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**China's Technological Leapfrogging and Economic Catch-up:
A Schumpeterian Perspective**

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“Can China Avoid the Double, Thucydides and Middle Income, Traps?”

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Preface

I am pleased to publish this second book on China after an almost 30-year interval since the first one (*Chinese Firms and State in Transition*, 1991, ME Sharpe). The first book was an outgrowth of my doctoral thesis from the University of California, Berkeley, and deals with China's system reform in the 1980s under Deng Xiaoping. This new book deals with a new and important topic for China: technological innovation, which has emerged as one of the most important factors for the current and future growth of its economy. Such a change in topic also reflects the change in the scope of my own research; I have shifted from being a scholar on economic system transition from planned economies to market economies to an innovation scholar following the Schumpeterian tradition.

Perhaps the change in my research interests has reflected the actual transitions in China in the intervening decades. When China declared a radical change from a closed communist economy to an open market economy in late 1978, many economists in the Western world doubted its success. China's success at this scale today is truly unbelievable. The pessimistic view in the past must have considered the possible conflict between the authoritarian political system under the Communist regime and the vitality of the market economy, which was partly applicable to the case of the former Soviet Union. However, as a Korean who also lived under a form of authoritarianism known as developmental dictatorship for several decades and witnessed the amazing East Asian miracle, I believed that China would have similar success as Korea did. Thus, I decided to study China's transition as the topic of my doctorate thesis under the guidance of professors Laura Tyson, Benjamin Ward, and Gregory Grossman, who are all big names in comparative economic systems involving research on the former Soviet Union and China. Berkeley was, at the time, the best place for such research.

After the miraculous economic growth known as the Beijing Consensus, China is now facing a slowdown. The attention has moved to the issue of the middle income trap, or the situation in which economic growth slows down as a country reaches the middle income stage. Such a trap has been experienced by many countries, such as Thailand, Turkey, and Brazil. One of the sources of the trap identified in the literature is the difficulty of building innovation capabilities that will enable upgrades from a low-wage-based industry to a high-end goods-based one. The prevailing view is that authoritarian rule cannot be combined with innovation. This book deals with this interesting issue in the context of China. It provides an assessment of how China has been able to transition from labor-intensive products to technology-intensive products, embracing innovation while remaining under Communist rule. It also discusses China's limitations and future prospects, especially after the rise of a new "cold war" between China and the US, which was signaled by the escalating tariff war initiated by the Trump administration. The latter discussion poses the question of whether China would fall into another trap called the "Thucydides trap," or conflict with the existing hegemon as a rising power. It also inquires whether the country would face further economic slowdown due to the US policy of containing the rise of China.

This book plays around three key terms, namely, the Beijing Consensus, the Middle Income Trap, and the Thucydides trap, and applies a Schumpeterian approach to these concepts. Schumpeter is an economist who put forward technological innovation and big business as the core factors that determine long-term economic growth. These two factors are also the most important factors that have affected and will affect the current and future economic changes in China, respectively. Thus, one of the unique features of this book is that it first conducts a Schumpeterian analysis of the Chinese economy at multiple levels, namely, the firm, sector, and macro levels. Second, this book conducts a comparative analysis that examines China from a Korean perspective based on the similar experience of growth under a developmental authoritarian state. Regarding the first aspect, I apply to China the theory and insight from my 2013 book (*Schumpeterian Analysis of Economic Catch-up: Knowledge, Path-creation, and the Middle-income Trap*), which earned the 2014 Schumpeter Prize. For the second aspect, I also apply to China similar ideas and analytical tools from my 2016 book on Korea (*Economic Catch-up and Technological Leapfrogging*).

These two aspects also mean that this book examines the Chinese economy from an "economic catch-up" perspective (Abramovitz 1986; Gershenkron 1962). Economic catch-up simply refers to a closing gap between a latecomer, like China, and a forerunner, like the US. However, a key insight

from my 2013 book is that a catch-up starts from learning and imitating a forerunner, but finishing the race successfully requires taking a different path along the road. This act is also known as leapfrogging, which implies a latecomer doing something different from, and often ahead of, a forerunner. Technological leapfrogging may lead to technological catch-up, which means reducing the technological gap, and then finally to economic catch-up in living standards (per capita income) and economic size (GDP: economic power). This linkage from technological leapfrogging and catch-up to economic catch-up corresponds exactly with a similar linkage from the Beijing Consensus to escaping (or not) the middle income and the Thucydides traps. One conclusion from this book is that China's successful rise as a global industrial power has been due to its strategy of technological leapfrogging, which has enabled China to move beyond the middle income trap and possibly the Thucydides trap, although at a slower speed.

One limitation of the book is that some chapters are rewriting, modifications, or updates of existing journal articles that I have co-authored with others. However, this limitation is also a mark of quality in that they have all undergone the referee process for journal publication. For example, the journal article version of Chapter 2 is now more than 400 times cited according to Google Scholar as of January 2021, and has become a classical analysis of technological catch-up and the rise of Huawei in China. I would like to acknowledge the following articles; the degree of revision, rewriting and updating for an inclusion in this book varies by chapter.

Chapter 2: Qing Mu and Keun Lee, "Knowledge Diffusion, Market Segmentation and Tech. Catch-up," *Research Policy*, Vol 34 (6): 759-83, 2005. Chapter 3: Keun Lee and Young Sam Kang, "Business Groups in China," in *Oxford Handbook of Business Groups*, edited by A. Colpan, T. Hikino, and J. Lincoln, 2010. Chapter 4: Sungho Rho, Keun Lee, and Seong Hee Kim, "Limited Catch-up in China's Semiconductor Industry," *Millennial Asia*, 2015/10. Chapter 5: Keun Lee, Mansoo Jee, and Jong-hak Eun, "Assessing China's Economic Catch-up at the Firm-Level and Beyond," *Industry & Innovation* 18 (5), 2011. Chapter 6: Keun Lee, Xudong Gao, and Xibao Li. "Industrial catch-up in China." *Cambridge Journal of Regions, Economy and Society*, 2016. Chapter 7: Jun-Youn Kim, Tae-Young Park, and Keun Lee, "Catch-up by Indigenous Firms in the Software Industry and the Role of the Government in China," *Eurasian Business Review* 3(1): 100-120, 2013. Chapter 8: Si Hyung Joo, Chul Oh, and Keun Lee. "Catch-up strategy of an emerging firm in an emerging country," *International Journal of Technology Management* 72 (1/3): 19-42, 2016. Chapter 9 is a substantially revised and updated version of the following article: Keun Lee and Shi Li, "Possibility of Middle income trap in China," *Frontier of Economics of China*, 2014.

I would also like to acknowledge the colleagues who provided various feedback and inputs to earlier versions of the articles and chapters at different times, starting from the early 2000s. I profusely thank B. Lundvall, Justin Lin, Ed Steinmuller, Dominique Foray, Eduardo Albuquerque, Young-Rok Cheong, Hwy-Chang Moon, Dong-Hoon Hahn, Young-Nam Cho, Seung Hoon Lee, Sang Seung Yi, Suck In Chang, Jae-Hong Lee, Wanwen Chu, Lu Ding, Jong-hak Eun, Zhuqing Mao, and Mansoo Jee. A special thanks go to Justin who provided me with many occasions for me to interact with Chinese colleagues, such as Yong Wang and Jiajun Xu, at the Institute for New Structural Economics found by him. Similar thanks go to Jin Chen at Tsinghua University, and Xiaobo Wu and Shi Li at Zhejiang University. This work was also supported by the Laboratory Program for Korean Studies by the Ministry of Education of the Republic of Korea and the Korean Studies Promotion Service of the Academy of Korean Studies (AKS-2018LAB-1250001). Finally, I thank tremendously Adam Swallow, the editor of the Oxford University Press, for his support for this project from the beginning to the final publication, as well as three anonymous reviewers who provided important feedback for the final revision of the manuscript.

In January 2021, in the middle of the 2nd wave of the coronavirus crisis

Keun Lee

Chapter 1

Introducing Schumpeter to China

1. Beijing Consensus, Middle-Income Trap (MIT), and Thucydides Trap

When China opened its door and reformed its policies in December 1978, its per capita income was less than 10% of the world average in terms of the purchasing power parity-adjusted dollars in 2000 prices. By the early 2010s, the GDP (Gross Domestic Production) per capita had reached over half of the world average, which made China an upper middle-income country, with its per capita income higher than 20% of the US level. By the late 2010s, the per capita income of China reached the 30% level of the US, which was a similar level to that of Brazil. This phenomenon indicated a rapid catch-up, from merely 2.5% of the US level in 1980 (Figure 1.1). China had successfully reduced absolute poverty; the population living under the poverty line had decreased from more than 50% in 1980 to less than 10% in 2001 (Ravallion and Chen 2007; Table 10).

However, such rapid growth was accompanied by worsening income inequality for four decades or at least until the late 2000s (Li 2018). China's sudden rise as the number two giant economies (from 10% in 1980 to 65% size of the US economy in 2018) alarmed the incumbent superpower, the US, to change its former policy from engagement to containment starting with the trade war in 2018. A simple way to understand such a remarkable achievement and an emerging challenge in China is by referring to a series of keywords, starting from the Beijing consensus to the middle income trap (MIT) and then to the Thucydides trap.

