Innovation Performance in China:
Innovation Systems, Market Structure and State Ownership

Dissertation

zur Erlangung des Grades

Doktor der Wirtschaftswissenschaft (Dr. rer. pol.)

der Juristischen und Wirtschaftswissenschaftlichen Fakultät
der Martin-Luther-Universität Halle-Wittenberg

vorgelegt von
Kou Kou

Halle (Saale),
Juni 2017

1. Gutachter: Prof. Dr. Ulrich Blum

2. Gutachter: Prof. Dr. Shiwei Shi

Tag der Verteidigung: 20. Dezember 2017

Acknowledgements

Firstly, I would like to express my sincere thanks to Prof. Ulrich Blum for his intellectual guidance and constant supervision. He brought me from China to Germany and helped me come up with the thesis topic. During my doctoral career he provided me with various opportunities to broaden my knowledge in different disciplines and to learn how to do real research, and gave me the freedom I needed to move on. I still remember he used to say "Ihr Erfolg ist mein Erfolg!" (Your success is my success!), which made me feel that he is not only a good supervisor, but also a true leader. The enthusiasm and joy he has for academic research was contagious and motivational for me.

I am greatly thankful to Prof. Shi Shiwei for his support of my research on the Chinese and German economy. He has been supportive since I was a master student in China and brought me into the academic world step by step. I would not forget when I was suffering the "pain" of difficult economic courses in my first semester as a doctoral student in Halle, he said "You are still young. Just learn it!" to encourage me to face up to the academic challenges.

My sincere thanks also goes to the Konrad-Adenauer-Foundation, which provided me with a doctoral scholarship throughout the last years. Without its financial support and training program it would not be possible to finish this research.

Besides, I wish to thank Prof. Feng Xiaohu, who established cooperation between Martin-Luther-University Halle-Wittenberg and University of International Business and Economics; Dr. Thomas Kohl, Dr. Georg Licht and Dr. Philipp Boeing for their support at the Centre for European Economic Research (ZEW) in Mannheim; Dr. Rainer Frietsch and Dr. Henning Kroll for their academic guidance at the Fraunhofer Institute for Systems and Innovation Research (ISI) in Karlsruhe.

Finally, last but not the least, I owe my deepest gratitude to my mother for her encouragement and spiritual support from China.

Contents

List of Figures

List of Tables

List of Abbreviations

BC	before Christ
CCER	China Center for Economic Research
CSMAR	China Stock Market & Accounting Research
EPO	European Patent Office
FP&S	Furman, Porter and Stern's Model
GDP	Gross Domestic Product
HHI	Herfindal Index
IO	Industrial Organization
LL	Leader-and-Laggard Market
NERI	National Economic Research Institute
NIS	National Innovation System
NN	Neck-and-Neck Market
OECD	Organization for Economic Co-operation and Development
POE	Privately Owned Enterprises
R&D	Research and Development
RIS	Regional Innovation System
S&T	Science and Technology
SASAC	State-owned Assets Supervision and Administration Commission
SCP	Structure, Conduct and Performance Paradigm
SIC	Standard Industrial Classification
SME	Small- and Medium-Sized Enterprise
SOE	State-owned Enterprise
TFP	Total Factor Productivity
UK	United Kingdom
US	United States
USPTO	United States Patent and Trademark Office
WTO	World Trade Organization

1. Introduction

1.1 Motivation

Knowledge is the information which is acquired through experience or education and can help to understand inner or outer world. Between the 8th and 3rd centuries BC, new knowledge and new ways of thinking appeared in different regions of the world in a striking parallel development, without any obvious direct cultural contact between the regions, including that which took place between PLATO (428/427 BC. – 348/347 BC.), ARISTOTLE (384 BC. – 322 BC.), ZENO (322 BC. – 262/261 BC.) and EPICURUS (341 BC. – 348/347 BC.) in Greece, GAUTAMA BUDDHA (563 BC. – 483 BC.) in India, ZOROASTER/ZARATHUSTRA (? – 583 BC.) in Iran, ISAIAH (lived in the 8th. Century BC.) in Palestine, and LAO TSE (604 BC. – 531 BC.) and CONFUCIUS (551 BC. – 479 BC.) in China. This phenomenon was called by the German-Swiss philosopher Jaspers (2014) as the "Axis Age" (*Achsenzeit*) in his book *The Origin and Goal of History*. These ancient sages are considered the greatest and the most important thinkers in their countries (regions) to this day, and the knowledge they discovered shaped the philosophical system, and the behavior of the people in their region. From the 14th to the 18th century – in the age of the Renaissance and Enlightenment – the heritage of the ancient Greek philosophy was revived after the medieval period in Europe. Since then recognition of an individual's consciousness has become a foundation of European society; such recognition did not take place in China.

The revolution in knowledge and growing awareness of individual freedom, liberty and rationalism helped to incite a new competition mechanism and stimulated the spirit of innovation among people in Europe, and is considered one of the motivations leading to the "scientific revolution" (Koyre, 1943) with the emergence of modern nature science – including mathematics, physics and astronomy – resulting then in the industrial revolution in Europe. It not only boosted the development of science and technology (S&T) but also the economic growth of European countries like England, Germany and the Netherlands. But at the same time, China turned inwards and cut off its contact with the rest of the world. According to the Maddison Database, in the 18th century, western European countries surpassed China in terms of GDP, with an economic boom commencing, while China entered into a long, difficult economic age, identified by Pomeranz (2000) as "the Great Divergence" and – on the European side – by Jones (2003) as "the European Miracle". With respect to per capita income the West

exceeded the rest of the world in the 13th century and has kept its economic dominance since then (see Figure 1.1).

