises that succeed in national and global competition are those that have developed the capabilities to produce higher quality, lower cost goods and services than other firms in their industries. The name for the process that generates a higher quality, lower cost product than was previously available is *innovation*. The markets for (p.2) these innovative products may be internal to China, with the nation’s rapidly growing middle class creating vast opportunities for selling these goods and services. Or the markets for these products may be global, in which case there

is an opportunity for Chinese business enterprises to advance in terms of the quality of products that they can supply, often moving up global value chains through upgrading their productive capabilities.

Even with over three decades of sustained rapid growth, per capita incomes in China remain that of a developing economy. Large sections of China's population still live in poverty, and many aspiring young people have been unable to achieve their full potential because of limited education and employment opportunities. With massive investments in physical infrastructure and human knowledge in place, the only way for China to sustain its growth is by becoming an "innovation nation." The purpose of this volume is to assess China's transition to innovation-nation status.

China's future growth path is not just of concern to the Chinese people. The development of the world's most populous nation has been carried out in a highly globalized economy with countries around the world being affected in many ways by the rate and direction of China's growth. Some nations export vast amounts of goods, including natural resources, to China and the health of their economies has become dependent on China's continued growth. Under various arrangements, many multinational companies have a large and growing presence in China, producing for the burgeoning Chinese domestic markets or engaging in value-added production of components or end products for global markets. And increasingly, just as has happened in the cases of Japanese and Korean development, companies around the world have to be concerned about the emergence in China of indigenous companies that through investment in productive capabilities can compete globally in even the most sophisticated technology industries.

The Chinese government's stated goals are for China to join the top rank of "innovative nations" by 2020, and become a world-leading technology power by the mid-21st century (Li 2012). Central to this vision is Zizhu Chuangxin (自主创新), translated as "indigenous innovation," a strategy that was formally articulated in the Medium- and Long-Term Plan for Science and Technology in 2006.[2] Zizhu literally means self-

directing. It stresses autonomy and strategic control at the national government and domestic enterprise levels, involving organization building, technology selection and transfer, and innovative learning. This current policy represents a correction from the expectation of the 1980s and 1990s that, through technology transfer, a complete embrace of globalization would automatically result in industrial (p.3) upgrading and technological progress in China. Zizhu Chuangxin also signals the increased involvement of the Chinese state in the innovation processes.

Are these goals realistic? One cannot answer this question simply by looking at government policy or macro-economic indicators such as GDP growth or changes in the balance of trade. Nor can we make this judgment by looking at science and technology (S&T) indicators such as patenting, R&D expenditures, and China's STEM (science, technology, engineering, mathematics) labor supply. These indicators can be useful, but they must be analyzed in the context of evolving technologies, markets, and competitors of the particular industries, and in some cases the particular firms, that develop and utilize innovative capabilities. In the attempt to generate the higher quality, lower cost products that represent innovation, industries vary dramatically in terms of the organizations that must be transformed, production technologies that must be continuously upgraded, and the product markets that must be accessed. China also has to compete with the productive capabilities of other national industries for global and domestic market shares. And within a national industry there will be particular firms, with unique competitive capabilities, that emerge as leaders in global competition. The analysis of China as an innovation nation must therefore delve into the conditions for dynamic industrial sectors to continuously generate high-quality, low-cost products across a range of industries, while paying particular attention to the strategies and structures of the leading business enterprises and industrial districts within those sectors.

This volume provides studies of a range of industries of importance to China's future as an innovation nation, along with analyses of the evolving roles of investment by

government agencies and business interests in the process. Each of the chapters has been written by one or more leading academic experts, recruited by the volume editors not only for their deep knowledge of the industries concerned but also for their insights into the role of industrial innovation in the larger process of economic development. The volume includes traditional industries such as mechanical engineering, railroads, and automobiles; rapidly evolving and internationally highly integrated industries such as information and communication technology (ICT); and newly emerging sectors such as wind and solar energy. The industries included in this volume are not exhaustive; for example, we did not include a study of the newly emerging biotech industry. But the sum total of the studies provided in this volume is, we think, a big step (if not a great leap) forward in our understanding of the industrial foundations of China's attempt to become an innovation nation.

With these industry case studies taken together, the book attempts to understand China's growth path in terms of the conditions, characteristics, and impacts of technological innovation over the past decades and into the future. Specifically, this volume is motivated by the following larger questions.

(p.4) • What is the state and potential of China's indigenous innovation in important industrial sectors?

• How important is innovation to the sustainability of Chinese growth and national competitiveness?

• How do China's innovation paths differ from those of advanced or other newly industrialized countries?

• What are some of the key social conditions and characteristics that underpin the paths of Chinese innovation?

• What are the social implications of Chinese innovation for the stability of economic growth, the equity of income distribution, the social wellbeing of the Chinese people, and China's contribution to global wellbeing?

The volume sheds light on these questions. Definitive answers are not possible because the paths of innovation are long and inherently uncertain. The state of Chinese innovation is diverse across industries and enterprises and fluid over time. In each sector, we observe continued co-evolution of state policy, market demand, and technology development. The strategies and structures of individual companies and industrial ecosystems are changing rapidly. In almost all sectors, the gaps between Chinese indigenous companies and the global lead firms are shrinking, but at varying rates. Chinese governments and businesses are engaging in a variety of experiments in corporate governance, business models, employment management, and financial arrangements. Rather than viewing the Chinese path of innovation as a top-down movement, mostly powered by state-owned enterprises (SOEs), we are struck by the diversity of the types of business enterprises and the diversity of innovative experience across different industrial sectors. China's innovation path is being shaped by both top-down initiatives and bottom-up strategies, building productive capabilities from both technology transfer from abroad and indigenous investment. In our view, China has great potential to shape its institutions and organizations to be an innovation nation. But it still has a long way to go in developing and utilizing its innovative capabilities to achieve higher living standards, environmental sustainability, and social equality.

What is an Innovation Nation? Lessons from Japan and the United States

It is generally assumed that a nation needs innovation to prosper. Why? "Innovation" signifies that a national economy has acquired the capability to produce "higher quality" products than it was previously capable of producing. For any product, there are myriad dimensions of quality. Take a passenger (p.5) car as an example, a product that, as in many of the world's most advanced economies, has been strategically important for the economic growth of China over the past 15 years or so. In the passenger car industry, "high quality" may mean that a car is safe (high-quality brakes, high-quality tires, seat belts, airbags, injury-proof, etc.), fuel-efficient, and environmentally friendly—dimensions of quality

that are of public concern and are hence often subject to regulation. It may also mean that the car is rust-resistant, air-conditioned, roomy, stylish, comfortable, etc.—dimensions of quality that will be left to consumer choice. But it costs money to build quality into cars, and different types of government regulators and car buyers may register very different views about what “high quality” means and how much they are willing to pay for it.

Most nations have some car-producing capacity but few nations have the capability to produce high-quality cars. The “innovation nation” question is whether a national car industry can transform from producing low-quality cars to high-quality cars on a scale that has a significant impact on the nation’s economic growth. In the age of globalization, such high-quality cars also have to be competitive on global markets.

The dramatic development of the Japanese economy in the last half of the twentieth century demonstrated the possibility of transforming national industries into world-leading producers of sophisticated manufactured goods, including cars. Coming into the 1970s, after almost two decades of high-speed growth, Japan was still known in the West as a nation that produced low-quality goods. But by the 1980s the Japanese had become renowned for their high-quality production of automobiles, consumer electronics, memory chips, machine tools, and steel. The passenger car industry was at the center of the transformation of Japan from a relatively poor nation into a relatively rich nation within a few decades. A short review of this transformation process illustrates the social conditions of innovative enterprise that a nation such as China must put in place.

From the late 1950s, Japanese carmakers, including Toyota, Nissan, and Honda, had been trying to sell their small (“compact”) imported cars in the United States, gradually cutting into the leading market share of the Volkswagen Beetle. The inexpensive, fuel-efficient Japanese cars made some progress from the late 1960s, and then attracted the attention of a growing proportion of US consumers during the oil crisis of 1973–4, when prices at the gas pump quadrupled. But it was only from the last half of the 1970s, as Japanese

cars became recognized as high-quality as well as low-cost, that Japanese car exports to the United States entered into sustained growth.

Most observers of the car industry in the early 1970s attributed Japanese competitive advantage to the low wages and long working hours of its labor force as well as a favorable exchange rate. Yet in the last half of the 1970s the Japanese compact cars attained a reputation for being very high quality, (p.6) especially given their relatively low cost. Indeed during the 1980s, as Japanese wages rose rapidly and the Japanese yen strengthened, the Japanese car producers continued to gain market share in global competition. Japanese car producers also started to make massive investments in manufacturing plants in the United States as well as in Europe. Thus, besides exporting its high-quality products to the West, Japan also began exporting its management methods. Meanwhile the Japanese car producers transitioned from competitive advantage in compact cars to leadership in producing the whole range of vehicles, and by 1989 Toyota with Lexus and Nissan with Infiniti were able to compete with the high-quality German car producers, Mercedes-Benz and BMW, at the top of the price range of mass-produced luxury cars.