The first term, Beijing consensus, is to describe the successful rise of China and its possible difference from the existing ways of economic growth, such as the Washington consensus or East Asian model.¹ China has shown some deviation from the conventional prescription of the Washington consensus (Williamson 1990) and the IMF or World Bank lines. However, Yao (2010) suggested that such a deviation also follows certain common policy lines of the Washington consensus, such as openness. As a developmental state, China shares such features as mercantilist export orientation with the East Asian miracle model (World Bank 1996) pioneered by Japan and followed by the Asian tigers, Korea and Taiwan (Lee, Lin, and Chang 2005). Chapter 5 of this book presents the commonalities and differences among the three consensuses (Beijing, Washington, and East Asia).

The Beijing consensus is now less mentioned in and out of China because the rates of economic

¹The term Beijing consensus has not been academically defined. Ramo (2004) defined it as a combination of emphases on innovation, sustainability, equality, and self-determination. Yao (2010) called it authoritarian growth. See Lee (2006) or Rodrik (1996) on the comparison of the Washington consensus with the East Asian model.

growth peaked at 14% around 2008 and then continued to decline to less than 7% or 5% toward the end of 2010s (Figure 1.2). The second term, MIT, is extensively discussed and has risen as an important issue in the Chinese economy.² World Bank (2012: 12) defines the MIT as a situation in which a country's per capita GDP stays within the box of 20% to 40% of the US level for several decades; many countries, including Mexico, Thailand, and Brazil, are considered stuck in the trap (Lee 2019: Ch. 1). China has reached the 30% level of US per capita income or exactly the middle point of the box range. The issue is whether China will be similar to Brazil and fall into the trap or keep growing beyond the box, as Japan or Korea did in the past. This issue is the focus of Chapter 9 of Part III of this book.

The US government since Trump took actions (e.g., tariffs) to stop China from growing into another superpower that would threaten the American hegemony; consequently, China currently faces another trap, namely, the Thucydides trap. The original meaning of the trap is a situation in which a war is almost inevitable when one power threatens to displace another (Allison 2018). We and this book, focusing on the impact on China, define the Thucydides trap as a situation in which the US causes China to stop expanding as an economic power. The issue is whether China will fall into this trap, which is dealt with in the last chapter of this book (Chapter 10). In the chapter, the global value chains (GVCs) of China are also analyzed to show their role in linking MIT to the Thucydides trap.

[figures 1.1 and 1.2]

In a way, this book is an assessment of China's economic catch-up for such concepts as the Beijing consensus, MIT, and Thucydides trap. The history of the word "catch-up" dates back to the famous work of a Russian economic historian, Gerschenkron (1962), where he discussed the process in which latecomers in Europe in the late 19th century tried to catch up with the forerunning UK. Such a concept of catch-up was also adopted in Abramowitz's (1986) article on "catching-up, forging ahead, or falling behind" when he compared the economic performance of European countries during the post-WWII period. Thus, economic catch-up has been simply defined as the narrowing of a latecomer firm's or country's gap vis-à-vis a leading country or firm (Fagerberg and Godinho 2005; Lee and Malerba 2018). We focus on such data as per capita income levels and economic size measured by the GDP of China, US, and other countries to discuss economic catch-up. Technological catch-up means closing the gap in technological capabilities measured qualitatively or quantitatively (e.g., patent counts and R&D to GDP ratio).

² In 2007, Naughton (2007: 5–6) observed that the challenges that China faces are shifting and increasingly resembling those faced by other middle-income developing economies than those faced by former planned economies.

The abovementioned three keywords are running through the book; nevertheless, this book adopts a Schumpeterian perspective as its theoretical framework. Schumpeter is the economist who emphasizes the importance of innovation (creative destruction) and big businesses as leading engines of economic change. These factors are particularly relevant when we discuss the possibility of MIT in China in Chapter 9 and of the Thucydides trap in Chapter 10. The important elements of the Beijing consensus have also affected the rise of large and innovative firms, which rarely happened in typical developing countries.

Considerable studies have considered MIT to occur when middle-income countries are trapped between low-wage manufacturers and high-wage innovators because their wage rates are excessively high to compete with low-wage exporters and their level of technological capability is considerably low to enable them to compete with advanced countries (Lin 2012a; Williamson 2012; Yusuf and Nabeshima 2009; World Bank 2010 and 2012). That is, the MIT phenomenon is a problem of growth slowdown because of weak innovation.

The importance of large businesses in the process of economic development has long been recognized in the literature. Schumpeter emphasized in his earlier work that entrepreneurship is mostly associated with startup or SMEs. Nevertheless, his later work (Schumpeter 1943: 71–72) discussed the contribution of large businesses in generating innovation by large R&D investment and thereby enhancing the living standard of people.³ Although the use of the criterion of large businesses in assessing MIT is relatively new, Lee et al. (2013) verified the importance of large businesses in economic growth in and beyond the middle-income stage via a rigorous econometric method. Their study determined that many middle-income countries command an insufficient number of large businesses, which is one of the reasons for their slow-down in the middle-income stage. Thus, Chapter 3 of this book discusses the origins of large businesses in China, particularly business groups.

This book adopts the Schumpeterian economics of catch-up as its theoretical framework. Nelson and Winter (1982) initiated a great revival of evolutionary economics, and motivated research applying Schumpeter's insight to the study of technological and economic catch-up. Such research includes a series of works, including those of Verspagen (1991), Nelson (2008ab), Fagerberg and Godinho (2005), Lee (2013; 2019), and Mazzoleni and Nelson (2007). A distinctive feature of these works by Schumpeterians is the emphasis on innovation and technological capabilities as the enabling factors of catch-up. Fagerberg and Godinho (2005) and Mazzoleni and Nelson (2007) noted that in the 1960s and 1970s, the main factor supporting catch-up was capital accumulation. However, in the 1980s and 1990s, the accumulation of technological capabilities was more relevant than other factors.

³. Schumpeter (1932: originally 1911 in German) discussed the role of entrepreneurs in economic development. This changing emphasis from entrepreneurship to large businesses is called Schumpeter marks I and II. Chandler's (1990) *Scale and Scope* also showed how large businesses in the US and Germany have contributed to these countries' economic growth.

At present, only the countries that have immensely invested in the formation of skills and R&D infrastructure seem to be capable of catching up; those that did not tend to fall farther behind.⁴ Lee and Kim (2009) found that secondary education and political institutions are important for low-income countries, whereas policies facilitating technological development and higher education seem to be highly effective in generating growth for upper middle- and high-income countries.

A typical sequence of catch-up by latecomers starts with learning from forerunning countries before moving into the innovation phase (Nelson 2008ab). Therefore, a successful catch-up should consider the institutions of knowledge learning and creating and the modes for access to the foreign knowledge base. Thus, our primary objective is to provide a comparative analysis of China in terms of the modes and performance of learning and building technological capabilities mostly at the hands of large businesses. Then, we aim to assess the performance and prospects of China in acquiring ‘indigenous innovation capabilities’ of domestic firms to transcend the middle-income stage and overcome the Thucydides trap. Our analysis starts at the firm or sector level and continues to the national and policy dimensions.

Several unique elements of the learning and knowledge access strategies of China can be called the Chinese catch-up model (i.e., the “Beijing consensus”), which is different from the experience of Korea or Taiwan (Lee et al. 2011). These unique features include the following: 1) parallel (indirect) learning from foreign direct investment (FDI) firms to promote domestic companies in the framework of “trading markets for technologies,” which is considered “forced technology transfer” in the US terminology in their negotiation with China; 2) forward engineering (the role of university spin-off firms) in contrast to reverse engineering (copycat making) adopted in Korea and Taiwan; and 3) the acquisition of foreign advanced technologies and brands through international merger and acquisition (M&A) and going global (*zouchuqu*) at an earlier stage of the economic development.

Chapter 5 of Part 2 of this book compares this defined Beijing consensus with the East Asian model and Washington consensus. Chapters 6, 7, and 8 discuss successful cases of firms and sectors in China, which represent some or all of the three elements of the Beijing consensus defined above. In this regard, an outstanding exemplar firm leading China’s catch-up is Huawei. We accordingly start by explaining the origins of Huawei in the next chapter, and the process of how it caught up with the Swedish giant Ericsson is elucidated in Chapter 8.

The analyses in these chapters utilize a common framework called a Schumpeterian model of technological leapfrogging and catch-up, as elaborated in the next section.

2. Schumpeterian Model of Technological Leapfrogging and Catch-up

⁴ Such emphasis on capabilities is in line with the so-called capability triad in Best (2018), which is comprised of three factors of the business model, production capabilities, and skill formation, and their interconnections.

2.1. Schumpeterian Theory of Technological Leapfrogging and Catch-up

Although Schumpeter emphasizes innovation as a key determinant of long-run economic change, technological innovation remains exogenous or unpredictable. In neoclassical economics, innovation is still a black box or residual. Then, it is modern Schumpeterians, called neo-Schumpeterians with their collected work is in Dosi et al. (1988), who explained that innovation is unnecessarily unpredictable because innovation also happens in a relatively ordered pattern (“order in change”). A step toward this direction of endogenizing innovation is the emergence of the concept of “innovation systems” (Freeman 1987; Nelson and Winter 1984) as a key concept of neo-Schumpeterian economics.