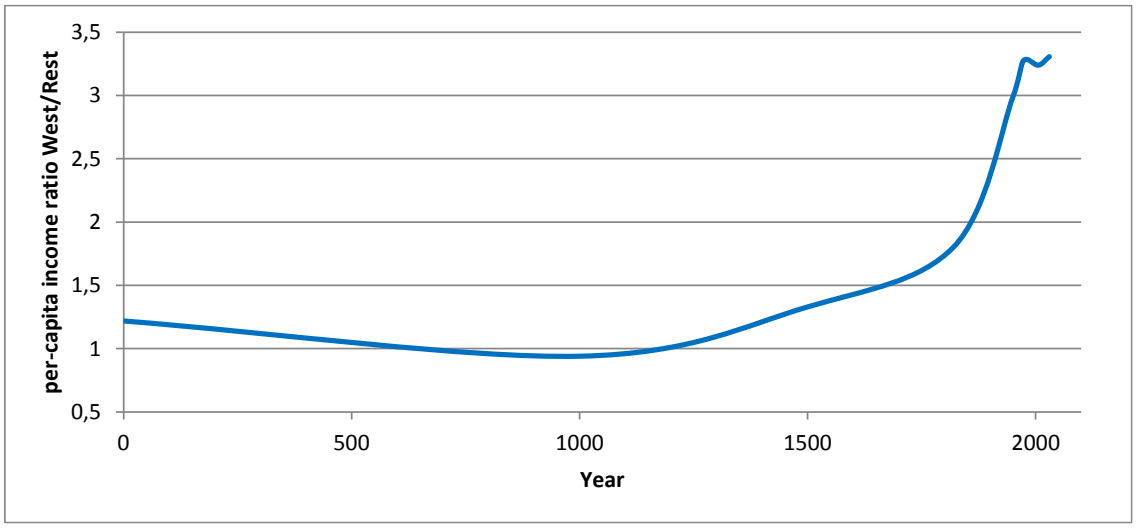


Figure 1.1: The West and the Rest: A long-term perspective

Source: Blum (2017b), Maddison (2010).

The British scientist and historian Needham (1969) raised a famous question half a century ago: why had China been overtaken by the West in science and technology, despite its earlier successes? This puzzle is one of the most intriguing issues for researchers of Chinese economic history. Lin (1995) argues that because in premodern times, most technological inventions stemmed from the experiences of people, they would be more likely to occur in a large society with large population like China, while in modern times, technological progress mainly results from mathematized hypotheses and experiment, which has become an important trend in Europe since the scientific revolution of the 17th century. In contrast, the institutional arrangements in pre-modern periods of China, like civil service examinations and the criteria of promotion, distracted the attention of people away from human capital investment to scientific research. In the book *Civilization: The West and the Rest*, Ferguson (2012) explains the success of European civilization ("the West") with six factors largely missing elsewhere in the world ("the Rest"): competition, science, the rule of law, medicine, consumerism and the work ethic.

Acemoglu and Robinson (2012) trace the divergence of growth to institutional elements in their book *Why Nations Fail: The Origins of Power, Prosperity, and Poverty*. Inclusive institutions would favor nations and benefit the economic prosperity, while extractive institutions in which individuals exploit the society and the rest of the population, would lead countries to poverty

and backwardness. The book *The Wealth and Poverty of Nations* of Landes (1999) indicates the following reasons why the west experienced a rapid growth while the rest stagnated: the culture thesis, namely Protestant work ethic of Weber (1905); the geographic condition; political competition and economic freedom; and innovation pressure that promotes the technological development. Blum and Dudley (1999) argue that economic divergence is inspired by Schumpeter's concept of the destructive impact of innovations on existing technologies.

In fact, the Chinese have never stopped searching for ways to revive their country using knowledge and science. In the "New Culture Movement" of the 1910s, a group of Chinese scholars appealed to create a new Chinese culture based on global and Western standards, especially in science, known in metaphorical terms as "Mr. Science" in China at that time. But the wars and unrest of the 20th century delayed any modernization that could take place through S&T until the reform and opening up policy in the 1970s. At the beginning of the reform, the Chinese leader Deng Xiaoping implemented the recovery of "Gaokao" (national higher education entrance examination), which was officially canceled during the Cultural Revolution. With the implementation of this examination, the higher education system – the most important channel in cultivating human capital – was recovered. Since then, the system of S&T began to be transformed to encompass a market-oriented structure. Innovation and knowledge have been considered important elements of economic growth in China.

China's rapid economic growth in the last decades has been driven by two sets of factors: 1) marketization reform, which has built up a market-oriented system in China to reduce administrative commands to strengthen property rights and to introduce competition in the market (Xu, 2011); and 2) economic fundamentals, above all comparative advantages (Lin, Cai, & Li, 2003), including a favorable demographic structure, low labor cost and participation in the global labor division (Wei, Xie, & Zhang, 2017). In contrast to eastern European countries, China's initial reform began with experimental changes and a gradual transition aimed at improving economic performance rather than directly building up a Western market economy. One of the advantages of gradualism was that policymakers could learn from the experience gained from previous experiments and thereby reduce the cost of the decision (Knight, 2014). This "Trial and Error" strategy has avoided the risk and side effects of the Shock Therapy, but some features and elements of the pre-transition system have survived to this day. Rather than a "big bang", China's reform path could be more aptly described as "growing out of the plan" (Naughton, 1994).