How did the Japanese manage to upgrade the quality of their cars in the 1970s and 1980s? The answers to this question provide us with insights into what China must now do to become an innovation nation. Japanese carmakers, led by Toyota, had three “social conditions of innovative enterprise” working on their behalf, that permitted them to produce cars that were higher quality than their competitors at lower unit costs, even when the advantages of low wages, long working hours, and a weak currency had disappeared (Lazonick 2007: 21–69; 2010a: 317–49; 2010a: 675–702).

- The first condition of innovative enterprise is “strategic control.” Japanese executives with both the abilities and incentives to build world-class car producers controlled the allocation of resources in the Japanese companies. Their abilities came from their careers as professional managers, often with

engineering backgrounds and their incentives came from the expectation of career progress within the company, rather than remuneration that depended on the company's stock price as increasingly became the case in the United States. Indeed from the 1950s, Japanese companies constructed a system of stable shareholding, also known as cross-shareholding, that protected their corporate treasuries from being looted by outside shareholders.

• The second condition is "organizational integration." The range of Japanese management methods that from the 1980s became famous in the West from just-in-time inventory systems to continuous improvement (kaizen) to total quality control entailed the integration of the skills and efforts of shop-floor workers with managerial (professional, technical, administrative) personnel. This organizational integration enabled the collective and cumulative learning processes that resulted in high-quality cars and large market shares. Supporting this organizational integration was the Japanese norm of permanent employment, also known as lifetime employment.

• The third condition is "financial commitment." The Japanese companies retained corporate profits and reinvested them in the physical and human (p.7) capital that would ultimately, but with great uncertainty, enable these companies to generate higher quality products at lower unit costs than their competitors. These investments were not just in plant and equipment. The Japanese institution of permanent employment turned labor into a massive fixed cost that then required the attainment of large market shares to transform these high fixed costs into low unit costs. Central to this process of transformation of the high fixed costs of human capital into low unit costs was the combination of sustained organizational learning and hard, steady work. In the immediate postwar decades, Japanese car companies faced financial shortages, but were

able to leverage their retained earnings with loans from Japanese banks under what became known as the main-bank system. By the 1980s the most successful Japanese car companies, along with companies in many other industrial sectors, had become so competitive on global markets that they were awash with cash (and were no longer dependent on bank loans), even as their employees enjoyed soaring living standards as they shared in their companies' gains from innovative enterprise.

Given the phenomenal growth of the Chinese car industry over the past 15 years or so, there are many lessons from the Japanese experience for understanding the possibilities and problems of China as an innovation nation through the development of this particular industry. China's manufacturing capacity of cars has increased rapidly. In 1998 just over half a million cars were produced in China, out of world production of 37.2 million (OICA 2013). Fifteen years later, in 2013, China's production of cars was 18.1 million, or 27.6 percent of the world total of 65.5 million. In units, in 2013 China's production just surpassed the *combined* total of Japan (8.2 million), Germany (5.4 million), and the United States (4.4 million). Right behind the United States was South Korea with 4.1 million cars produced, a big leap from 1.6 million 15 years earlier, and another success story that, like that of Japan, can be explained by the "social conditions of innovative enterprise" framework.

Enabling the growth of the Chinese automobile industry has been the domestic market populated by expanding numbers of upper middle-class households who now have the incomes to afford to buy cars. Of the 18.1 million cars produced in China in 2013, less than 600,000 were exported, mainly to low-income nations (almost 20 percent of these exports went to Algeria, China's largest foreign car market) (China Auto Web 2013). While China's total car output in 2013 was 2.2 times that of Japan's, China's total population is ten times that of its Asian neighbor. While the Chinese car industry cannot yet match the quality of Japanese, German, American, and Korean cars, the quality of Chinese cars has already surpassed those

produced (p.8) by the industries of India (3.1 million cars) and Russia (2.9 million), which have far longer histories of making cars. In comparative-historical perspective, the Indian and Russian car industries have lacked the organizational learning at the enterprise level that car companies operating in China have been acquiring over the past three decades.

The Chinese market is dominated by the foreign brands of cars produced through joint ventures (JVs) with Chinese SOEs, with relatively limited technological contribution from the indigenous carmakers. As Kaidong Feng details in his chapter (Chapter 5) on the automobile industry, under a policy called "Trading Market for Technology" (TMFT), launched in the first half of the 1980s, the Chinese state has permitted multinational companies (MNCs) to engage in JVs with SOEs based at the municipal or provincial levels. Through these JVs, China has been able to transfer automobile manufacturing from abroad. Now a number of these JVs are the leading producers of cars in China.

Under TMFT, however, the development of capabilities within the JVs has been constrained by the dependence of the Chinese SOEs on the foreign partners to provide them with the knowledge that is needed to produce cars that would be considered high quality in the Chinese market. This limitation of TMFT has thus translated into the lack of strategic control by the Chinese partners in the JVs (see more details in Chapters 2 and 5).

Feng argues that the exercise of strategic control by Chinese automobile firms is a critical next step for Chinese innovation in the automobile industry. Now there are a number of indigenous firms in the Chinese car industry that have gained significant market shares, with the aspiration of becoming leading global competitors in the next decade or two. In 2013 three indigenous companies—Geely with 554,000 cars produced in China, BYD with 511,000, and Chery with 459,000—ranked nos. 13, 14, and 15 respectively in Chinese car production. Together these three companies had just under 8 percent of Chinese car production. Geely's acquisition of Volvo has transformed the company into a small global competitor,

but to date very few Geely cars have been exported from China.

Competition within the Chinese car market has intensified in recent years, with slower growth and a crowded field. Newer indigenous companies face difficult challenges in producing cars that are comparable in quality with those of the established carmakers. Geely CEO An Conghui was quoted as saying: “Chinese can not only make cars, but are also capable of making good cars. We are utilizing the very best designers the automotive world offers to create a new global design language” (Ying 2014). No one can say whether Geely’s strategy will be successful, or the extent to which, over any given timeframe, it will be able to reap a significantly larger share of the Chinese car market. But we can say that the innovative strategies of indigenous companies like Geely, BYD, (p.9) and Chery will be central to the competitive dynamics that will over the next decade or two bring increasingly higher quality, lower cost cars to China.

The biggest lesson that we can draw from this comparative experience of the Chinese automobile industry is that the building of an innovation nation is a long process of collective and cumulative learning, with no certainty of success. At the enterprise level, strategic control is essential to put in place the organizational learning processes that can generate higher quality products. It is then imperative for the innovative company to attain a large extent of the market to drive down unit costs.

Investments in organization and technology in advance of product revenues, which is inherent in the innovation process, require what many have called “patient capital”; i.e. financial commitment. The extent of financial commitment required to sustain the innovation process depends on not only the size of the investment as a point in time but also the duration of time from when investments in the innovation process are made until, through the creation of competitive products, market sales can provide financial returns.

What are the sources of this financial commitment? The answer to this question varies dramatically depending on the

capital requirements of the particular industry in question. The Chinese state is well known for investing in long-term infrastructure projects. The Chinese government financed the building of the modern railroad system, including high-speed rail (see Chapter 6); a highway system; a telecommunication system; and an electric power system. Through SOEs, the Chinese government has also overseen the financing of a steel industry that in 2014 produced 49.5 percent of the world's crude steel.[3] In effect, steel has also functioned as an infrastructural input without which China's construction and transportation booms could not have taken place. The car industry, for example, could not have experienced its spectacular growth in China if it had had to wait for the necessary indigenous steel capacity to be put in place.

China used to have a highly centralized financial system with the state-owned banks being the only source of finance capital. In recent years, however, much of the decision-making for allocating financial resources to China's industrial development has occurred at the local government level, as detailed in Chapter 2. Even then, central government financial agencies have played key roles. The capital available to local governments has not been constrained by the current taxpaying capacity in the local region. Rather the ability of local governments to finance industrial development has been supported by loans from the China Development Bank, with local land, often purchased from peasants, as collateral (Sanderson and Forsythe 2013). The (p.10) local government can also compete for subsidies from the central government to help fund strategic industries, as documented in more detail in the chapters on semiconductors and clean technology (Chapters 7, 11, and 12).