Innovation systems can be discussed at various levels, such as national, sectoral, subnational, regional, firm, or inventor. At the national level, the concept of national innovation systems (NIS) has been proposed by Lundvall (1992) and Nelson (1993) and is defined as the various elements and relationships that interact in the production, diffusion, and adoption of new and economically useful knowledge. At the sectoral level, the concept of sectoral systems of innovations (SSI) is proposed by Malerba (2002). A Schumpeterian thesis has presented that this innovation system determines the performance of nations and firms, as verified in many empirical studies.⁵ A malfunction of these systems is called ‘system failure’ compared with the market failure in neoclassical economics. A comprehensive application of this SSI concept in many sectors was presented in a collected volume of Malerba (2004), which dealt with sectors in advanced or European economies. A follow-up study on the sectors in the late-comer economies was undertaken by Malerba and Mani (2009) and Malerba and Nelson (2011). The application of Schumpeterian theory to the context of catch-up by latecomers has led to a recognition that latecomers’ catch-up can also be well-explained because it also follows certain regularities and patterns (Lee 2013).

Economic catch-up is defined as the narrowing of a latecomer firm’s or country’s gap vis-à-vis a leading country or firm in the literature (Fagerberg and Godinho 2005). Nevertheless, Lee and Malerba (2018) proposed that catch-up by latecomers does not mean only the act of cloning because what is achieved by a successful catch-up invariably diverges from practices in the countries serving as benchmark models. This divergence reflects the fact that exact copying is almost impossible and that a successful catch-up involves changes and modifications to existing products and technologies.

This issue of cloning versus divergence can also be considered in terms of imitation versus innovation (Kim 1997) and is one of the most fundamental questions facing latecomers in their effort to catch up. This issue in catch-up can also be observed from the evolution of the literature.

⁵. Lee and Lee (2019) developed a composite NIS index and proved the linkage of this index to economic growth in a country-panel analysis.

Traditional literature, such as Lall (2000), Westphal et al. (1985), and Hobday (1995), has observed that latecomers tried to catch-up with advanced countries by assimilating and adapting incumbents' more-or-less obsolete technology. On the contrary, a new and contrasting view, such as by Lee and Lim (2001) and Lee (2013), is that latecomers do not simply follow the advanced countries' path of technological development; rather, they sometimes do something new, skip certain stages, or create a new path that is different from those of the forerunners. That is, several choices are available for a possible entry or catch-up strategies by latecomers, such as path following, stage skipping, and path creating, in which *path* means the trajectory of technologies and *stage* means the stages in the trajectories.

Following Lee and Ki (2017), Figure 1.3 shows the different trends of the productivities (the vertical axis) of technologies of different generations (with the horizontal axis representing time), which explains the three strategies mentioned above. We suppose that the current time is period 91 in the figure and that the leading incumbent firms have adopted the currently most up-to-date, second-generation technology and are thus benefitting from the highest productivity. Therefore, three choices or strategies are available for a latecomer firm that intends to make a late entry.

[Figure 1.3]

The **first choice** is to adopt the first-generation or oldest technology with the lowest price, that is, the path-following strategy. This strategy indicates that latecomers move along the old technical trajectories of incumbents. An advantage of this strategy is that established firms are unaffected by the transfer or leakages of proprietary technologies because latecomers target and aim to purchase the oldest technologies. Such technologies are readily available at low prices, particularly during business downturns. However, given their lowest level of productivity, late-entrant firms cannot compete with incumbents in the same market-entrant ones. Thus, these firms must try to enter a different segment (low-end segments) typically during the mature stage of a product life cycle while utilizing other advantages, such as low costs in labor. For instance, the late entry and gradual catch-up of the Korean steel company, POSCO, is a path-following strategy backed up by the government to seek its survival as a late entrant while utilizing the business downturns in the global steel industry to purchase facilities and equipment at low prices (Lee and Ki 2017).

The **second choice** is the stage-skipping strategy, which refers to the case in which latecomer firms follow the same path as that of incumbents but skip older-generation technology (Generation 1 in Figure 1.3) to adopt the most up-to-date technology (Generation 2 in Figure 1.3); this technology is of the same generation as the technology of incumbents. Thus, a fierce competition may occur between incumbents and late entrants because the latter fully utilizes the advantage of latecomers to be able to adopt up-to-date technologies (Gerschenkron 1962). In addition to available financial resources to

purchase up-to-date technologies, another issue is the market availability of such up-to-date technologies or the willingness of any established firm to transfer such technologies to latecomer firms. In this context, intellectual property right (IPR)-based protection of technologies may be a barrier for a catch-up. If this aspect of technology transfer or acquisition is solved for the benefit of a late entrant, then this firm may emerge as a powerful rival because the late-entrant firm not only benefits from the same productivity level as incumbents have but also utilizes the probably low costs of labor or other factor conditions. The forging ahead of POSCO from Korea with its expansion of capacity with a second mill is an example of a stage-skipping strategy because it adopted up-to-date technologies, and such stage skipping was facilitated by a downturn (Lee and Ki 2017).

The **third choice**, which is an ambitious and risk-taking strategy, is the path-creating strategy. This strategy refers to the case of a latecomer exploring its path of technological development by utilizing a new techno-economic paradigm or a new generation of technologies. Figure 1.3 shows that, in this strategy, the late entrant chooses the emerging or third-generation technology ahead of the incumbent or leading firms, which have adopted a second-generation technology. This strategy is consistent with the idea of leapfrogging discussed by Perez and Soete (1988), who observed that leapfrogging could happen during the shifting in generations or paradigms of technologies.

An apparent advantage of this path creating or leapfrogging is that this strategy chooses technologies with high long-term potential or productivity, as shown in Figure 1.3. However, a risk is that the emerging or new technology is neither stable nor reliable, and it has lower productivity or higher costs at its early stage than the productivity or costs associated with the current generation technology adopted by incumbents.⁶ Thus, despite the high potential of this emerging technology, a firm that adopts technology has to endure high costs. Losses might be incurred during the initial stage in the market. Not every firm, but probably late entrants or inferior firms with productivity levels lower than those of a leading firm, has many reasons to shift rapidly and lightly to new technologies. In this sense, latecomers have a greater incentive than incumbents have to take the risk of adopting new technologies. Nonetheless, even such risk-taking by latecomers usually requires initial support from the government. Without subsidies or incentives, latecomer firms would not dare to take the risk of adopting emerging technologies because they tend to face small or weak demand during the initial entry stage and thus would have a difficult time achieving the initial production volume that would enable some degree of scale economy (Lee et al. 2005).

Technologies have accordingly been regarded as exogenous, and firms, particularly latecomer firms, are considered to face a binary choice of either adopting new technologies or not. However, latecomers do not usually only assimilate adopted technologies but also substantially improve them. On this basis, we consider two modes of path creation. One is the radical innovation-based mode, in

⁶Two risk types with leapfrogging strategy are discussed in Lee et al. (2005).

which a new path is created by the in-house, endogenous innovation activities of a latecomer. The other is the *adoption and follow-on innovation mode*, in which an outside supplier-driven innovation is adopted ahead of incumbents and is further improved. in the Chinese context in the Chinese context. An example of the latter is the so-called ‘secondary innovation’ (Wu et al. 2009) or second-generation innovation (Breznitz and Murphree, 2012), which transforms acquired foreign technologies into domestic innovations.

Another dimension of leapfrogging can be conceived in terms of inter- and intrasectoral leapfrogging, depending on whether it occurs within the same sector or across different sectors. Intersectoral leapfrogging is similar to a ‘long jump’ to a certain extent according to Hidalgo et al. (2007), who argued that latecomer economies must shift to a core product space located far away from their current or peripheral position. By contrast, intrasectoral leapfrogging involves jumping across generations of technologies within the same sector. Intrasectoral leapfrogging is easier or less risky than the intersectoral long jump if latecomers have already built certain absorptive capabilities, such as manufacturing experience, in relevant industries.

Table 1.1 shows the preceding discussion on the variations in the concept of leapfrogging (Lee 2019b).

Table 1.1 Variations of technological leapfrogging (source: the author’s work, Lee 2019b)				
1) Compared with the path of the incumbent (Lee and Lim 2001)				
	a) Stage-skipping			
	b) Path-creating			
	c) Path-following catch up			
2) Two variations of path-creating leapfrogging (Lee and Ki 2017)				
	a) Follow-on innovation-based leapfrogging			
	b) Radical innovation-based leapfrogging			
3) Inter- vs. intra-sectoral leapfrogging (Lee 2019a)				
	a) Intra-sector leapfrogging			
	b) Inter-sector leapfrogging			

Although the path-following strategy based on the initial factor–cost advantages serves as the gradual catch-up of late entrants’ market shares, a sharp increase in the latecomers’ market shares is likely to occur when a shift in technologies or demand conditions occurs. Such a shift is utilized by the path creation or stage skipping of latecomers, both of which can be considered a case of leapfrogging. That is, leapfrogging is “a latecomer doing something differently from forerunners, often ahead of them.” The leapfrogging thesis of Perez and Soete (1988) suggested that the shift in generations of technologies could be a “window of opportunity” for latecomers to rise ahead with the rapid adoption of new technologies, whereas incumbents could fall into the “incumbent trap,” that is,

being locked in existing technologies given the superiority associated with them. A decisive investment at the opening of new windows irreversibly changes the leadership in an industry, namely, a forging ahead, which pushes old incumbents to the cliff of falling behind (Lee and Malerba 2017).