China's economic system under Mao Zedong was transferred from the model of the Soviet Union, which was characterized by the absolute dominance of the government controlling the power of resource allocation. Although the centrally planned economy has reached a quick growth rate at the beginning of the post-war era, its disadvantages, such as misallocation of resources and low efficiency, appeared gradually and led the country to a long period of economic turbulence and downturn. A good example is the campaign "Great Leap Forward" from 1958 to 1962, which aimed to rapidly transform China from an agrarian economy into an industrial country through radical approaches, but finally failed with famine and economic depression. Since economic reforms began in the late 1970s, China sought to partly liberalize the market and decentralize its trade system to integrate itself into the international trading system. Figure 1.2 illustrates the growth rate of China and its reform policy since 1961. It is notable that most reform measures have triggered considerable growth impulses successfully when the economy had fallen into recession. Through economic policy the Chinese government has reduced negative influences of economic fluctuations and overcome growth weakness in the last decades.

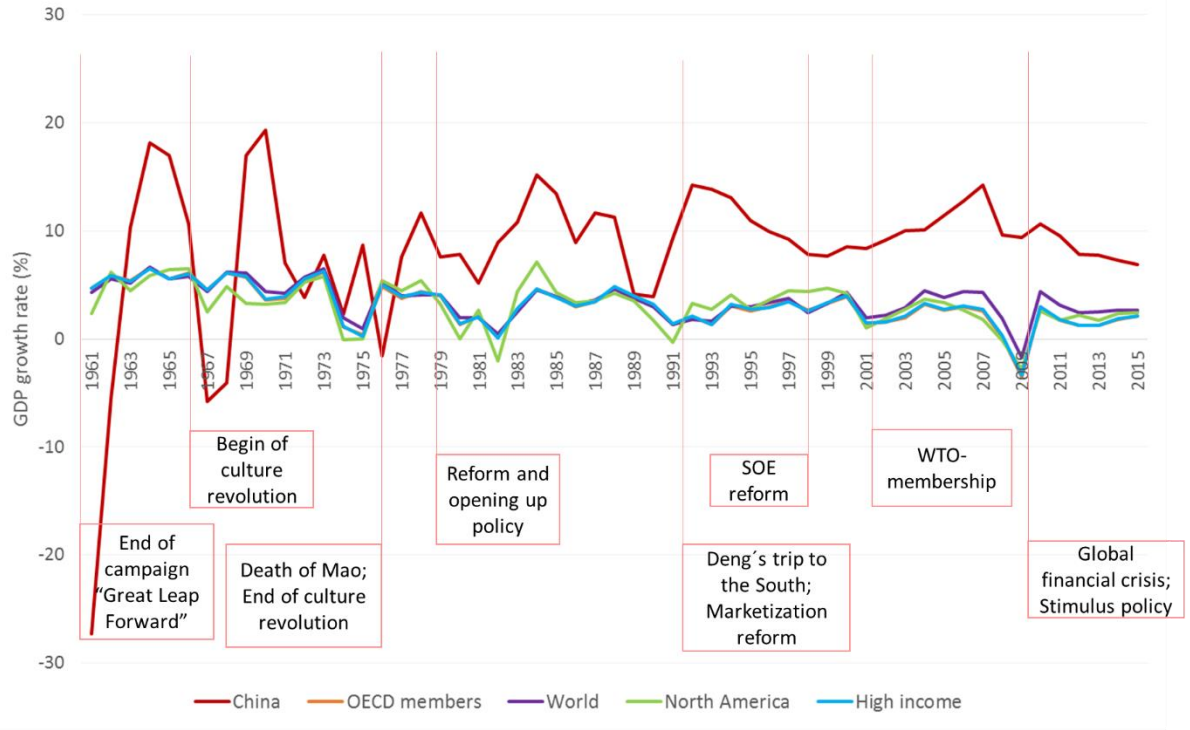


Figure 1.2: China's growth rates vs. the Rest and its economic policy assessment

Source: Blum (2017b), World Bank

One “secret” behind China’s successful transition is restructuring an incentive mechanism, which encourages local officials to concentrate on economic development by increasing the level of competition between local governments. Setting incentives for local bureaucrats to encourage growth is unusual, but has proven itself to be a powerful tool, stimulating growth and indirectly promoting investment and development projects (Naughton, 2017). Xu (2011) argues that China’s institution is a *regionally decentralized authoritarian system*, which indicates that political control is centralized, while economic management is decentralized to local governments. Knight (2014) considers China as a “developmental” country, because the government gives high policy priority to economic growth and this target is built into the system at all levels. In the last almost 40 years, China’s transformation from the centrally planned system to a market-oriented economy has achieved a great success: Since the beginning of the reform and opening up policy in 1978, China’s GDP has increased by over 9% per year. By redefining the role of government and restructuring state enterprises, developing private enterprises and promoting market competition, China has implemented structural reforms to strengthen the foundations for a market-based economy (World Bank, 2013).

However, it should not be ignored that despite the rapid GDP growth there exists still a development gap with high income countries in terms of per capita GDP (see Figure 1.3). In fact, China has not caught up the world average level until today.