The sources of capital for innovation are becoming more diversified. Chinese companies have made creative use of foreign stock markets to raise capital. In the 1980s and 1990s, a number of SOEs and non-SOEs were able to list on the Hong Kong stock exchange to gain direct access to foreign exchange. Over the past decade, as is shown in this volume's chapters on venture capital (Chapter 3) and the solar panel industry (Chapter 12), young Chinese companies have been

able to raise significant amounts of capital on the NASDAQ stock exchange or the New York Stock Exchange (NYSE) in the United States. In 2011, there were 179 Chinese firms listed on NASDAQ (up from 41 in 2006), 84 on NYSE (up from 23), 43 on AMEX (8), 549 on the Hong Kong Stock Exchange (333), 182 on Singapore Stock Exchange (117), 81 on London AIM (47), and 141 on others (29) (Pan and Brooker 2014). This stock-market financing has been highly speculative, and if and when, as happened in 2011 in the solar panel industry, the Chinese companies go bankrupt, the productive capacity remains in China but foreign speculators are left holding valueless shares.

More recently, as is detailed in the chapter on venture capital (Chapter 3), startup companies in China have had access to US-style venture capital in China and abroad. But, as was the case in the United States, venture capital in China has emerged as a source of finance at a relatively late stage of industrial development, after governments and large corporations have made the massive investments in physical and human capital that make startups possible (Lazonick 2009a). In the United States from the late 1970s, lobbying by Silicon Valley interests, taken to the national level, convinced the US Congress that the attraction of venture capital to support innovation required dramatically lower tax rates, ignoring the fact that government and business investments in the previous generation had made new high-tech ventures possible. When companies such as Cisco Systems, Microsoft, Intel, Apple, and Amgen, among many others, have transformed themselves from small new ventures to enormous going concerns, their executives have viewed their profits as “returns” to shareholders, in some cases expending more than 100 percent of corporate profits over the past decade on stock buybacks even while paying ample dividends. Yet public shareholders have made *insignificant* investments in the productive assets of these companies, raising the question of why they are entitled to such high levels of rewards (Lazonick 2009a, b, 2014a, 2015; Hopkins and Lazonick 2014). In other cases, especially in the US biopharmaceutical industry where it can take at least a decade and $1 billion to develop an approved medical drug, venture-backed companies have been

able to list on the stock market, and financial interests have been able to make vast amounts of money, even when no product is produced (Lazonick and Tulum 2011).

(p.11) Since the 1990s, China has attempted to replicate the US “New Economy business model” through a combination of foreign direct investment, global value chains, Chinese high-tech returnees from the United States and elsewhere, the establishment of various domestic stock exchanges, and high-profile initial public offerings in the United States such as that of Alibaba (see Chapters 2 and 3). At this stage, it is fair to say that venture capital development supplements the weakness of China’s state-owned banking system in supporting the small private startups. China’s variant of the internet sector has been a focus of the venture capital boom in China.

In the long run, however, there is a distinct danger that Chinese business executives, along with the Chinese public, might become enamored with the speculative stock market as the primary institution for financing innovation. Unless China, like Japan, develops its own institutions to prevent financial interests from capturing the lion’s share of the gains from innovative enterprise, China runs the risk of having its financial economy dominate its productive economy as has happened in the United States, with, as the results, an extreme concentration of income among the richest households and the stifling of a prosperous middle class.[4]

Building Chinese Institutions for an Innovation Nation

If China is to become an innovation nation, the Chinese government will have to pay attention to three types of national institutions—governance institutions, employment institutions, and investment institutions—that can support or undermine the social conditions of innovative enterprise. Through the evolution and operation of these institutions, China can learn how to develop and utilize its indigenous innovation capacity in relation to the global production systems in which its industry is deeply intertwined. Let us consider each of these institutional types in turn.

Governance Institutions

A critically important characteristic of China's development since the late 1970s has been the willingness to encourage the establishment of business enterprises with strategic autonomy from state control. The former Soviet Union did not permit such a strategy and to this day has not spawned even one important global manufacturing enterprise. In contrast, the Chinese state, (p.12) in a business sense, let a hundred flowers bloom to the point that China today permits the coexistence of a variety of corporate governance regimes. Some Chinese high-tech firms such as Lenovo and ZTE were originally spun off from Chinese research institutes or state-owned enterprises. Others such as Alibaba, Huawei, Tencent, and Xiaomi were private startups. Even with this autonomy, however, Chinese business continues to rely heavily on state investments in physical infrastructure and human capital as foundations for business investment in the value-creating capabilities that can bring innovative products to the market. Along with state support come industrial policies, financial incentives, and legal regulations and restrictions that may enable or proscribe business activity.

There has been a heated debate in the West about the rise of state capitalism as opposed to liberal capitalism, with China being the prime example of the former.[5] The definitions of state capitalism vary, but the most common view is that it is characterized by the state use of its power to establish and promote favored enterprises, most likely SOEs, to become national champions in the market (Bremmer 2009). This volume provides a reality check on this perspective on state capitalism as the central feature of the Chinese economy, with every chapter in the volume addressing the issue in one way or another of the role of the Chinese state in innovation. The critical insight from the studies in this volume is that, far from the overarching Leviathan image of Chinese state capitalism, the roles of the Chinese state are extensive and multifaceted, but entail reflexive and collaborative interactions with business enterprises, many of them non-SOEs. Chapter 2 shows that while the Chinese state has indeed maintained a consistent vision of seeking technological leadership and autonomy from the West, it has changed its policies and

practices dramatically in the last 60 years, responding to domestic economic reform agendas, global relations, and technological transformations.

In the 1980s and 1990s, the Chinese government set up advanced-technology enterprises through SOEs or JVs in strategic sectors such as automobiles (Chapter 5) and semiconductor fabrication (Chapter 7), in line with the state capitalism model. However, with the exception of China Railway Corporation (formerly Ministry of Railway), these companies, with strategic control in the hands of the state, did not do well in keeping up with rapid technological change. As Chapter 6 on high-speed rail makes clear, this particular sector lends itself to a state capitalism model because of the need for central planning of the system, enormous financial commitment, and the absence of international competition.

(p.13) The various chapters in this volume demonstrate that not all industries are created equal. They can differ dramatically in terms of technologies, markets, and competitors. In industrial sectors in which decentralized decision-making is more important for transforming technologies and accessing markets, financial commitment less severe, and international competition more intense, the Chinese state has deployed a growing list of flexible instruments to promote innovation by diverse actors from SOEs to private companies. These instruments include direct R&D finance to state-owned research institutes or enterprises, preferential finance and tax policies for strategic industries, public procurement, and domestic technological standards.

The roles of central and local governments have expanded and contracted at different stages of the growth of enterprises or industries, as exemplified by the cases of Huawei and ZTE (Zhongxing Telecommunication Equipment Corporation) in the communication equipment sector (Chapter 8). In the railroad (Chapter 2) and semiconductor fabrication (Chapter 7) industries, state direct investment in SOEs or JVs remains central. In the clean-tech industries (Chapters 11 and 12), governmental subsidies, supportive pricing, and regulatory policies such as feed-in tariffs have been critical mechanisms for government influence. In the ICT sectors, public

procurement and industrial technological standards have been immensely influential. In all sectors, low-cost land and subsidized rent in industrial districts and science parks, preferential tax rates for innovative startups, as well as local government loans, have been used to support a variety of enterprises.

There are questions, however, whether such local support is serving to preserve local industrial capacity as sources of tax revenue and employment or to encourage the development of higher quality products. Of particular concern is the tendency of governments, especially at the local level, to protect established enterprises through bank loans and subsidies regardless of their performance, while discouraging the emergence of new competitors. In the automobile industry, for example, for decades the state established regulatory barriers to prevent new entrants into the industry that could challenge the JVs set up under TMFT (Chapter 5). These barriers disappeared, however, after China joined the World Trade Organization (WTO) in 2001 (Chapter 5), and, as we have seen, a number of indigenous companies have become serious competitors in the automobile industry.

Overall, the drivers of China's innovation efforts are both top-down and bottom-up, with shifting combinations depending on the nature of the industries and extent of global integration. Top-down state investment has played critical roles in building China's infrastructure and human resources, which directly affect technology markets and business enterprises. China's state governance regime over the management of innovation processes is still evolving through trial and error in response to feedback from industry. For China to (p.14) become an innovation nation, it needs a governance regime that ensures the complementarity of government and business investment in productive capabilities. As such complementarities are being negotiated between assorted governmental and business players, the emerging governance institutions must guard against "rent-seeking" tendencies, based on value extraction in excess of contributions to value creation, by powerful parties within the governmental and business entities. Each of the chapters in this volume provides examples of these problems.