Windows are always doomed to open because generations of technologies and business cycles frequently change. Therefore, leadership change and catch-up by latecomers can be predicted to occur repeatedly. Lee and Malerba (2017) have considered three kinds of windows of opportunity. The first is, of course, emergence of new techno-economic paradigm or of new generation of technology, as originally mentioned by Perez and Soete (1988). The second type of window of opportunity can be opened with changes in market demand and business cycles (especially downturns), as analyzed by Matthews (2005) for the cases of semiconductors and liquid crystal display. The rationale is that downturns set a brake on the incumbent, and resources become cheap, reducing the cost of the late entry. Finally, a third source of opportunity can open with the change in government regulations or intervention in the industry. Ramani and Gueniif (2012) analyzed how the change in regulatory system has given a chance to Indian firms in the pharmaceutical industry. The role of the government has also been prominent in several East Asian cases of catch-up, such as China's telecom equipment industry (Mu and Lee 2005) and South Korea and Taiwan's high-tech industries (Lee and Lim 2001; Mathews 2002).

Along the line of thoughts discussed above, the main hypothesis we are trying to state in relation to the concept of leapfrogging is that all successfully finished catch-up (closing the gap) in *ex post* sense tends to involve a variant of leapfrogging, which is a necessary condition in this sense, although leapfrogging involves risks and thus may not be a sufficient condition for success. Technological leapfrogging is a precondition for success in technological catch-up or in closing the gap with incumbents in terms of technological capabilities. Then, such technological catch-up in several sectors may lead to economic catch-up in terms of the growth of per capita GDP or economic power. This eventual linkage from technological leapfrogging to economic catch-up via technological catch-up is what we mean by the title of this book. We focus on this main hypothesis with the Chinese experience in this book.

2.2. Specifying the Model for the Chinese Context

Malerba (2004) stated that a sector is a set of activities unified by linked product groups that share common knowledge. The building blocks of SSI are as follows: (a) regimes of knowledge and technologies, (b) demand conditions (or market regimes), (c) actors and the networks among them, and (d) surrounding institutions, including IPRs, laws, and culture.

The first component in SSI is knowledge and technological regimes. According to Malerba (2009), knowledge and technology play important roles in innovation and production. Technology is a unique

trait of firms that cannot be automatically diffused and freely shared. Knowledge and technology are absorbed—albeit at varying levels—based on the capability that firms have developed for a long time. Therefore, the pattern of entry, technology development process, and potentialities of catch-up differ according to the attributes of knowledge and technology.

Demand and market regimes comprise the second major component of SSI. In general, competitive advantage in markets is determined by three factors, namely, cost leadership, product differentiation, and first-mover (Lee and Lim 2001). Cost leadership is a strategy by which, customers are attracted by offering lower prices than competitors. Although it is mainly based on low production cost by improving productivity, it is often driven by low wage labors. The strategy of using low wage labors is a typical pattern of latecomers' catch-up. The difference is in the manner with which new functions or new designs are introduced to meet the varying needs of customers. Finally, the first-mover advantage is a benefit resulting from know-how, sales and distribution channels, brand value, and market power.

Actors comprise the third major component of SSI. The most important actor is the firm, because firms are in charge of innovating, launching, and selling commodities; they are likewise the ones accumulating knowledge and technology along with their objectives, capabilities, and organization (Malerba, 2002). Other actors include research institutions, the government, and even financial institutions.

Then, the SSI framework applied in the catch-up context implies that catch-up dynamics can be explained by referring to the ease and difficulty associated with the particular nature of the regimes of technologies and market and then by analyzing how actors, such as firms and governments, respond to exploit the potentials through deploying diverse strategies (e.g., variants of leapfrogging) while trying to overcome the limits imposed by the regimes. Such divergence reflects the heterogeneity of sectors and the responses by the actors.

Many studies have examined industrial catch-up in emerging or latecomer economies. Lee and Lim (2001) tried to link the technological regime to catch-up possibility. They focused on such elements of the regime as the frequency of innovations, the fluidity of technological trajectories, and the degree of access to foreign knowledge. Jung and Lee (2010) found that catch-up tends to occur in sectors with technologies in which the involved knowledge is highly explicit and easily embodied in capital equipment latecomers can import and install. Lee (2013) confirmed that technologies with a short cycle of time could lead to a high possibility of catch-up, which is consistent with a leapfrogging thesis. Mu and Lee (2005) observed that the segmentation of the Chinese market into several tiers (low to high ends) is a unique trait, and the lower end markets may serve as entry points and nurturing bases for indigenous firms. Lee et al. (2009) considered modularity as another determinant of the technological catch-up in China and found that indigenous firms in the cell phone and automobile sectors achieved a fast catch-up upon their entry into the market because of the high (cell phone) or

increasing (automobile) modularity of the technologies.

The current study modifies the existing catch-up model to be highly suitable for the case of China. First, this study considers how the large market size and strong bargaining power of China affect access to foreign technology. Thus, we investigate the role of market segmentation as a nurturing ground for indigenous firms. The current study follows Mu and Lee (2005) and focuses on catch-up in market shares in the domestic Chinese market, whereas Lee and Lim (2001) focused on catch-up in the export market. This difference is a result of the differences in the size and degree of openness between the domestic markets in China and Korea. Chinese markets are more open and competitive from the beginning compared with Korean ones; thus, discussing the competition of foreign versus indigenous firms in these markets is reasonable.

Second, we include the technology cycle time of sectors as an additional element in the technology regime to reflect the double-edged nature of the frequent generation change in technologies. Lee (2013) argued that short cycle technology-based sectors means low entry barriers for latecomer, given their quick obsolescence of exiting technologies owned by incumbents, and, at the same time, correspond to high growth prospects associated with frequent innovations. So, it make sense for latecomer to target such sectors. However, such short cycle technology based sectors could provide latecomers with a high chance to catch up only when the latecomers have accumulated a certain level of technological capability. Otherwise, frequent changes in technologies could hinder these latecomers from catching up by truncating their learning processes (Lall 2000).

Third, we explicitly separate firms from the government because of the paramount importance and complexity of the role of the government in China. The decentralized political structure of China (Xu 2011; Chung 2016) and inefficient financial systems (Fuller 2016) often leads to the conflict of roles between the central and local governments, and weak growth of private firms. The divergent catch-up dynamics in China has often been attributed to the inconsistency and discoordination among the different levels of governments, which has also to with the size of the economy divided into many country-like provinces (Thun 2006; Chu, 2011).⁷ Thus, interaction between national and regional innovation systems is one of the most critical dimensions in understanding the Chinese industry (Breznitz and Murphree 2012).

After learning from the previous failures, for instance, in auto sectors in the early days (Lee et al 2021), the central government has turned to more interventionistic and effective techno-industrial policies (Chen and Naughton 2016; Chu 2011). So, it can be said that the Chinese state have evolved to become more like east Asian style developmental states (Johnson 1982; Amsden 1989) or state capitalism (Fuller 2016; Milanovic 2019), trying to achieve another ‘compressed development’ in a bit

⁷ A study of auto sector by Thun (2006) suggests that there are three types of development model in China, with Guangzhou and Beijing as a local laissez-faire system, Shanghai as a model of local developmental state, and Changchun and Wuhan as a model of state-owned enterprises.

different context than the east Asian tigers or Japan (Whitaker et al. 2020).⁸ This factor of the government or developmental states plays a key role in the discussion of catch-up in many sectors dealt in Chapter 6 and in IT services in Chapter 7 in particular.

Figure 1.4 depicts the preceding discussion and presents our theoretical framework, which was also introduced by Lee et al. (2016). It first consider catch-up as increasing in market share and then reflects the idea that substantial resources should be allocated to R&D to increase market shares (catch-up) and that firms will devote abundant R&D resources only when they are sure of the linkage between high R&D expenditure and high R&D outputs (product development or innovation). Then, the new R&D outcome is combined with the firms' capabilities in manufacturing, marketing, and logistics as parts of the value chain to produce a commodity heading for a test in the market. Here, technological regime components serve as determinants of the expected chance for product development; for instance, high barrier to accessing foreign knowledge and uncertainty tends to make firms unsure of whether their R&D effort can provide tangible results. Such factors, such as cost edge, product differentiation, market segmentation, and first-mover advantages, act as determinants of the expected competitiveness of the to-be-developed products. The framework indicates that the eventual outcome in market share catch-up emerges from the complex and delicate interaction of the technological and market regime and the strategies and policy intervention by firms and governments.

This framework (Figure 1.4) is applied to cases of catch-up in diverse sectors treated in this book. Each catch-up episode is explained as an outcome of the interaction of the technological and knowledge regime and the responses by the actors, such as firms and the state. In the Chinese context, the term catch-up primarily refers to closing the gap between forerunning non-Chinese (or foreign) and indigenous Chinese firms in terms of their market shares and technological capabilities.