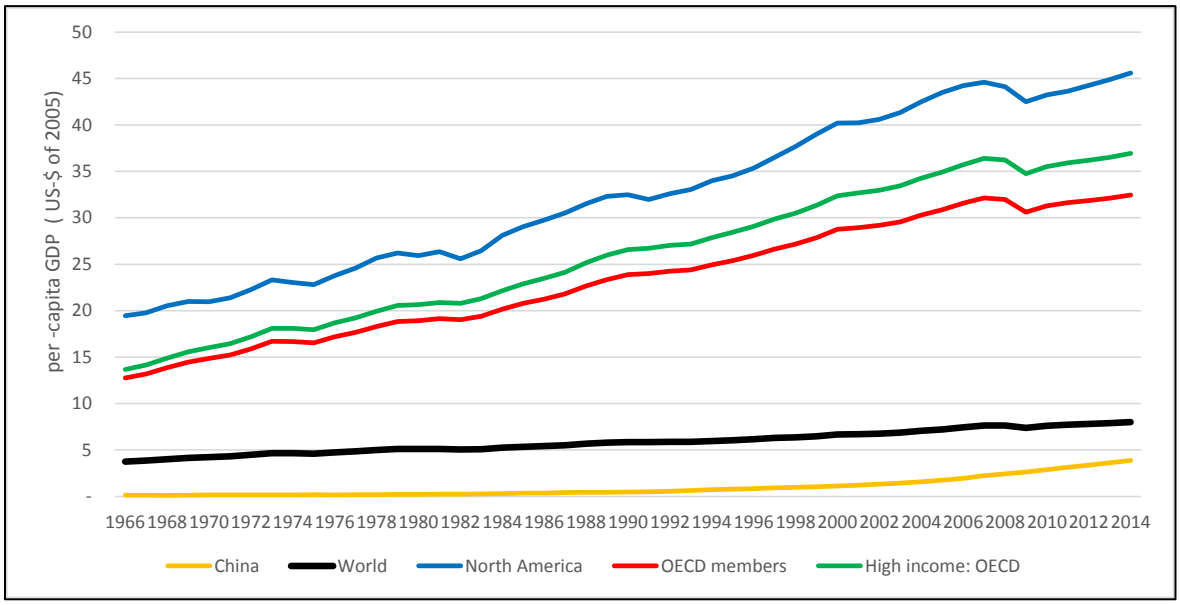


Figure 1.3: The West and the Rest: Since the reforms

Source: Blum (2017b), World Development Indicators

Moreover, China's development has reached a crossroad since 2010. The GDP growth rate of China has decelerated since the financial crisis (see Figure 1.4). Part of the reason for the slowdown could be cyclical, namely, a weak world economy. But a major part of the reason comes from structural und fundamental shortcomings (Wei et al., 2017). China's economic surge has benefited from catching up in industry and services with the help of absorbing sophiscated technologies and attracting foreign investment from developed countries or regions, and from low human cost and a favorable demographic structure, which has almost been exhausted.

Firstly, the working age population in China – defined as people between the ages of 15 and 64 – has been shrinking since 2012 (see Figure 1.5) and is predicted to fall by more than 10% by 2040, equivalent to 90 million workers, as estimated by the World Bank[1].

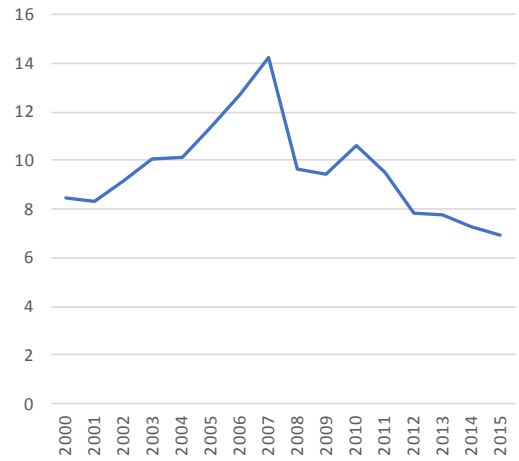


Figure 1.4: GDP growth of China (%)
Source: World Bank

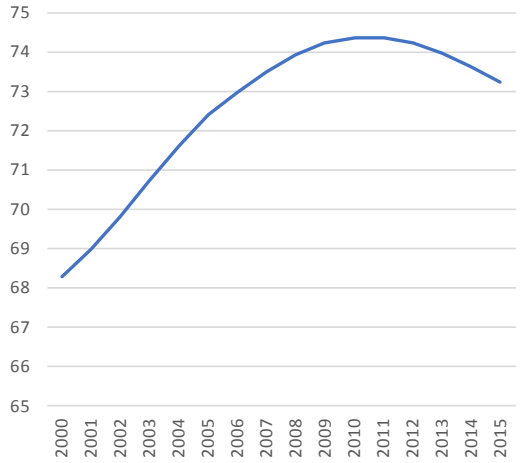


Figure 1.5: Working age (15-64) pupulation (% of total)

Secondly, wages in China have increased rapidly since the financial crisis. Now Chinese wages are higher than the majority of non-OECD economies and are almost three times as high as in India (Wei et al., 2017). Many industries that had contributed to China's growth but demand a large amount of cheap labor have been transferred to more low-cost countries. Akamatsu (1962) calls this industrial transfer in East Asia the "flying geese paradigm," which indicates that leading countries transfer their overcapacities to underdeveloped economies successively, like the pattern of flying geese. Stan Shih, the founder of Acer Inc., framed the concept "smilling curve" around 1992, which describes how value-added varies across the different stages of

[1] https://www.ft.com/content/d6681cba-9e3c-11e5-b45d-4812f209f861

bringing a product to the market in a manufacturing industry, with high value-added in the initial R&D, low value-added in the middle-part of assembly, and then high value-added in the final part marketing and distribution (Bartlett & Ghoshal, 2000; Hung & Whittington, 2011; Shin, Kraemer, & Dedrick, 2012). Many Chinese firms still stay in the middle of value chains, resulting in that they obtain low value-added and profits from international division of labor. Therefore, it is necessary to accelerate shift from assembly to global marketing and R&D to develop innovative technologies.