Stock markets are prime institutions that can enable excessive value extraction (Lazonick 2013). The growth of stock markets and shareholding companies are new phenomena in China since the 1990s, modeled after similar institutions in the United States. It should not be assumed, however, that the publicly listed business enterprise represents the corporate governance model best suited to becoming an innovation nation. In the United States, for well over a century, the advantage of the publicly listed corporation for investing in innovation has been the separation of share ownership from managerial control, which is the fundamental role that the stock market plays. Contrary to conventional wisdom, the separation of ownership from control in the United States did not occur because companies had to raise money from the stock market to enable the growth of the firm. Rather the constraint on the growth of the firm was managerial capability (Lazonick 2014a). By listing on the stock market, the original owner-entrepreneurs and their financial supporters could exit from their investments, leaving salaried managers who had helped make the company a success in positions of strategic control. In the current environment, however, with their compensation mainly in the forms of stock options and stock awards, top executives of US companies have used their positions of strategic control to engage in massive value extraction that benefits themselves. Research by Lazonick and colleagues has shown that this value extraction undermines innovation.[6]

Given the interconnections of the US and Chinese economies, combined with the growing influence of the stock market in China, there is a distinct possibility that Chinese executives will be drawn to the highly financialized business model that now dominates in the United States. If China is to remain on the path to becoming an innovation nation, Chinese government policy must ensure that corporate profits are returned to those taxpayers, workers, and financiers who have *actually invested in productive capabilities* rather than to financial interests who simply buy and sell corporate shares. We should also note that China’s most successful high-tech company, Huawei Technologies, is 100 percent employee-owned, and is not listed on any stock market.

(p.15) Huawei’s history to the present exemplifies the roles of strategic control, organizational integration, and financial commitment in the operation and performance of a business enterprise.[7] In the years after the company’s establishment in 1987, in the face of intense competition, Huawei’s founder, Ren Zhengfei, pursued a strategy of making the company the leading indigenous producer of high-quality telecommunication switches. The company first manufactured equipment for service providers in China’s rural areas, which were neglected by MNCs and SOEs. This strategy provided Huawei with not only its first customers but also opportunities for organizational learning. In an industry with about 200 competitors that were seeking to supply equipment to China’s burgeoning telecommunications networks, Ren sought to attract, retain, and motivate personnel by sharing ownership of the company with employees. Known collectively as The Union, Huawei employees now own 98.6 percent of Huawei’s shares and participate in the election of a two-tier governing board. Ren owns only 1.4 percent of the shares, but he remains chairman of the company and has veto power in decision-making. Employee ownership has provided an institutional foundation for the organizational integration of Huawei’s personnel into the company’s organizational learning processes while helping to finance the growth of the firm in the 1990s because employees took their raises in the form of shares. From the mid-1990s, Huawei was able to tap local government financing, and from the late 1990s the company secured loans from the China Development Bank to finance Huawei’s customers to purchase its equipment. Because Huawei is not listed on a stock exchange, it can use its cash flow as it sees fit for developing the company’s competitive capabilities without interference from outside shareholders.

Huawei’s experience is a path-dependent process that is difficult to replicate, especially in an era in which speculative stock markets make founders of young companies billionaires when they do initial public offerings (IPOs) at home and abroad. While the ability to do a quick IPO certainly attracts venture capital to startups, it also creates the danger that financial interests both inside and outside the company might

have more of an interest in extracting value than creating value and, as has been evident in the case of the United States, use the ideology of “maximizing shareholder value” to reap where they have not sown (Lazonick 2014a, b, c, and forthcoming).

As China seeks to determine the system of corporate governance that will enable it to transform itself into an innovation nation, it needs to understand the structures of strategic control that have enabled its most successful companies to achieve sustained competitive advantage. At the same time, it needs to recognize the ways in which, for publicly listed corporations in the West, (p.16) and particularly in the United States, the ideology that companies should be run to “maximize shareholder value” has been destructive of innovative enterprise.[8] Rules and regulations concerning corporate governance must recognize that innovation is inherently an uncertain process in which decision-makers must have both the abilities and incentives to invest in learning organizations; hence the centrality of human capital for both strategy and learning in the innovation process. At the same time, a system of corporate governance that promotes innovation must ensure that strategic decision-makers within the firm recognize the multi-dimensional roles of the society in which the firm is embedded in contributing to the innovation process, and advocate for a system of corporate resource allocation that returns a fair share of corporate profits to its employees in the forms of employment stability and wage increases while, through the tax system, reproducing the ability of the state to support the next generation of innovation just as these companies have been supported in the past.

It may be that the leaders of some of the most successful Chinese companies that have been listed on the stock market might have found ways to deal with the problem of predatory shareholders. For example, China’s Alibaba, whose $25 billion IPO on the New York Stock Exchange in September 2014 is the biggest IPO in history, has a partnership structure that, like Google and Facebook in Silicon Valley, permits widespread public shareholding while leaving strategic control over corporate allocation decisions in the hands of the

founding partners. Although shareholder-value activists rail against dual shares and other modes of keeping outside shareholders at bay, it gives those insiders who exercise strategic control the power to ensure that value creation takes precedence over value extraction and that those who engage in value extraction are the parties who contributed to value creation. In shaping its own corporate governance institutions, the Chinese government should be aware of the ways in which the relation between value creation and value extraction can support or undermine the achievement of stable and equitable economic growth. It needs to be wary of those financial interests and business academics who argue that the highly financialized US new economy business model represents the foundation for a prosperous society.

Employment Institutions

Innovation results from a learning process. The learning that enables a company to transform technologies and access markets to generate higher quality, (p.17) lower cost products is both collective and cumulative, and hence organizational rather than individual. Learning is collective because large numbers of people in a hierarchical and functional division of labor must engage in interactive learning. Learning is also cumulative because the knowledge that the learning organization developed yesterday provides an indispensable foundation for what that organization is capable of learning today. The most intense and coordinated learning processes tend to occur within particular business enterprises, but collective and cumulative learning can also occur in industrial districts, of which China's most well-known is Zhongguancun in Beijing (Zhou 2008b). Our volume also studies other industrial districts such as mobile phones in Shenzhen (Chapter 10) and IC design in Shanghai (Chapter 9). The mobility of labor from established companies to startups and, in the case of expatriates, from foreign nations back to China are also important for launching or sustaining an innovation process. But that process will only be successful if key contributors remain committed to the collective and cumulative learning processes in the new business organizations that they join.

Indeed, the hypermobility of high-tech labor from one firm to another can undermine the organizational learning that is the essence of the innovation process. By the same token, inflexible employment relations, such as the “Iron Rice Bowl” that used to predominate in Chinese SOEs can severely restrict the ability of a business enterprise to adapt to changes in the market, technological, and competitive conditions that characterize its industry. The mobility of labor between firms and between government, business, and civil society organizations is essential to a society that promotes individual freedom. But an innovation nation requires employment relations that enable and motivate freely mobile labor to remain committed to organizational learning processes for sustained periods of time. At the same time, an innovation nation must have policies that ensure the preservation and, if possible, enhancement of human capital for workers with long years of work experience later in their careers. In recent research, mainly focused on the United States, Lazonick and his colleagues have highlighted the importance for an innovation nation of employment institutions that support “collective and cumulative careers” over the four or five decades that individuals seek to remain in the labor force as productive employees (Lazonick et al. 2014: 51–4).

Compared with Japan and the United States, China has a very fluid labor market, with the exception of employment in SOEs. The intense competition for highly skilled workers means most high-tech companies, even those owned by the state, typical suffer from hypermobility of labor (Zhou 2008b). An inability to retain employees long-term thus represents a significant challenge for Chinese high-tech enterprises to preserve and enhance their human capital. As China concludes its fourth decade of sustained growth since the Economic (p.18) Reforms of 1978, government policy at both the local and central levels should consider how employment institutions can be structured to support collective and cumulative careers in a world of highly mobile labor.

As labor costs have risen steeply in China since 2005, it is increasingly imperative for Chinese enterprises to retain their experienced workers. For example, China’s most highly profiled nation-wide talent search program, One-Thousand-

Talent, promises attractive funding for elite researchers from abroad, but lacks similar inducements that target experienced domestic talent (Qiu 2009). The stock-option culture that has become synonymous with Silicon Valley and to which many Chinese high-tech workers have been exposed during periods in the United States tends to foster individual labor mobility at the expense of collective and cumulative learning (Lazonick et al., 2014). As companies in China become enmeshed in this stock-based labor-market competition, they will need the government to step in to help stem the hypermobility of labor, by for example placing restrictions on exercising stock options or higher taxes on stock-based pay. Thus far, the Chinese government has paid scant attention to the formulation of institutional arrangements to encourage collective and cumulative learning or to discourage the hypermobility of high-tech labor.