[Figure 1.4]

If we specify the main hypothesis proposed in the preceding subsection to the Chinese context, it is that China's successful catch-up in technological capabilities and market shares has been possible owing to the strategy of technological leapfrogging, although the eventual outcomes are also shaped by other factors, including interventions by the governments and broad institutions. China's successful rise in telecommunication systems and handsets, with Huawei as the leader, is associated with its stage-skipping-style leapfrogging at an early stage of its growth, as will be discussed in Chapters 2 and 6, and then with moving onto a path-creation-style leapfrogging at a later stage, as will be discussed in Chapter 8 in comparison with Ericsson. By contrast, the limited catch-up in semiconductors will be explained in Chapters 4 and 6 through several factors, including the difficulty

⁸ D'Costa (2014) uses another term, compressed capitalism, to refer to a system-wide account of the unfolding of global capitalism in late-industrializing countries that goes beyond industrial change

in trying leapfrogging due to the late entry (low absorption capacity), frequent changes in technology (short cycle times), and tight restriction against technology transfer to China, in addition to inconsistent industrial policy. In consideration of another factor emphasized in the catch-up model (Figure 1.4), the role of the government industrial policy will be assessed in various sectors, such as IT services in Chapter 7 and IT manufacturing in Chapters 2 and 6, in terms of its interaction with firm-level effort to find a new path different from that of incumbents, thus mitigating the risk involved in leapfrogging.

The last part of this book discusses the national-level implications of diverse sectoral stories of technological leapfrogging and catch-up. That is, we explore the linkage from technological leapfrogging and catch-up to economic catch-up of closing the gap with the US in terms of per capita income (MIT issue) and the size of GDP as a measure of economic power (the Thucydides trap issue).

In the subsequent section, we provide a summary of the key findings of each part and chapter. We start from Part 1 that discusses the origins of technological catch-up in China, focusing on the emergence of large businesses, such as Huawei in telecommunication and semiconductors. Part 2 provides a comparative analysis of China's technological catch-up in consideration of the experiences in other regions, nations, and firms. Part 3 is a concluding part discussing the prospect of the Chinese economy.

3. Main Findings from Each of the Three Parts

3.1. Origins of Catch-up and the Early Effort

The first part of this book deals with the origins of technological catch-up in China. In consideration of China's catch-up spearheaded by large flagship companies in IT sectors, the first chapter (Chapter 2) in this part first elaborates on the origin of Huawei, a leading company in China that is successful in telecommunication systems and handset products for domestic and global markets. Then, Chapter 3 indicates the broad origins of large businesses in China that are mostly state-owned enterprises in the early period but are presently diversifying into privately owned companies. Chapter 4 discusses the issue of why China's catch-up is limited in the semiconductor sector and searches for answers in the hard and soft institutions surrounding the sector. Summaries of the key findings of the chapters in Part 1 follow.

Chapter 2 examines the growth of technological capability in the telecommunication industry in China, with a focus on Huawei and ZTE, which have become well known due to Trump's measures against them. These companies grew rapidly by localizing the production of fixed-line telephone switches, which were imported or produced by foreign joint venture (JV) companies before. While the market used to be completely dominated by foreign products in the 1980s, four locally owned companies caught up with foreign companies in market shares and became the complete

leaders by the end of the 1990s. To explain this interesting and first case of catch-up, the chapter utilizes the Schumpeterian model of technological learning and catching-up proposed in the preceding section. This case can be considered a variant of technological leapfrogging because it involves the stage-skipping catch-up. In terms of the technological trajectory of telephone switches, China skipped the analog-based telephone switches but leapfrogged into digital-based telephone switches (Shen 1999; Mu and Lee 2005). Such stage-skipping was possible because the technological regime of the telephone switches was featured by a more predictable technological trajectory and a lower cumulateness, and the involved technologies were already mature ones; thus, technology transfer was not that restrictive.

The catch-up can be explained by three factors, namely, 1) the famous Chinese strategy of technology transfer called “trading market for technology,” 2) the knowledge diffusion from the first foreign joint venture (JV), Shanghai Bell, to the local R&D consortium and then to other locally owned companies including Huawei, and 3) the explicit promotion measures by the government. Given the large market in China, access to knowledge was made possible by the strategy of “trading market for technology,” which pushed the JVs to transfer their technologies to the Chinese side. The case of a JV, Shanghai Bell, shows that China took advantage of its large market size to push the foreign partner in the JV, Alcatel’s BTM, into a contract-enabling technology transfer. The Chinese partner was able to acquire a related technology of manufacturing, installing, and engineering through the establishment and operation of Shanghai Bell. Public research consortium led by Center for Information Technology benefited from such technology diffusion, and eventually developed the first indigenous digital automatic switch, HJD-04, in 1991. Moreover, the indigenous Chinese firms were able to secure their competitive advantage due to the segmented nature of markets. The telecommunication equipment market in China is segmented, and indigenous firms differentiate their products to meet various demands in the low-end markets, such as rural markets. Finally, the initial protection and promotion by the government, such as high tariffs on imported goods and coordinated loans, provide an additional competitive advantage for indigenous firms. In summary, the key success factors include the coordinated acquisition of foreign technology by taking advantage of the bargaining power associated with market size, the regulation of JVs to allow knowledge diffusion, and the plan for domestic capability building given the initial condition of segmented markets.

Chapter 3 elaborates on the origins of large businesses, particularly business groups, which have been leading the economic catch-up in China. The Chinese government explicitly defines the business groups that must be registered with the State Administration for Industry and Commerce. Business groups, which have at least five affiliated companies, must be registered; their number has increased rapidly to form the backbone of the economy. The majority of firms listed in the stock markets are business groups, which are comparable to their counterparts in Japan (keiretsu) and in Korea (chaebols). However, one of the most important characteristics of large business groups in

China, which is distinct from their counterparts in Korea or Japan, is that most business groups are less diversified and are owned by the state but not by particular families (as in Korea) or commercial banks (as in Japan). The central and provincial governments, including their diverse agencies and subsidiaries, controlled 45% of business groups in 2007. The dominance of the state was more evident in terms of total revenue; the state-controlled ones accounted for 78% of total revenue. However, non-government ownership is growing fast, and business groups of private and other ownership accounted for approximately 45% of 2,856 in 2007, although their share in terms of sales remained less than 20%. In terms of sectors, the top 30 business groups tended to be present heavily in energy, utilities, and services, whereas increases in the share of manufacturing were dominant in the top 500 business groups.

Chinese business groups typically maintain a vertical structure with its core company at the first tier, closely related companies at the second tier, semi-closely related companies at the third tier, and loosely related companies at the bottom. The core firms are also called parent company or group company because it owns majority equity shares to subsidiaries and unites the business group into a single controlled structure. They are generally large industrial or commercial enterprises, whose business defines the primary business area of the group. Several large business groups have finance companies and R&D companies as affiliated companies. The performance of the business groups improve over time, but they show several inferior or comparable performance relative to stand-alone firms. Chinese business groups also have the strength (high growth) and weakness (lower profitability) of business groups similar to neighboring countries, such as chaebols in Korea, which is understandable because business groups in China are also known to have multi-tier structure, leading to asset stripping and agency costs similar to their counterparts in other countries.

Chapter 4 analyzes China's semiconductor industry from the sectoral systems of innovation perspective. The innovation systems of China's semiconductors have been ever-evolving, with the government playing the crucial role of policy actor. However, the industry remained limited in terms of catch-up in market shares and technology. The chapter explains the reasons for limited catch-up first in terms of the characteristics of the technology regime of the industry. In the semiconductor industry, innovations are frequent, and technologies are highly cumulative, which places the latecomer in a disadvantageous position in terms of entry possibility. Furthermore, the market for standard integrated circuit (IC) chips is not segmented but highly integrated, which implies no low-end niche market for latecomers to enter first. Therefore, latecomer firms encounter difficulty in seizing a market opportunity through differentiated marketing. The situation worsens with the continued increase of the required investment and shortening of life cycles. Furthermore, the existing practice of Western countries restricting the transfer of core technologies to Communist countries, such as China, had aggravated the difficulties faced by Chinese firms.

Although China's semiconductor industry has faced many obstacles in its quest for catch-up, several promising signs emerged in the 2010s, at least before Trump administration took measures to hold the rise of Chinese firms in high-tech areas. The first is the continuing explosion of the Chinese market and its increasing importance after the global financial crisis. Second, China would expect an increased flow of human capital equipped with up-to-date technology in this field by working in foreign firms and by obtaining education and training in foreign countries, although this factor has become complicated in the period of the Trump government in the US. As these favorable factors are combined with the consolidation of the domestic innovation system, such as R&D capabilities of domestic firms, research organizations, and universities, China's position is expected to rise, and technology catch-up may become a possibility in varying degrees. Thus, as the general absorptive capacity of actors in China increases, changes and rise of the new generation of technologies could serve as a window of opportunity for leapfrogging. However, some delay is now expected if Chinese firms are forced into increasing difficulty in terms of access to key high-technology components owing to the US–China hegemony struggle since 2018. China must find a way not to rely on foreign technologies but to allocate more resources for indigenous innovation, which means more delays in catch-up.