Thirdly, some segments and sectors of Chinese industry are approaching the technology frontier, indicating that the contribution of capital and cheap labor as growth drivers will decline (World Bank, 2013). The "learning from abroad" strategy of firms now seems to be unworkable. An important reason lies in the growing worry of technologically advanced countries about the transfer of China's role from business partner to competitor in world markets.

Last but not least, the side effects of China's unsustainable development have emerged gradually: from latent dangers for the economy, including rapidly increasing local-government public debt and overcapacity in some basic industries such as cement and steel, to various forms of environmental pollution such as air, soil and water, which has caused and is causing widespread health problems. Therefore, the past "growth miracle" phase is now ending (Naughton, 2017).

Economic growth is no longer to be China's most important objective and the government has begun to introduce new instruments to achieve other goals, such as social outcomes. As for the development pattern, China has planned its development model on the basis of an innovation-driven path with own its technologies. According to the Outline of China's National Innovation-Driven Development Strategy of State Council in 2016, the Chinese government is aiming for the country to become an innovative nation by 2020, an international leader in innovation by 2030 and a world powerhouse of innovation by 2050[2]. In fact, the performance of China in innovation is rising rapidly. In recent years, China's spending on research and development (R&D) and education has shown a steep upward trend and, consequently, the innovative capacity has already become a crucial factor in national competitiveness.

Innovation is identified by Schumpeter (1942) as the critical dimension of economic change. He introduced the term "creative destruction" to describe innovative entry by entrepreneurs and the disruptive process of transformation that accompanies such innovation. Romer (1989) endogenizes the accumulation of knowledge into economic growth and argues that the

[2] Outline of China's national innovation-driven development strategy of State Council (http://news.xinhuanet.com/politics/2016-05/19/c_1118898033.htm)

technological change and accumulation of human capital make great contributions to economic growth. Aghion and Howitt (1992) construct a model of growth through creative destruction and find that individual innovations are sufficiently important to affect the entire economy.

In the book *The national system of political economy*, List (1841) analyzed the problem which could be transmitted as "the national system of technology strategy" from a modern perspective (Blum, 2017a): For a technological catch-up strategy (in the context of List: Germany's strategy to catch up England in the 19th century) the following elements are necessary: 1) human capital, especially a different qualification structure and training systems, 2) import best available technologies, 3) the integration of human capital and invested capital, 4) manufacturing industry, 5) orders and institutional frameworks, in order to guarantee constant national economic policy and reduce transaction costs, and 6) protective tariffs with the aim of protecting domestic industries.

If we return to the rapid catch-up path of China over the last decades, we can find that China has fulfilled almost all the requirements indicated by List: from human capital, training and import of foreign technologies to promotion of manufacturing sector. Compared to these factors, however, an efficient institutional framework seems to be a "weakness" of China's growth pattern. According to institutional economics, institutional arrangements will be relevant, as soon as transaction costs occur (Blum, 2017a). Transaction costs are always combined with establishment and operation of institutions (North, 1992), in the form of e.g. contract cost and organization cost. In turn, institutions aim to increase the efficiency of society and decrease transaction costs. Despite the improvement of market environment since the reforms in China, the establishment of an efficient and fair institutional mechanism and economic order to reduce transaction costs still has a long way to go.

As to innovation activities, an institutional mechanism can be seen as an innovation system. In the recent years, researchers have dedicated more attention to the innovation system in innovation research. According to the OECD report, innovation is the result of a complex interaction between various actors and institutions (OECD, 1999). Technical change does not occur in a perfectly linear sequence, but through feedback loops within this system. The innovation system includes a network of enterprises, universities, research institutes and also governments, where the flows of technology, information and knowledge between people are key to the innovative process. The framework of innovation systems emphasizes the importance of institutions. It is especially meaningful for China because, in recent decades, China has experienced a thorough institutional change in order to establish an efficient market-oriented

framework and reduce transaction costs, and this process is still on-going. Both innovation systems and institutional factors are influenced by this marketization transformation.

In innovation systems, a firm is viewed as a core innovation actor, because in a mature economy, firms invest the majority of R&D capital and implement most innovation activities. Since the concept of "innovation" denotes not only inventions, but also "new combinations" that are readily available to markets (Schumpeter, 1934), firms own more information about market circumstances, especially demand, than any other innovation participants (North, 1990). The activities of firms are not independent of economic system and institutional change. In fact, the institutional environment is viewed as a critical determinant that distinguishes a firm's performance in transition economies from that in mature market economies (Li & Xia, 2008). In the context of China's transformation, the institutional transition measures – including decentralization of control, ownership restructuring and industrial policy – impact a firm's performance by shaping managerial incentives and affecting transaction agency costs (Park, Li, & David, 2006).