To be sure, in certain periods and in certain sectors, a high level of labor mobility has been beneficial to industrial clusters. Many chapters of this volume document the emergence of industrial ecosystems, much of which were created through spin-off of key engineers or business managers from the existing enterprises. The ever-evolving divisions of labor and modularized value chains have been the prominent characteristics of the contemporary production system, knitted through inter-firm networks of supply chains and producer services. Since China hosts a significant portion of the global production system, working at different levels in ever-evolving value chains, it draws labor and other resources from within and outside China. The transfer of people with collective and cumulative learning from JVs to indigenous Chinese companies is evident in the automobile industry (Chapter 5), where experienced engineers from JVs have been the backbone for the newer indigenous automakers. Similar cases are also common in the machinery equipment industry (Chapter 4), with the chapter focusing on two companies founded by former employees of a related enterprise or a research institute.

International labor mobility has been important to the accumulation of productive capabilities in China. Returnees from the United States were China’s first generation of

venture capitalists, and they help to train the newer generation of venture capitalists from China (Chapter 3). Returnees have also powered China's IC foundry and design industries (Chapters 7 and 9). The positive effects of collective and cumulative learning within a specific industrial district are also evident in the cellphone industry. The cluster in (p.19) Shenzhen hosted a large number of *Shanzhai* cellphone makers during the 2G era. With the arrival of 3G technology, some of the cellphone makers used their previous expertise to set up companies that upgraded to become important brand-name smartphone makers. In general, at this stage of its development, in the highly dynamic electronics industries in which China is most integrated with global markets, Chinese enterprises tend to prioritize speed of adaptation to changing market opportunities over securing the long-term commitment of employees (Chapter 10). Yet, as a subject for further study, we would hypothesize that, given the collective and cumulative character of the innovation process, even in highly dynamic sectors, it will be those enterprises and those districts that are in the forefront in organizational learning that will be best positioned for competitive advantage.

The Chinese system of higher education has had to adapt to the rapidly changing requirements of China as an innovation nation. Since the 1990s, China's higher education system has expanded at an unprecedented speed. Enrollment increased by close to seven times between 1998 and 2010 (Li 2012). The *New York Times* reported that, in 1996, one in six Chinese 17 year olds graduated from high school, the same proportion as in the United States in 1919. By 2013, however, three in five Chinese 17 year olds graduated from high school, matching the United States in the 1950s. There are concerns about the preparedness of these high school and college graduates in the wake of such a dramatic surge, and whether the Chinese market can absorb the more highly educated population (Bradsher 2013). There has also been a longstanding criticism of the Chinese education system for its suppression of creativity and the failure of its curriculum to respond to changing socioeconomic needs (Zhao 2014). However, these are also common complaints in Japan and South Korea, but

these limitations have not prevented those countries from transforming themselves into innovation nations. Since 2000, there has been a sharp increase in Chinese students studying abroad and since 2007 also a similar increase of overseas students returning to China (Zhou and Hsu 2010). Chinese nationals in 2010 represented 25 percent of foreign doctorate recipients in science and engineering fields from American universities, more than double the proportion from India, the second largest national group (National Science Foundation 2012). With growing and diversifying channels for obtaining a higher education, both in China and abroad, China's more highly educated workforce constitutes a foundation of human capital for China to transform into an innovation nation.

Investment Institutions

Innovation requires financial commitment, or what is sometimes called "patient capital." Money needs to be tied up in productive resources until a (p.20) business enterprise can develop and utilize those resources to generate competitive products that can then generate financial returns. Since innovation is uncertain there is no guarantee that these returns will be forthcoming. Since innovation is collective, the productive resources in which this money is invested include human capital as well as physical capital. The investments in human capital will include the costs of training and retaining people, only some of which are captured in R&D expenditures.[9] And it is because of the cumulative character of the innovation process that financial *commitment* is needed; the innovative enterprise requires sustained access to finance until it can transform investments in productive resources into the high-quality, low-cost products that can generate financial returns.

Some of the chapters in this volume, including those on venture capital (Chapter 3), integrated circuit fabrication (Chapter 7), and solar panels offer substantial new information and insights (Chapter 12), but much research on the sources of financial commitment in Chinese development remains to be done. Clearly, by investing in a wide variety of infrastructure projects, the Chinese government has enabled the rapid economic growth of the past three and a half

decades. But, as emphasized earlier, all of this investment in infrastructure would have simply entailed high fixed costs and would not have been translated into sustained economic growth without business enterprises that were able and willing to make use of these infrastructure investments by producing competitive products. For example, the massive investment in highways by the Chinese government would be largely wasted without the mass production and sale of cars and trucks in China to drive on them. But without these prior investments in highways, the usefulness of these cars and trucks to most (potential) buyers would be vastly reduced.

In the financing of infrastructure projects, China's high-speed rail system represents one of the nation's most impressive achievements. Massive loans from the state banks were used to construct over 13,000 km of high-speed railroad tracks from scratch in a decade. China Railway Corporation (formerly Ministry of Railway) imported and developed high-speed train technology and built the largest high-speed networks in the world, an impossible feat for any business enterprise that would need to generate profits over a reasonable time horizon to survive (Chapter 6).

(p.21) The dedicated passenger rail system liberated the capacity of the overburdened existing rail system to better accommodate freight shipments, with the two systems working together vastly speeding up the movement of goods and people, and thus transforming China's economic geography. A World Bank study done in 2014 found that the number of China's high-speed rail passengers grew five-fold from 128 million in 2008 to 672 million in 2013, with 530 million of the passengers in 2013 using dedicated passenger lines. In 2013, the passenger-km on high-speed rail was slightly more than the rest of the world combined (Ollivier et al. 2012). Such infrastructure development, financed almost entirely by government loans, means that China Railway Corporation will be heavily in debt well into the future. But the infrastructure investment, which only the government could have financed, has provided Chinese households, businesses, and government agencies with a public good that has profound positive implications for China's urban and industrial development.

As a general rule, it can be argued that the Chinese state has taken control over investment and production through SOEs in those industrial sectors in which massive infrastructure investments must be made to enable Chinese development but in which rapid innovative responses to global competition are not required. Thus the Chinese government has taken direct control over investment in the steel industry, to the point where China now accounts for almost half of the world's crude steel production, to ensure that there would be sufficient indigenous capacity to support the development of the construction and transportation (particularly rail and automobile) industries. In the ICT industries, the Chinese government used SOEs to fund and operate the service-provider networks but encouraged competition among non-SOEs to develop indigenous ICT equipment. In the critical integrated-circuit fabrication industry, the Chinese government initially favored SOEs but since about 2000 came to see that non-SOEs, formed by returnees, of which SMIC (Semiconductor Manufacturing International Corporation) and Grace are the most important examples, were much more capable of making the strategic decisions necessary to remain close to the technological frontier in an industry in which rapid change in process technology is the norm. Yet, as shown by Yin Li in Chapter 7, the extremely high fixed costs of investing in new-generation IC foundries has meant that the Chinese government has been compelled to help finance these non-SOEs if it wants China to retain the possibility of becoming a world leader in this crucial industry.

We have already discussed the relatively new role of venture capital in the Chinese economy, as well as the potential for this source of finance to become "impatient" if it looks for quick returns on a speculative stock market in advance of generating competitive products. The development of venture capital in China has complemented a weak apparatus of state financial institutions for supporting startups. Given that this venture-capital system was (p.22) established only recently, most of China's successful technology enterprises to date have not primarily relied on this mode of finance. A prime example, already discussed, is Huawei Technologies with its employee stock ownership plan (ESOP), put in place at the beginning of

the 1990s. Huawei's shares have never been listed on the stock market, and the company does not pay dividends to its shareholders. Indeed, one can argue that by protecting the company from the value-extracting pressures of a public stock-market listing, Huawei's ESOP has funded the growth of the firm. Once it was clear in the late 1990s that Huawei had emerged as the strongest indigenous innovator among Chinese communication equipment firms, the China Development Bank extended large low-cost loans to Huawei to help fund its expansion as a global company (*Bloomberg News*, 2011). Despite its exclusion from the US market on national security grounds, in 2013 65 percent of Huawei's markets were outside China (although from 2012 to 2013 China was Huawei's fastest growing market) (*Huawei Annual Report*, 2013: 23). In 2014 Huawei surpassed Sweden's Ericsson as the world's larger vendor of equipment to carrier networks, the most technologically sophisticated segment of the communication equipment industry.

In principle, the stock market can serve as a source of finance for investment in productive capabilities. In practice, however, it has become in many places a mode of extracting value from the productive economy. If China wants to become an innovation nation, it needs to learn the lessons of Huawei in the ongoing structuring of its investment institutions, and recognize the significant dangers of a stock-market-oriented economy in empowering financial interests over productive interests, with a failure to become an innovation nation as the likely result. Chinese companies that list on the stock market, as high-tech companies with growth potential, will need to find ways the ensure that the listing supports rather than undermines the value-creation process, with government policies that regulate financial markets supporting this developmental objective.