3.2 Assessing the Catch-up in a Comparative Perspective

Part 2 of this book assesses China's catch-up and leapfrogging from a comparative perspective. Chapter 5 provides the first comparison of China's catch-up model, namely Beijing Consensus, with the Washington Consensus and East Asian Model. Chapter 6 assesses China's catch-up in key manufacturing sectors compared with catch-up by Korea in the same sectors. Chapter 7 deals with catch-up in IT services compared with that in manufacturing. Finally, Chapter 8 focuses on Huawei to show how it has been able to catch up with Swedish Ericsson in the telecommunication system sector.

Chapter 5 assesses China's catch-up model, often called Beijing Consensus, in a comparative perspective. This chapter extend a similar comparative analysis in Lee's (2006) which compared the Washington Consensus with East Asian sequencing. The idea of sequencing originated from Rodrik (1996), who pointed out that although Latin America endorsed and simultaneously tried all 10 elements of the Consensus, Korea and Taiwan adopted only the first half (i.e., macroeconomic stabilization, 1–5) but maintained microeconomic intervention by not committing to the second half (i.e., privatization, liberalization, and deregulation) until the latter stages. Now, China shares several elements of the East Asian model because it also pursued the export-oriented, outward-looking growth strategies (Lee, Lin, and Chang 2005). A further commonality lies in its emphasis on the elements missing from the Washington Consensus, namely, technology policy and higher education revolution.

However, the Chinese catch-up model (i.e., the Beijing Consensus) has several unique elements that are not found in Taiwan or Korea. These unique features include the following: first, parallel

learning from FDI firms, followed by active promotion of indigenous firms; second, forward engineering (the role of university spin-off firms) in contrast to reverse engineering adopted in Korea and Taiwan; third, acquisition of foreign technology and brands through international M&A. One may also say that several commonalities are observed across Chinese and neighboring Asian strategies that can be summed up as the “BeST (Beijing–Seoul–Tokyo) consensus” (Lee and Mathews 2010); the BeST consensus identifies firms and the state developmental agency as the two primary vehicles for latecomer development.

However, the specific implementation process has several distinctive Chinese flavors that are associated with its size. For instance, tremendous bargaining power associated with the size is an important factor in the technology transfer strategy, and the international M&A strategy is related to the size of the cash power of large corporate sectors. The initial success of the university spin-off firms is associated to a lesser degree with the availability of a large population of educated human capital at a lower cost that can also take advantage of the agglomeration economy in college locations. These characteristics must be understood in a relative sense. However, during the early stage of their catch-up, Taiwan and Korea did not experience the emergence of university spinoffs to the extent that China experienced in the 1990s and 2000s. In terms of parallel learning from FDI firms, Taiwan also pursued this goal can be argued, although China is capable of relying on stronger bargaining power in its negotiations with MNCs for technology transfer. The sheer size of its economy and its attendant cash power enable China to utilize this strategy (‘trading market for technology’) on a much larger scale.

In general, these strategies help China achieve a “compressed catch-up” and avoid several of the risks involved. China avoids the risk of the “liberalization trap,” where premature financial liberalization leads to macroeconomic instability, by following the East Asian sequencing rather than the Washington Consensus. In this sense, the current Beijing model seems to be a natural extension of the earlier gradual approach (Lin et al. 1996) to system transition responsible for China’s early success.

Chapter 6 assesses China’s catching up and leapfrogging in key manufacturing sectors compared with the Korean experience. In the four sectors, catch-up performance is measured by the changes in market shares by indigenous firms. The market share trend by indigenous cellphone makers has been very volatile, which is characterized by quick catch-up, retreat, and recent regaining of the catch-up. By contrast, the telecommunication system sector initially exhibited a slow catch-up through the path-following strategy and then has displayed a rapid catch-up through a path-creation strategy or leapfrogging. The automobile sector is characterized by a steady catch-up with medium speed, which is slower than that of the IT sector. Finally, the semiconductor sector has the most modest performance of catch-up. The chapter explains the varying records of market catch-up by referring to the diverse aspects of the regimes of technologies and markets, such as modularity,

degrees of embodied technical change, tacitness of knowledge, knowledge accessibility, and frequency of innovations.

The easy access to foreign technologies from developed countries (mobile phones versus semiconductors), the high degree of modularity (mobile phones versus automobiles and semiconductors), and the frequent changes in the generations of technologies or short cycle time of technologies (mobile phones, telecommunication systems versus automobiles) generally help latecomers catch up. More importantly, sectors with a high degree of tacit knowledge (e.g., automobiles) tend to show a slower speed of catch-up than the manufacturers of telecommunication equipment with a high degree of explicit knowledge. Whether markets feature segmentation (or the existence of low-end niche segments for Chinese latecomers) seems to play an important role in the market regimes. Chinese firms manage to achieve initial success from a low-end market in segmented market conditions (e.g., telecommunication equipment and mobile phones) or markets protected by the government (e.g., telecommunication equipment). Conversely, they face high entry barriers in markets with no such segmentation (e.g., memory chips), which is one of the reasons for the slow progress of Chinese firms in the memory chip sector (see also Chapter 4).

A tricky point in this condition is the double-edged nature of the technological regime featured with rapid technical change or short technical cycles. The short cycle time of technologies and frequent changes provided opportunities for latecomers in mobile phones and telecommunication equipment, whereas the frequent generation changes interfered with the Chinese effort to catch up with the ever-moving forerunners in IC manufacturing. Therefore, the difference must come from the level of initial absorptive capacity (or the initial gap) and the degree of lateness in entry by latecomers, beside the degree of market segmentation. For instance, the Chinese entry into the IC chip market is relatively behind than that into the mobile phone market. Lee (2013) clarified that short cycles provide latecomers with a good chance to catch up only when they have already accumulated certain absorption capabilities. Otherwise, the frequent changes in technologies become an additional barrier against catch-up. Therefore, sectors with short-cycle technologies require the leapfrogging strategy to target and jump to emerging or next-generation technologies, as exemplified by the TD-SCDMA standard.

The above stories of the sectors also suggest that technological regimes are not the only paramount determining factor; the outcomes are affected by the roles of actors, including firms and governments. Despite having a similar regime of rapid technical changes, the wireless telecommunication sector in China has succeeded in catching up in contrast to IC manufacturing. In these comparable cases, one of the sources of the difference is the varying roles of the government; the Chinese government has been timely and consistent in implementing its supportive role in the telecommunication sector but not in the semiconductor sector in China during its early days, where the government was not confident and was thus inconsistent (Chapter 4). The case of the early days of the semiconductor industry in Korea

is an example of how the difficulty posed by the nature of technological regime can be mitigated by the supportive role of the government in conducting joint R&D with private actors. The government may indeed play the role as a facilitator in the process of catch-up roles, but this statement does not mean that such a condition is always necessary, as shown by the case of cell phones where the successful catch-up was achieved without much government activism.

Finally, concerning the choice among the alternative catch-up strategies (e.g., path-following, stage-skipping, or path-creating), the path-following strategy on the basis of initial factor–cost advantages may serve as the gradual catch-up of market shares. However, the implementation of this strategy alone may not be sufficient to stage a rapid catch-up or overtake the incumbents, which may require the leapfrogging (path-creating or stage-skipping) approach. In the path-following strategy, latecomers move along the existing technical trajectories of incumbents, but incumbents tend to become increasingly reluctant to provide the former with technologies if the latter emerge as competitive threats in the market. This situation indicates the need and reason for latecomers to turn to the leapfrogging approach, as observed in sectors in China and Korea. However, given the intrinsic risk in using the leapfrogging strategy (e.g., uncertainty in standard choice and (non)-existence of initial markets, identified by Lee et al. (2005)), supplementary actions are often required by governments.

Chapter 7 analyzes the market and technological catch-up of indigenous Chinese firms in two IT service sectors, such as games and business software (enterprise resource planning (ERP) and security software) and focuses on two aspects. The first aspect is about how latecomer firms have been able to learn from and access foreign knowledge bases and acquire their innovation capabilities. The second aspect is the role of the government and regulation in the process of catch-up. Indigenous firms in China have selected different learning and catch-up strategies in different technological regimes. For the online game sector, where imitation is easier and incremental innovation is more important than radical innovation, these Chinese firms started with handling the publishing (or distribution) of games developed by foreign incumbents and later secure in-house game development capabilities by imitating the products of global leaders. In the business software sector, where imitation and creative innovation are difficult, Chinese firms acquired third-party technologies through M&As and then differentiated their products by taking advantage of local specificities.