The change in the market and industrial structure is one of the factors of transition influencing a firm's performance. On the one hand, the marketization reform is one of the key measures of the institutional change from planned to market-oriented economy. According to the marketization index of the National Economic Research Institute, the market reform process has been promoted step by step since the end of the 20th century (Fan, Wang, & Zhu, 2011), enabling State-owned Enterprises (SOE) to operate as market-oriented firms and to reduce state interference in the market by changing the legal and business environment in which firms operate (van der Hoeven & Sziraczki, 1997). The new market structure, which allows for both competition and monopolies, along with the remaining state intervention, influence and shape innovation activities of firms. Though the relationship between market structure and innovation is considered an important topic both in the field of industrial organization and innovation economics, the results still remain controversial under different conditions with different datasets (Acs & Audretsch, 1987; Castellacci, 2011; Scherer, 1965). It makes it reasonable to investigate the situation in China with data of Chinese firms instead utilizing the existing assumptions and experiences in other countries. On the other hand, against the backdrop of industrial transfer in East Asia since the 1960s and the accession to the WTO in 2001, the industrial structure has been changed and updated from low-tech and labor-intensive to medium- and high-tech, while also encompassing knowledge-intensive industries. Innovation has gained more importance in technologically advanced sectors than in traditional industries,

from R&D input and innovation behavior to innovation output. For that reason, it tends to be necessary to distinguish between the innovation performance of firms in distinct industries.

Besides competition in the market, the ownership of firms is also an essential determinant that impacts on the ability of firms to allocate efficiently (Vining & Boardman, 1992), including economic performance like innovation. In fact, market structure and ownership are two factors that are interconnected. One reason why SOEs have performed below private counterparts is that SOEs are shielded from competitive pressures by the state (Budiman, Lin, & Singham, 2009). The key driver of SOE reform in China is believed to be the introduction of competition across China's economy, both from new forms of domestic ownership, like private enterprises, and the expanding access to modern business models and technology methods from abroad (Jefferson, 2016).

Coase (1937) argued that every company will expand as long as the company's activities can be performed cheaper within the company (internal transaction costs), than by outsourcing the activities to external providers in the market (external transaction costs). Due to information asymmetries and high costs of hierarchical coordination, transaction costs of SOEs are generally higher than those of private firms. Nevertheless, in countries where market failure is severe, SOEs may be a viable mode of organization because private firms do not exist or may not have sufficient capacities to promote economic development (Rajan, 2011). For that reason, SOEs often arise in underdeveloped economies, such as China in the 1950s – 1970s, and could reduce transaction costs if economies are infested with severe market failure (Peng, Bruton, Stan, & Huang, 2016).

However, with economic growth and the introduction of market institutions, the imperfections of state ownership would become an obstacle to improving economic performances of firms. The role and reform of SOEs have attracted the interest of researchers since the 1980s. In the period of a centrally planned economy, state ownership dominates almost all aspects of market and is associated with the life and work of people. However, the institutional problems of SOEs, such as unclearly defined property rights and high information asymmetry and transaction costs, have impeded the efficiency optimization of firms and then become an obstacle to the development of the whole economy. SOEs are considered to consume a much larger proportion of capital, materials and intermediate inputs to produce similar or even less output than the private sector (World Bank, 2013). Since the reforms, in particular during the 1990s, an effort to restructure the SOEs has been carried out aiming to increase their economic performance, which includes converting vaguely defined state ownership to more explicit, legally defined

ownership categories (Naughton, 2007). China's rapid economic growth since 2003 has benefited from SOE restructuring and the development of private sectors (World Bank, 2013). The weak performance of SOEs has been criticized by several researchers and many previous studies have argued that private firms perform better than SOEs in China (Bai, Lu, & Tao, 2006; Jefferson & Su, 2006), although SOEs have received more subsidies and political support from the government (Wei et al., 2017). There are at least two reasons for SOEs performing less efficiently: the first is internal institutional demerits, including unclearly defined property rights and the principal-agent problem (Shirley, 1999). The second stems from the assumption that managers of SOEs lack the clarifying objectives of their private counterparts, for instance profit maximization. In many countries, SOEs are responsible for delivering public services such as energy and infrastructure, which means they are constrained to offering regulated prices. The motives of SOEs are usually associated with political targets like maintaining social stability and fulfilling social outcomes. In turn, SOEs obtain more subsidies and political support from governments, enjoy preferential access to production resources like state-owned funding sources and, in turn, benefit from their privileges in competing with their private and foreign rivals.

As one of the frequently used measurements of firm performance (OECD, 2016), innovation performance is viewed as a commonly discussed difference between SOEs and private enterprises. Blum and Dudley (1998) trace the distortion of economic choices in East Germany back to state control of investment, which led to a serious under-capitalization of the industrial sector and the absence of incentives of workers and managers.

Using the dataset of China's large- and medium-size enterprises, it was found that SOEs with the highest concentrations of state assets perform at the low end with regard to innovation performance (Jefferson, Hu, Guan, & Yu, 2003). In some previous studies, however, it was also not uncommon finding that the SOE reform of China – the so-called corporatization without privatization – was an effective way of improving the performance of SOEs (Aivazian, Ge, & Qiu, 2005). Scholars argue that the poor performance of SOEs is less a result of political responsibilities, such as high social welfare burdens, but of weak market incentives and government interference in enterprises (Park et al., 2006). If SOEs were given priority to maximizing profit as private enterprises do, they might achieve an economic performance similar to their private counterparts (Bozec, Breton, & Cote, 2002). It is argued that the privatization model of Western countries might not be implemented in China and the Chinese government would not withdraw from corporation governance of SOEs completely. The SOE reform focuses more on incremental instead of cumulative parts, which means the government

reduces its interference in market, but at the same time maintains its partial ownership. Privately owned capital is encouraged to invest in state owned industries and firms, and meanwhile share profits (Blum & Zhao, 2015).