Managing Indigenous Innovation in a Global Production System

A crucial difference between the rapid industrial growth of China and the earlier transformations of Japan and the United States is the ever-tightening articulation of global production networks (GPNs) today. In the post-World War II decades,

national production systems were still the norm, so the rise of leading national companies usually meant the corresponding rise of the entire supply chain within the country. From the late 1960s, however, a transformation in vertical production relations began to take place, with (p.23) GPNs becoming the norm. China's rapid growth from the 1980s coincided with the expansion of GPNs, especially in the ICT industries, with Chinese producers becoming integral to their development.

A GPN is "the globally organized nexus of interconnected functions and operations by firms and non-firm institutions through which goods and services are produced and distributed" (Coe et al. 2004: 471). Under such a system, production processes have become modularized and distributed across different countries. Large transnational corporations, usually located in advanced countries, which Ernst and Kim call "flagship" corporations, take on the strategic, technological, and organizational leadership in GPNs (ibid. 2002). As they state: "The main purpose of these networks is to provide the flagship with quick and low-cost access to resources, capabilities and knowledge that are complementary to its core competencies" (Ernst and Kim 2002: 1420). The 2013 World Investment Report estimated that some 80 percent of international trade is organized through GPNs (Yeung and Coe 2015).

GPNs provide China with opportunities to manufacture for the world market, as Chinese companies or foreign subsidiaries become subcontractors of leading corporations in the advanced economies. But GPNs also make it harder to achieve strategic control of technology development because of the interdependent character of the networks. For example, China policymakers initially devised TMFT strategy in the automobile industry (Chapter 5) and integrated-circuit industry (Chapter 7) to transfer technology from abroad to localized production. But the modularization of global production means that control over the core intellectual property rights or crucial technology components can be separated from the particular stages of manufacturing that take place in China. GPNs have also created higher entry barriers for certain segments of production. For example,

several global giants in the semiconductor fabrication industry supply the entire world market. Their economies of scale and control over technology standards make it very difficult for latecomers to break in. Examples include Qualcomm and Samsung in IC chips for cellphones, and TSMC and UMC in IC foundries. To compete with these established players requires such a massive investment that even China has been unable to mount it (Chapter 7). China's desire for indigenous innovation is thus constantly bumping into the reality that key intellectual property or crucial product components are controlled by enterprises in more advanced countries that participate in the GPNs.

Given the modularization of production, Breznitz and Murphree (2011) describe China's strategy as "the Run of Red Queen" in which Chinese enterprises shun novel product innovation, but specialize in competitive second-generation products and processes that entail incremental innovation. They criticize the techno-fetishism that underestimates the frequency and cumulative effect of the innovation that routinely occurs in Chinese (p.24) enterprises. We agree with this perspective on the significance of cumulative incremental innovation in China's development thus far. But it is not sufficient to build China as an innovation nation. Both Taiwan and South Korea entered GPNs in the low-end segments in ICT industry, but have now moved to the higher value-added segments of GPNs. The success of such a transformation is contingent upon strategic control of the enterprises within a national economy. If China is to become an innovation nation, Chinese enterprises will have to work with GPNs while avoiding being captured by the networks with a lack of strategic control over the paths of China's technology development.

Several chapters in this volume examine how Chinese enterprises work within GPNs in ways that enhance their strategic control in global production. One way is through control of the system integration of technology. The rapidly growing size of the Chinese market has become an irresistible magnet for foreign companies to engage in FDI in most technology sectors, drawing technology suppliers from all over the world and creating a technological landscape that is

notably more plural than those of its counterparts in East Asia. China's high-speed rail network, for example, has transferred technology from Germany, Spain, Japan, and France. Its automobile industry has a prolific array of Japanese, American, German, and Korean models, all produced through JVs with SOEs. Its 3G mobile phone network operates on three global standards: WCDMA, CDMA2000, and indigenous TDS-CDMA. A similar coexistence of a variety of technology platforms can also be found in clean-tech energy industries such as wind turbines and solar panels (Chapters 11 and 12). Chinese companies, therefore, are now well positioned to learn, compare, and select technology best suited for their markets. By moving up GPNs to become systems integrators, domestic companies can gain more in-depth understanding of different foreign technologies and, based on such understanding, can provide innovative products.

The second approach is to achieve strategic control of the technology-transfer processes. Here the ability of Chinese enterprises varies among industrial sectors. In railroads, the state monopolizes the planning, construction, operation, and regulation of the entire rail system. Because China was practically the only viable major market for high-speed technology in the 2000s, China's Ministry of Railway had tremendous leverage in negotiating favorable technology-transfer agreements with foreign technology providers, thus permitting the China Railway Corporation to integrate foreign technology and develop a distinctive Chinese high-speed rail system that it is now even attempting to export to other countries (Chapter 6).

The success of state-directed technology transfer in the case of high-speed rail is, however, more an exception than a rule. In the automobile and IC industries, the Chinese government brokered marriages between MNCs and Chinese SOEs in the 1980s and 1990s under its TMFT policy. These JVs (p.25) provided China with the technological experience that subsequently made it possible to establish completely indigenous enterprises in which strategic control over all technology and market decisions resides in China. With this strategic control, indigenous Chinese companies in the automobile industry have continued to seek out foreign

technology through licensing as well as through the acquisition of foreign auto companies (Chapter 5). We see similar strategies of technology acquisition in renewable energy sectors (Chapters 11 and 12).

The third way to maintain strategic control is through strengthening internal R&D. In the ICT sector where GPNs are the most well developed, successful companies such as Huawei and ZTE have relied mostly on internal R&D development while referencing foreign technology trends. National security concerns from the West have made it difficult for Chinese telecommunication companies to gain access to advanced technology (Chapter 8). Internal R&D has also been very important for machine equipment sectors where non-standardized interaction with customers is the technological norm. In the cellphone sector, the technology improvements behind smartphones have been accomplished through a combination of top-down governmental R&D on the Chinese national 3G standards and bottom-up incremental improvements among a large number of firms in the industrial ecosystem. While it continues to be necessary to collaborate with foreign companies, studies in this volume show that indigenous innovation can take place only when the Chinese companies have strong internal R&D capabilities.

Last but not least, we found that enterprises can strengthen their strategic control by targeting China’s domestic market. Zhou’s work on China’s IT industry in the earlier 2000s suggests that the synergy between China’s export production capacity and domestic market growth has underpinned the success of China’s most competitive technology firms (Zhou 2008a, b). This remains the case. In particular, the Chinese market provides buoyant demand among low- to middle-class customers or price-sensitive enterprise clients. They cannot afford best-quality foreign products, but still desire reliable technology. Chapter 9 on IC design suggests that the competitive edge of China’s IC designers has been in the cost of their products compared with more expensive counterparts from foreign companies, Chapter 10 describes Chinese cellphone companies as specializing in “good enough” innovation.

However, providing lower cost products cannot be a sustainable strategy without simultaneous improvements in quality. As mentioned earlier in this introduction, Japanese carmakers were able to transform Japanese-made cars from low to high quality within two decades. China's middle markets are changing rapidly with rising incomes and higher expectations for product quality. Unless Chinese firms are able to move with the shifts in demand, they are likely to lose their markets to foreign competitors that have traditionally occupied the high-end market segments. Xiaomi, popularly known as China's (p.26) "Apple," is able to produce cellphones with leading technical specifications and appealing designs, while offering prices that are less than half the mainstream global brands. This combined low-cost and good-quality strategy enabled Xiaomi to emerge as China's leading cellphone retailer in 2014, only four years after its establishment. As China's domestic market has grown in size and sophistication, only those Chinese companies that are capable of providing higher quality products will be able to survive in domestic and global competition.

In sum, whether China can become an innovation nation depends on whether it can create a governance regime that ensures the complementarity of government and business investment in productive capabilities—a collaboration that inevitably means a collaborative division of labor in the exercise of strategic control. This strategic control must be maintained and extended while Chinese companies remain integrally involved in the global economy in GPNs, which can be achieved through system integration, control of technology-transfer, and targeting distinctive domestic markets. China's emergence as an innovation nation is also contingent on employment institutions that can facilitate collective and cumulative learning within enterprises and industrial districts. And last but hardly least, China has to develop and sustain investment institutions that provide diverse but committed patient capital that supports and rewards investment in value-creating productive capabilities rather than value-extracting financial engineering.