In general, IPRs are critical in the business of these two segments. Despite this entry barrier effect of IPR protection by the foreign incumbents, the latecomer firms discussed in this chapter were shown to circumvent the barrier to entry and learning and to acquire their innovation capabilities. However, such learning and acquisition would not have led to commercial success without government regulation against foreign companies, such as business restrictions in online gaming and exclusive procurement for indigenous products in applied software (ERP and security software). Such restriction against foreign companies is a critical constraining factor against their market share

expansion in the Chinese market. This study underscores the importance of the government and regulation in “artificially opening” windows of opportunity for latecomers, although the process often involves “unfair” business practices from the incumbent point of view. However, such intervention has led to a market structure that is more competitive than monopoly by a few (foreign) companies, which means more economic efficiency. Thus, the policy implication is that the initial protection of domestic markets and firms may be essential in the early stage because latecomers have limited resources and need time to learn. However, after acquiring their in-house R&D capabilities, policy-makers may switch to a new institutional regime, allowing fairer competition with foreign companies. This observation implies that when access to foreign knowledge is not difficult, the necessary intervention can be merely the protection of the initial market in the form of entry limit or exclusive procurement, and does not have to be in the form of direct sharing R&D cost or activity itself.

Chapter 8 explores the question of how Huawei has been able to rise as the leading firm in the telecommunication system sector, overtaking the long-lasting incumbent Swedish giant, Ericsson; Huawei overtook Ericsson in terms of sales revenues in 2012. The chapter answers this question by focusing on the theoretical question of whether a latecomer firm uses technologies that are “**similar or rather different**” from those of the forerunners when it tries to catch up with a forerunning firm. The study investigated the patents by Huawei and Ericsson and found that Huawei relied on Ericsson as a knowledge source in its early days but subsequently reduced this reliance and increased its self-citation ratio to become more independent. The results of mutual citations (direct dependence), common citations (indirect reliance), and self-citations provided strong evidence that Huawei caught up with or overtook Ericsson by taking a different technological trajectory. Compared with Ericsson, Huawei developed its technologies by relying on more recent and scientific knowledge; the results of citations to scientific articles and citation lags showed that Huawei extensively explored basic research and maintained up-to-date technologies to accomplish its technological catch-up.

Overall, this study suggests that leapfrogging by exploring a new technological path different from that of forerunners is a possible and viable catch-up strategy for a latecomer. The higher reliance on scientific articles by a latecomer, Huawei, makes sense because articles are free from IPR protection and litigations with incumbents, which is different from patents. A higher reliance on recent patents is consistent with the idea that a latecomer should try to minimize reliance on old or existing knowledge (patents) owned by incumbents. Moreover, Huawei’s case re-confirms the hypothesis that catch-up in technological capabilities tends to precede a catch-up in market share, which was verified in the Samsung versus Sony case on consumer electronics by Joo and Lee (2010). Huawei overtook Ericsson in terms of quantity and quality of patent before annual sales. In summary, the results suggest that Huawei’s catch-up with Ericsson in the telecommunication equipment market is owing not only to its cost advantage, the large domestic market, or the Chinese government’s support but

also more importantly to its technological leapfrogging based on its technological strength and independence.

3.3. Prospect of the Chinese Economy under the Double Traps: MIT and Thucydides

Part 3 of the book links the discussion of technological catch-up in the preceding parts to the issue of economic catch-up at the national level as measured by GDP size (economic power) and per capita income (living standards). Thus, this part tackles recent and broad issues, such as the MIT and Thucydides trap, but discussions extend many micro and meso analyses performed in the preceding parts.

Chapter 9 discusses the possibility of China falling into MIT in terms of three checkpoints: innovation capability, big businesses, and inequality. The main finding is that China is performing well in terms of the first two criteria of innovation and big businesses, but some uncertainty lies in the last criterion of whether China generates Kuznets curve-type dynamics of the growth leading to better equality. Additional details are discussed in the following paragraphs.

First, China has increasingly become innovative; thus, it differs from other middle-income countries. China has strongly been pushing for considerable R&D expenditure and has been ahead of the typical middle-income countries. The spending of China on R&D as a percentage of GDP, known as R&D intensity, more than doubled from 0.6% of the GDP in 1995 to over 1.3% in 2003 and is now over 2.0%, which is higher than that of several high-income economies. Moreover, the number of US patents filed by China exceeded 2,500 in 2010, which exceeds that filed by other middle-income countries (less than 300 patents per year). During the 9 years from 2010 to 2019, the number increased by nearly 10 times and reached to 21,726, which is more than that of Germany (21,074) and close to that of Korea (22,183), which is now third after Japan.

Second, China has many world-class big businesses, which is more than its size predicts, not only in finance, energy, and trading as in the past but also increasingly in manufacturing. Thus, China differs from other middle-income countries with few globally competitive large businesses. In terms of the number of firms listed in the Fortune Global 500, Japan has substantially declined since the mid-1990s from 149 in 1994 to 52 in 2018, and the US since the 2000s from 197 in 2001 to 121 in 2018. By contrast, that number for China increased from 3 in 1993 to 20 in 2005, 61 in 2010, and 119 in 2018 (almost at par with the US). China outranks Japan as second across the world in terms of the number of large firms, which is consistent with the fact that China replaced Japan as the second-largest economy in the world in 2010.

Third, China faces some uncertainty in terms of inequality. The Gini coefficient continuously increased from approximately 0.3 in 1981 to reach its peak of 0.49 or so in 2009 or 2009 but decreased to roughly 0.46 to 0.47 since then. This recent decrease may be a sign that the Kuznets curve is coming to represent China. However, China is now facing new sources of inequality, such as

wealth (including financial and real estate assets) and non-economic (including corruption) factors. China should now pay more attention to the third aspect, that is, equity, than the two other aspects. A more flexible approach in rural to urban migration should be one of the key policy agendas in addition to providing broader access to education at the secondary and tertiary levels.

Chapter 10 analyzes the issue of whether China would fall into the Thucydides trap, which is defined here as a situation that the US causes China to stop expanding as an economic power. The US or at least the Trump government intends to stop China from growing into another superpower that would threaten the American hegemony. Whether the US will succeed is a vital question. China will not collapse unless the US dares to wage an all-out war by taking drastic measures across fronts of confrontation. Further, one unexpected factor is the outbreak of Covid-19 in 2020, which hit the US badly, whereas China boasted a V-shaped recovery to record even a positive growth rate in 2020. If we extend the most recent 10 year trend of catching up or reducing 30%P gap within 10 years, namely from 40% of the US in 2010 to 70% in 2020, we can expect that China will catch-up with the US in GDP size by 2030 or in 10 years or so.

Before Donald Trump rose to power, China was navigating steadily to grow beyond the MIT, building its China-led GVC and localizing formerly imported goods into domestic production. The Belt and Road Initiative was realized to scale up and globalize the China-led GVC. However, China suddenly faced another trap of Thucydides because of the US measure for containing the further rise of China as a superpower. The sudden emergence of this new trap disrupted the China-led GVC formed around Asia, which still relies on the west for key high-technology goods. Such disruption would have further repercussions on the prospect of China's growth beyond the MIT because China must now allocate resources not only on economic competitiveness and "Made in China 2025" but also on socio-economic stabilization and job creation, which gained importance in response to exogenous shocks and external challenges.

This rebalancing implies an additional fiscal burden, which tends to increase the fiscal deficits of the government and debts of the corporate sector. The overall national economy attained fiscal surplus in 2007 or before the global crisis, offsetting local deficits by central surplus. However, overall balance eventually turned into deficits, reaching 5% in 2018 as the deficits by local governments (higher than 10% of GDP) increased more than the budget surplus of the central government (5% or higher). Several worsening symptoms in the Chinese economy suggest that the policy response to external shock, including the trade war, by allocating resources to those problem sectors has increasingly burdened the domestic economy and government budget.

China wants to be different from its neighboring Asian economies in terms of the economic system, but it remains in a developmental state. Thus, this country shares several weaknesses of East Asian capitalism, such as weak financial sector, vulnerability to exogenous shocks, or cronyism associated with the tension between political authoritarianism and independent and sound private

sector growth. China does not necessarily have to adopt Western-style liberal democracy, but a viable alternative that is compatible with the people's rising demand for political democracy and basic human rights must be implemented. Such a demand has become increasingly visible through the Hong Kong crisis in 2019 and the coronavirus eruption in 2020. Asian neighbors have gone through their path of political democratization, but China now faces the challenge of crossing this unknown territory. This situation may be a more challenging trap compared with MIT and Thucydides trap. Therefore, China now faces triple traps.

4. Contributions and Limitations

Given the voluminous literature on the Chinese economy, this book contributes to the existing literature by taking a Schumpeterian perspective and focusing on technological innovation in the Chinese economy, which is timely and sensible because the growth engines of the Chinese economy have been moving away from FDI, low-value-added exports, and privatization to innovation and high-value-added exports.

The early success of the Chinese economy was well explained by Lin et al. (1996) and later by Lin (2011). Lin's works took a neo-classical economics approach to structural changes in the Chinese economy, from labor-intensive to capital-intensive industrial structure, but firm- or sector-level analysis of technological innovation is not the focus. Furthermore, Lin's work analyzed China's structural transformation mostly from a low- to middle-income economy, but this book focuses on the challenge at upper middle-income stage where innovation capability is the real binding factor for further economic growth beyond the MIT. Naughton (2018), which is a second edition of the well-known book (Naughton 2007), is very comprehensive as it covers and updates diverse aspects of the Chinese economy, such as demographic, macroeconomic, and institutional transitions. It also deals with industry and technology issues in agriculture, manufacturing, and foreign trade and investment. However, its approach is a broad touch. In comparison, the chapters in this book provides a more indepth analysis of technological innovation in China, such as the role of innovation in the rise of Huawei, the middle income trap and Thucydides Trap.