In summary, this work will analyze the innovation performance of China at: 1) provincial level – innovation systems; 2) industrial level – market structure; and 3) firm level – state ownership (see Figure 1.6). The core question that will be answered in this thesis is formulated as follows: *Which factors of innovation systems, market structure and state ownership influence the innovation performance of China against the backdrop of institutional transition?*

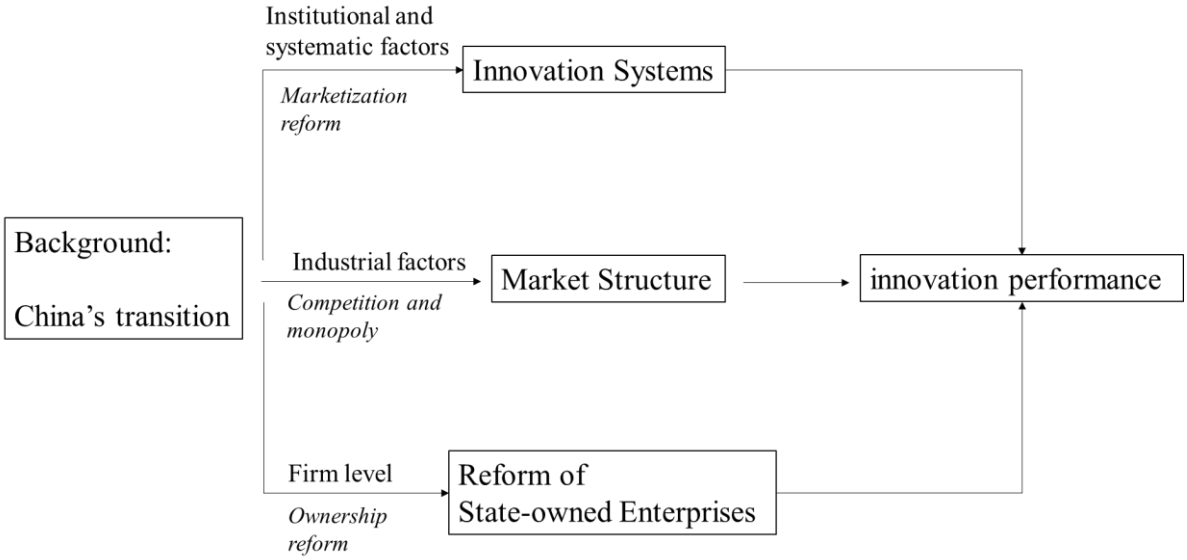


Figure 1.6: Analytical framework of the thesis

In addition to the development gap, there is also an "innovation gap" between different regions of China. The innovation performance of provinces and firms as well as political and institutional framework conditions vary from region to region. On the one hand, concerning the area and population, most provinces are as large as a European country. On the other hand, local governments are no longer controlled by the central government in all fields. Since the reform policy in 1978, the central government has provided substantial leeway and relative autonomy in the sense of economic policy to local governments, who can decide on the majority of concrete economic measures for themselves. Moreover, China is experiencing an industrial structure transformation from labor-intensive to capital-intensive and technologically advanced industry. Leading regions transfer their low-tech sectors to backward regions and develop knowledge-dependent industries, while in catching-up provinces in the middle and west,

innovation activities are dominated by mature industrial sectors, which not only leads to a disparity between technologies, but also to different industrial structures in different regions. For these reasons, it is appropriate to investigate the innovation performance of both provinces and firms on the basis of various criteria and thus, in this work, more categories – including disparity between regions and technology characteristics – will be taken into consideration.

1.2 Chapter summaries

The remainder of this work is organized as follows: Chapter 2 provides the background of this thesis; the literature review is presented in Chapter 3; Chapter 4 analyzes the effects of innovation systems on innovation performance in Chinese provinces; Chapter 5 investigates the influences of market structure on innovation output of China's industrial enterprises; Chapter 6 explores the effects of state ownership on innovation performance of China's listed firms; and in Chapter 7 the conclusion is presented.

Background:

Chapter 2 introduces the background of this dissertation, namely, China's transition since the reform in 1978. The reform and opening policy is the most important background feature not only for the innovation performance, but also for the whole economy of China. Although the economic measurement is called "reform and opening policy" and seen as an entire policy, it has actually been implemented in order: The "opening" began at the first step, subsequently motivating in turn the reform measures (Shi, 2009). Under competition pressure from their colleagues of other provinces, officials of local governments, in particular, provincial governments, had to "compete" with each other in order to obtain more possibilities to get access to promotion. The governmental competition characterizes the reform and is considered an important factor in causing the economic surge in China.

Using the theories of governmental and institutional competition on the basis of evolutional economics, this Chapter firstly analyzes the competition of local governments during the institutional change in China of recent decades. The economic and institutional transition has changed the economic behavior of almost all economic actors and environments, with these being divided into three levels. In the second subsection of this chapter, we will introduce these three parts: The first is the innovation system, which indicates institutional and systematic changes at regional level. China's innovation systems or, at that time, scientific systems, were established according to the so-called Soviet Union Model. The state intervened in almost all

science activities and played a key role in R&D and innovation, while there were few private innovators, including enterprises and research institutes, participating in innovation activities.