A Brief Guide to the Chapters in This Volume

Chapter 2 traces the evolution of Chinese government policies on technological innovation. We are currently at a stage where the state is asserting its central role in promoting technological innovation following the stages of labor-intensive export-promotion and “TMFT” style import-substitution policies. The newly installed “indigenous innovation” policy employs a growing list of flexible instruments to spur innovation including direct R&D support, preferential finance and tax policies, public procurement, industrial promotion, and domestic technology standards. Foreign firms and local governments are also playing more prominent roles in bringing technological dynamism to the system.

Chapter 3 analyzes the venture capital (VC) industry in China. As a new and alternative instrument for financing innovation, distinct from state-owned or state-controlled financial institutions, the venture capital industry has supported China’s new generation of ambitious entrepreneurs, and is especially active in the ICT sectors. Institutional changes in China’s financial (p.27) markets, especially the launch of ChiNext, the Chinese-style NASDAQ, have encouraged the explosive growth of domestic VC funds and firms. With stock markets around the world, including those in Hong Kong and China, catering to technology enterprises, VC has become a main form of financing grassroots innovation by non-state firms. However, along with the growth of VC comes a growing risk that the processes of new-firm formation and growth will become infected by a combination of American-style financialization and Chinese-style corruption.

Chapters 4 to 6 examine China’s machine-based industries, as represented by mechanical engineering, automobiles, and high-speed rail. Unlike the ICT sectors, the markets for these industries are largely within China, and global integration is not as developed as in ICT. Chapter 4 focuses on the highly heterogeneous machine equipment industry. Echoing the successful German model, innovation in Chinese mechanical engineering relies on firms’ internal resources, close interaction with customers, and internal learning and

experimenting. Chinese firms have been engaged in indigenous innovation through either low-cost innovation by incremental improvements achieved through working closely with customers or, in contrast, deep R&D and international learning to create radical innovation.

Chapters 5 and 6 focus on automobile manufacturing and high-speed railroads in China. They highlight the advantages and limitations of the Chinese state in engineering the catch-up processes with the advanced economies. The contrasting practices of foreign technology-transfer are especially illuminating.

The automobile industry is often cited as a negative example of "TMFT." The technological capability of Chinese local carmakers developed remarkably slowly in the 1980s and 1990s, during which the government established joint ventures between Chinese and foreign firms and gave them protected market niches to encourage technology transfer. However, without the strategic control of the joint ventures, the Chinese partners in the JVs became passive players. The situation only changed in the late 1990s when indigenous companies were set up outside the Chinese governmental plans. These indigenous companies have stressed system integration and organizational learning in generating new products and processes.

Learning the lessons from the automobile industry, the high-speed rail industry took a different approach in which the China Ministry of Railway became the sole party in technology-transfer negotiations and the main systems integrator. It was able to win favorable terms for technology transfer and subsequently emphasized technology absorption and development. One cannot, however, conclude that more centralized organization works better in technology-transfer, as the success of China high-speed rail has owed greatly to the natural monopoly of this industry and the lack of foreign competition. In addition, Chinese state control of land procurement, the tradition of (p.28) rail travel, China's density of population, and a long accumulation of technological expertise in the industry all contributed to the uniqueness of China's technological achievements in high-

speed rail. While other sectors cannot be expected to emulate the top-down path of high-speed rail, the sector underscores the important roles of strategic control of domestic enterprises and long-term financial support from the state in the process of indigenous innovation.

Chapters 7 to 10 examine industrial dynamics in different subsectors of ICT. Chapter 7 analyzes the development of integrated-circuit (IC) foundry manufacturing. Chinese state policies in ICs parallel those in the automobile industry since both have been considered strategic industries, targeted by TMFT strategies. The state was directly involved in establishing domestic enterprises or joint ventures to jump-start these industries. The IC foundry industry however is different in that it is an integral part of the global production chain. Foundry production requires enormous financial commitment in the presence of rapid technological change that can make multibillion-dollar plants of relatively recent vintage obsolete. It has been exceptionally difficult for Chinese newcomers to break into the IC foundry industry even though China is the world's largest market for IC chips. As in automobiles, Chinese SOEs and joint ventures have been unable to become innovators. But newer firms, most notably SMIC and Grace, have been more successful as autonomous business enterprises with access to returnees, global technology, and capital raised though foreign stock markets. Yet the growth and catch-up of these foundries has been hindered by the localized, fragmented industrial financing scheme in China. The Chinese government has in 2015 started to consolidate financial support for the leading Chinese firms in this industry.

Chapter 8 examines the catch-up process of China's telecommunication equipment industry, with a focus on three Chinese firms: Huawei, ZTE, and Datang, all of which have become global leaders in the industry. Differing from the automobile and IC sectors, the Chinese government has emphasized cultivating the demand for domestically produced products as well as encouraging competition through restructuring the telecom service providers. Firms in this industry have stressed internal R&D in innovation rather than relying on technology transfer from foreign firms.

Chapter 9 analyzes the development of China's integrated-circuit design industry. IC design used to be carried out by the state IC firms. The slow development of China's IC industry has meant similar underdevelopment in the subsector of IC design. The vertically specialized model of the semiconductor industry, with the emergence of pure-play foundries, has created the possibility of growth in IC fabless design firms. Also enabling the growth of the IC design industry in China has been the increasing number of returnees who have gained education and work experience abroad. The IC design (p.29) industry has also benefitted from the diverse demand created by rising Chinese ICT industries. Overall, the IC design sector demonstrates the significance of the industrial ecosystem in the catch-up process.

Chapter 10 looks into China's mobile phone industry, particularly its shift to smartphones. China's domestic cellphone makers in the 2G era had been dominated by many small *Shanzhai* phone makers based on turnkey solutions provided by Taiwan's Mediatek. But the shift to 3G has led to consolidation of the industry into a few indigenous brands. The chapter argues that Chinese domestic phone manufacturers focused on good-enough innovation because of the vast and diversified demand of price-sensitive consumers. The transition to smartphones benefitted from existing expertise and supply chains, and innovation at the platform, middleware, and application levels. The new industrial ecosystem under 3G favors larger smartphone vendors. The cellphone sector is a prime case of cluster-based bottom-up incremental innovation, similar to the IC design sectors in Chapter 9.

Chapters 11 and 12 study China's newly emerged clean-technology industries. Chapter 11 demonstrates the importance of supporting government policies and an open global market in helping the growth and technology innovation of the Chinese wind power industry. The chapter documents the technological progress of Chinese domestic wind power manufacturers in wind turbine size, patents, and costs. It provides clear evidence that governmental support in the forms of R&D in state institutions, state-funded demonstration

programs, pricing policies, and industrial and trade policies have all contributed to the rapid rise of China's wind power industry. Unlike the automobile and IC sectors, Chinese local governments were not directly involved in setting up joint-venture enterprises. Instead, domestic firms have autonomously utilized licensing, merger and acquisition, or joint ventures, among other methods, to develop their technological competence.

Chapter 12 examines the rise of China's solar photovoltaic (PV) industry. The unique aspect of the industry is that its market demand initially came almost exclusively from abroad, especially European markets, in which governmental subsidies were instrumental in the initial stage of this industry. Its rapid growth in China, however, is the outcome of coordinated efforts of entrepreneurs and national and local governments. The state provided R&D funding, cheap industrial land, "patient capital" that has enabled enterprises to quickly scale up, and policies that have helped to cultivate the domestic market when the foreign markets have slackened. The state assisted the enterprises to overcome the technology, market, and competitive uncertainties in this new industry. The solar industry also benefitted from the industrial ecosystem made up of R&D in research institutes both in China and abroad, indigenous equipment manufacturers, and upstream polysilicon producers.

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References

Bibliography references:

Barro, R. J., and J-W. Lee (2000), *International Data on Educational Attainment: Updates and Implications*, Harvard Center for International Development Working Paper, 42, Appendix Data Files. Cambridge, MA: Harvard University. <http://www.cid.harvard.edu/ciddata/ciddata.html>.

Bloomberg News (2011), “Huawei’s $30 Billion China Credit Opens Doors in Brazil, Mexico,” Apr. 24, <http://www.bloomberg.com/news/articles/2011-04-25/huawei-counts-on-30-billion-china-credit-to-open-doors-in-brazil-mexico>.

Bradsher, K. (2013), “Next Made-in-China Boom: College Graduates,” *New York Times*, Jan. 16, <http://www.nytimes.com/2013/01/17/business/chinas-ambitious-goal-for-boom-in-college-graduates.html?pagewanted=all&_r=0>.

Bremmer, I. (2009), “State Capitalism Comes of Age: The End of the Free Market?” *Foreign Affairs* (May–June), <http://www.foreignaffairs.com/articles/64948/ian-bremmer/state-capitalism-comes-of-age>.