This book shares the same theme of innovation as Fu (2015). Fu's book also discussed diverse issues of innovation in China, but this book tackles technological leapfrogging as the core concept and analyzes it at the firm and sector levels. This book also differ in terms of scope from other books on China but focusing a few sectors, such as Breznitz and Murphree (2012) on IT sector, Fuller (2018) on integrated circuit industry. Dealing with more sectors and more dimensions of firms, sectors and a nation as a whole, this book takes a comparative approach, in which Chinese experience and path are compared with those of its Asian neighbors, such as Japan, Korea, and Taiwan, which all share the tradition of the developmental state and industrial policy. This book combines leapfrogging and

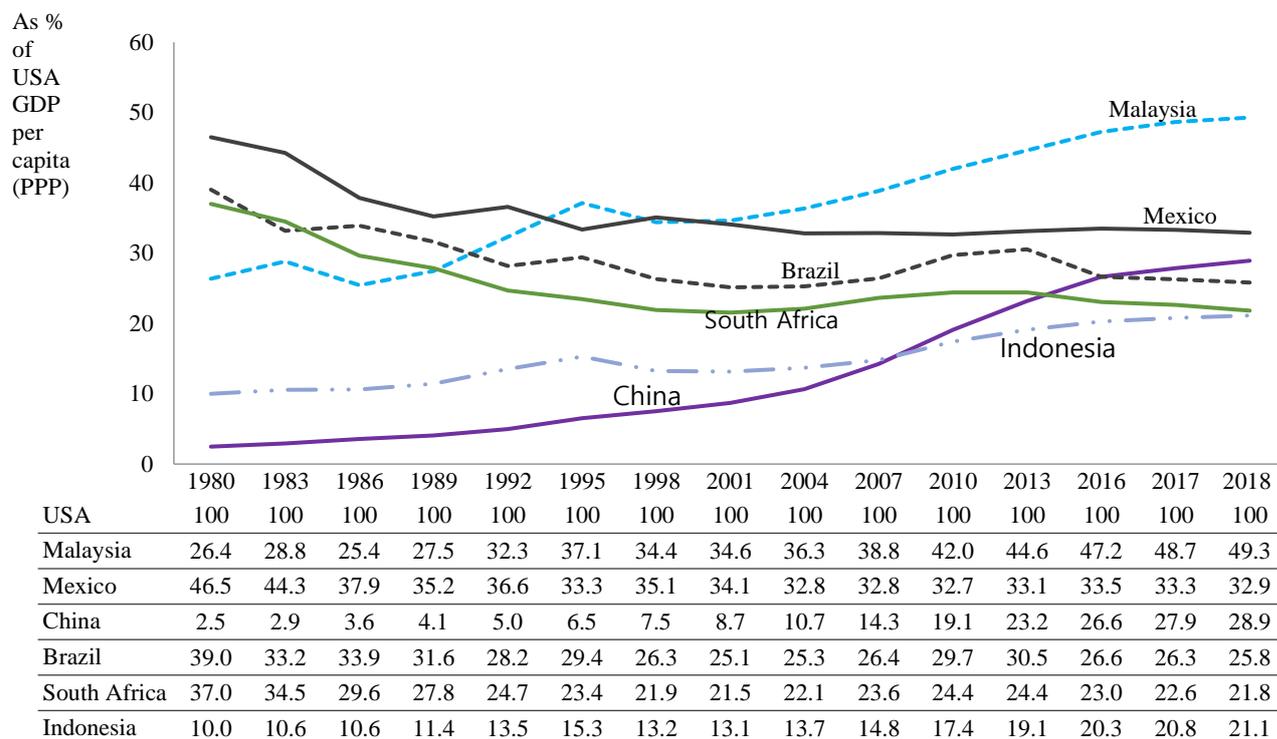
comparative analyses, and offers insight into the prospect of China going beyond MIT. This feature of the book linking technological leapfrogging and catch-up to macroeconomic catch-up in income levels and economic sizes extends to the issue of the Thucydides trap, which is one of the most recent issues facing China.

In summary, new and interesting features of this book are as follows. First, it provides a consistent treatment of the three key concepts related to China, namely, Beijing Consensus, MIT, and Thucydides trap. Second, it develops a Schumpeterian model of technological leapfrogging and catch-up and applies this to analyze Chinese firms and industries. Third, it finds that China's successful rise as the industrial power has been possible owing to its strategy of technological leapfrogging, which would enable it to move beyond the MIT and probably Thucydides trap, although at a slower speed.

The book would be more complete if a chapter is devoted to the three platform business giants of the so-called BAT (Baidu, Alibaba, and Tencent), which corresponds exactly to Google, Amazon, and Facebook, in terms of business models. However, the basic principle in the rise of BAT is similar to the explanation in Chapter 7 regarding the IT service sector, that is, the combination of China-specific contents and asymmetric protection by the government. They represent more business model innovations adapted for the Chinese context than technological innovations (Chakravarthy and Yau, 2017), although they keep evolving from the former to the latter direction and recently to a combination of both types of innovations as they keep embracing artificial intelligence in their new platform businesses (Jia et al. 2018).

Other aspects of limitation of the book relate with the fact that several chapters are re-writing, modifications and updates of the existing journal article of the author. However, this book is also of quality because those chapters has undergone referee process for journal publications.

Figure 1.1. Per Capita Income of Selected Economies as % of that of the US: The Middle-income Trap



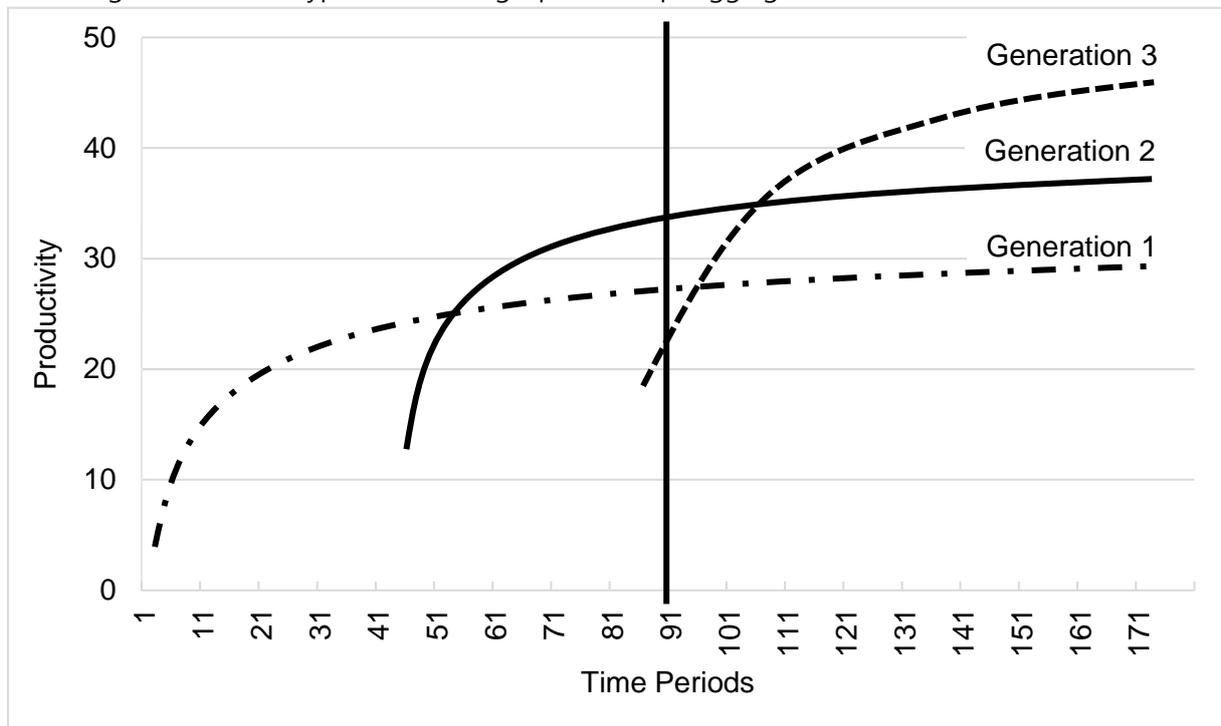
Source: Drawn using the raw data from the IMF database. PPP-based GDP per capita is used.

Figure 1.2. Trend of GDP Growth Rates in China



Source: GDP growth rate data come from the World Bank national account data and OECD national account data files; GDP growth rate (3-year moving average) is estimated by the author.
 Note: MIT stands for middle-income trap.

Figure 1.3 Three Types of Catching-up and Leapfrogging



Source: Adapted from Lee and Ki (2017)

Notes: Path-following strategy = To adopt the oldest (generation 1) technology

Stage-skipping strategy = To adopt the latest (generation 2) technology

Path creation (leapfrogging) strategy = To adopt emerging (generation 3) technology

Figure 1.4 Schumpeterian Model of Technological and Market Catch-Up
 (Source: the authors; Lee et al. 2016)