Breznitz, D., and M. Murphree (2011), *Run of the Red Queen: Government, Innovation, Globalization and Economic Growth in China*. New Haven: Yale University Press.

China Auto Web (2013), “Chinese Auto Exports Dropped Below 1 Million in 2013,” <http://chinaautoweb.com/2014/01/chinese-auto-exports-dropped-below-1-million-in-2013>.

China State Council (2006), *The National Medium- and Long-Term Program for Science and Technology Development (2006–2020)*. Beijing: China State Council.

Coe, N., M. Martin, N. Hess, H. W.-C. Yeung, D. Dicken, and J. Henderson (2004), “‘Globalizing’ Regional Development: A Global Production Networks Perspective,” *Transactions of the Institute British Geographers*, 29(4): 468–84.

Ernst, D., and L. Kim, (2002), “Global Production Networks, Knowledge Diffusion, and Local Capability Formation,” *Research Policy*, 31: 1417–29.

Hopkins, M., and W. Lazonick (2014), “Who Invests in the High-Tech Knowledge Base?” *Institute for New Economic Thinking Working Group on the Political Economy of Distribution Working Paper*, 6, Oct., <ineteconomics.org/research-programs/political-economy-distribution/papers/who-invests-high-tech-knowledge-base>.

Huawei Investment & Holding Co. Ltd. (2013), 2013 Annual Report, at http://carrier.huawei.com/en/about-huawei/corporate-info/annual-report/index.htm.

Lardy, N. (2014), *Markets over Mao: The Rise of Private Business in China*. Washington, DC: Peterson Institute for International Economics, U.S.

Lazonick, W. (2007), "Varieties of Capitalism and Innovative Enterprise," *Comparative Social Research*, 24: 21–69.

(p.31) Lazonick, W. (2009a), Sustainable Prosperity in the New Economy? Business Organization and High-tech Employment in the United States. Kalamazoo, MI: Upjohn Institute for Employment Research.

Lazonick, W. (2009b), "The New Economy Business Model and the Crisis of US Capitalism," *Capitalism and Society*, 4(2): article 4.

Lazonick, W. (2010a), "Innovative Business Models and Varieties of Capitalism: Financialization of the US Corporation," *Business History Review*, 84(4): 675–702.

Lazonick, W. (2010b), "The Chandlerian Corporation and the Theory of Innovative Enterprise," *Industrial and Corporate Change*, 19(2): 317–49.

Lazonick, W. (2013), "The Financialization of the U.S. Corporation: What has been Lost, and How it can be Regained," *Seattle University Law Review*, 36: 857–909.

Lazonick, W. (2014a), "Innovative Enterprise and Shareholder Value," *Law and Financial Markets Review*, 8(1): 52–64.

Lazonick, W. (2014b), "Profits without Prosperity: Stock Buybacks Manipulate the Market and Leave Most Americans Worse Off," *Harvard Business Review* (Sept.): 46–55.

Lazonick, W. (2014c), *The Theory of Innovative Enterprise: A Foundation of Economic Analysis*, AIR Working Paper, 13-02/01 Feb. (revised), <www.theairnet.org/files/research/

WorkingPapers/Lazonick_InnovativeEnterprise_AIR-WP13.0501.pdf>.

Lazonick, W. (2015), *Stock Buybacks: From Retain-and-Reinvest to Downsize-and-Distribute*, Washington, DC: Brookings Institution Center for Effective Public Management, White Paper, Apr. <http://www.brookings.edu/research/papers/2015/04/17-stock-buybacks-lazonick>.

Lazonick, W. (forthcoming), "Labor in the Twenty-First Century: The Top 0.1% and the Disappearing Middle Class," in Christian E. Weller (ed.), *Inequality, Uncertainty, and Opportunity: The Varied and Growing Role of Finance in Labor Relations*. Labor and Employment Relations Association.

Lazonick, W., and Ö. Tulum (2011), "US Biopharmaceutical Finance and the Sustainability of the Biotech Business Model," *Research Policy*, 40(9): 1170–87.

Lazonick, W., P. Moss, H. Salzman, and Ö. Tulum (2014), *Skill Development and Sustainable Prosperity: Collective and Cumulative Careers versus Skill-Biased Technical Change*, Institute for New Economic Thinking Working Group on the Political Economy of Distribution Working Paper, 7: 51–4, <ineteconomics.org/research-programs/political-economy-distribution/papers/skill-development-and-sustainable-prosperity>.

Li, H. (2012), "How Will China Become World Technological Power?" *Xinhua*, Sept. 24, <http://news.xinhuanet.com/english/indepth/2012-09/24/c_131870216.htm>.

National Science Foundation (2012), chapter 2, "Higher Education in Science and Engineering," in *Science and Engineering Indicators 2012*, <http://www.nsf.gov/statistics/seind12/c2/c2h.htm>.

Organisation Internationale des Constructeurs d'Automobiles (OICA 2013), "Production Statistics" at <http://www.oica.net/category/production-statistics/2013-statistics>, accessed Sept. 2015.

Ollivier, G., R. Bullock, J. Ying, and N. Zhou (2012), *High-Speed Railways in China: A Look at Traffic*. China Transport Topics, 11. Washington, DC: World Bank Group. Dec. 1, <http://documents.worldbank.org/curated/en/2014/12/23031378/high-speed-railways-china-look-traffic>.

(p.32) Pan, F., and D. Brooker (2014), "Going Global? Examining the Geography of Chinese Firms' Overseas Listings on International Stock Exchanges," *Geoforum*, 52: 1–11.

Qiu, J. (2009), "China Targets Top Talent from Overseas," *Nature*, Jan. 28, <http://www.nature.com/news/2009/090128/full/457522a.html>.

Sanderson, H., and M. Forsythe (2013), *China's Superbank: Debt, Oil, and Influence*. New York: Bloomberg Press.

World Steel Association (2014), "Crude Steel Production in Major Producing Countries and Regions in 2014 (in Million Metric Tons)," *Statista*, <http://www.statista.com/statistics/267263/world-crude-steel-production-by-region>.

Yeung, H. W-C., and N. Coe (2015), "Toward a Dynamic Theory of Global Production Networks," *Economic Geography*, 91(1): 29–58.

Ying, T. (2014), "Volvo Cars Billionaire Owner Revamps Chinese Brand Geely," *Bloomberg News*, Dec. 15, <http://www.bloomberg.com/news/articles/2014-12-16/volvo-cars-billionaire-owner-revamps-chinese-brand-geely>.

Zhao, Y. (2014), *Who's Afraid of the Big Bad Dragon: Why China has the Best (and Worst) Education System in the World*, San Francisco: Jossey-Bass.

Zhou, Y. (2008a), "Synchronizing Export Orientation with Import Substitution: Creating Competitive Indigenous High-Tech Companies in China," *World Development*, 36(11): 2353–70.

Zhou, Y. (2008b), *The Inside Story of China's High-Tech Industry: Making Silicon Valley in Beijing*. New York: Rowman & Littlefield.

Zhou, Y., and J. Hsu, (2010), “Divergent Engagements: Comparing the Roles and Strategies of Taiwan and Mainland Chinese Returnee Entrepreneurs in the IT Industry,” *Global Network*, 11(3): 398–419.

Notes:

([1]) See key statistics on trends and international comparisons of China’s demography, infrastructure, knowledge base, industry, and trade, at <http://fiid.org/?page_id=1572>.

([2]) See China State Council (2006).

([3]) The shares of the next largest crude-steel producers were EU2-8, 10.2%; Japan, 6.2%; and the USA, 5.3% (World Steel Association 2014).

([4]) For the US case, see Lazonick (forthcoming).

([5]) See discussion on “The Rise of State Capitalism,” *The Economist*, Jan. 21, 2012, at <http://www.economist.com/node/21543160>. For a rebuttal on China as the model of state capitalism, see Lardy (2014).

([6]) See the research at <www.theAIRnet.org>.

([7]) Currently, Kaidong Feng, William Lazonick, and Yin Li are researching and writing a history of Huawei Technologies from the perspective of the theory of innovative enterprise.

([8]) See Lazonick (2015). For Lazonick’s recent critique of the shareholder-oriented principles of corporate governance promulgated by OECD, see his comments at <http://www.oecd.org/daf/ca/publiccommentsreceivedonthe2014reviewoftheoecdprinciplesofcorporategovernance.h

([9]) These investments in human capital represent fixed costs to the firm. On a company’s financial statements, R&D expenditures appear as current costs in the profit and loss accounts. More generally, companies do not count investments in human capital as an asset on their balance sheets because the people in whom this human capital has been invested cannot be owned. Nevertheless, in terms of the economics of the innovation process, this human capital is an asset that

constitutes a fixed cost that can only be transformed into revenues by the production and sale of competitive products.