The establishment of Chinese modern innovation systems started with a range of policies at the central government level in mid-1980s. The reforms focus not only on basis research as prior to the reform, but also on the combination of basis scientific activities and industrial applications, along with the commercialization of S&T. On the other hand, the government rewards individuals for participating in scientific activities. In 2006, the National Medium- and Long-term Program for Science and Technology 2006-2020 was released by the central government, aiming to establish an innovation-oriented country by achieving "indigenous innovation".

We find that innovation systems are changed in step with the transition process of China. As the basis of innovation activities, innovation systems provide a framework for innovation actors and influence the innovation behavior deeply. Nonetheless, if we observe the "downstream" of the system, we find that the market structure and industry is also shaped and changed by the Chinese transition. Thus in the second subsection, we will present the transformation of market and industrial structures at sectoral level.

The impacts of the reform process on the market could be analyzed from two perspectives. The first is the change in the industrial structure as influenced by the opening policy, in particular, the industrial transfer that has taken place in East Asia since the 1960s. The economically advanced countries, starting with Japan, transfer their lagging industries to underdeveloped economies, which then – years later – move their overcapacities to other regions through investment. The relatively underdeveloped countries attract foreign capital with the help of their comparative advantages (Lin, 2012), for instance, the low cost of labor and resources. This industrial transfer model is named the Flying Geese Paradigm (Akamatsu, 1962). China has taken advantage of this development trend and, in the 1980s, began to absorb the investment from the four so-called "Asian Tigers", South Korea, Taiwan, Singapore and Hong Kong, helping China participate in the international division of labor.

The other aspect of the influence on the market is the marketization process, which is combined closely with domestic reform policy. The market structure was controlled by state power in almost every area during the period of the centrally planned economy. Since the reform, the market has become more open and private entities have, step by step, created a healthier and more efficient relationship between the government and the market, which has built up a new framework for various firms with different ownership types. Moreover, China's accession to the WTO in 2001 motivated the domestic reform from international circumstances, since a

member of the WTO must accept the principles of market economics and a range of preconditions to establish a fair competition environment.

The third level that China's transition influenced is the state ownership of SOEs. SOEs played a key role in pre-transition countries and were considered the pillar and core of the whole economy of China. However, the low efficiency of SOEs, unclearly defined property rights and favored political supports from governments are severely criticized by scholars (Jefferson & Su, 2006; Qian, 1996; Zheng, Liu, & Bigsten, 2003). Since the 1990s, the government has taken measures for reform or, in other words, has restructured SOEs, in order to increase their performance and establish new and modern corporate governance SOEs models with state participation, such as decreasing state shares, while also founding a new authority – the State-owned Assets Supervision and Administration Commission – to manage and supervise the remaining SOEs.

Literature review:

The theory of innovation economics can be traced to Schumpeter, who defined innovation as new combinations of new or existing knowledge, resources and equipment, including new products, new means of production, opening a new market, acquisition of a new source and carrying out new forms of organization. With the core term of his innovation theory, Schumpeter used "creative destruction" to describe the process of industrial mutation that revolutionizes the economic structure from within, not only destroying the old structure but also creating a new one, and to interpret the economic growth and change (Schumpeter, 1942).

In fact, innovation or other similar concepts like technological progress or knowledge have been used to enrich growth theories frequently since the 1950s. Solow (1957), Arrow (1962) and Romer (1989) have proven the importance of technology for growth in their respective theories. Although it is a widely-held belief that innovation or technology has an influence on economic growth, the question of what its influence is and the extent of such influence still remains controversial.

Innovation process models have experienced five rounds of evolution: the "technology push model" of the 1950s and mid-1960 (Carter & Williams, 1957), the "demand pull model" of the 1960s and 1970s (Myers & Marquis, 1969), the coupling model until early 1980s (Mowery & Rosenberg, 1979), the Integrated Model in the 1980s and 1990s (Rothwell & Zegveld, 1985) and the Networking Model since the 1990s (Rothwell, 1992). To this day, innovation is considered a consequence of national systems in terms of network concepts (Freeman, 1989; Lundvall, 1985; Nelson, 1993), and contains various innovation actors, including firms,

research institutes, universities and government, as well as their interactions and diffusion of knowledge. In addition, due to distinctions and the complexity of regional characteristics, it is argued that innovation systems should be investigated from a regional perspective (Asheim & Isaksen, 2002; Cooke, Uranga, & Etxebarria, 1997).

With respect to innovation and market structures, the most influential assumption is traced to Schumpeter (Schumpeter, 1942), who argued that a monopolist in the market performs with greater innovation than a firm with lower market concentration, because the monopolist possesses more resources to participate in R&D activities. Nonetheless, Schumpeter's idea that a monopoly increases innovation leads to a large-scaled discussion in this area. Arrow (1962) believes that a firm that dominates the market with high profits prefers to protect its status quo rather than taking risks to innovate, while Demsetz (1969) argues that Arrow's idea is not convincing in real-life situations because of incomplete information.

In empirical research, scholars have also obtained a variety of results, as in the theoretical field: A few researchers argue that there is no relationship between market structure and innovation (Scherer, 1965). In line with Schumpeter's assumption, some find that large firms with a higher market share tend to have an advantage in innovation activities (Acs & Audretsch, 1987; Kraft, 1989). In contrast, Blundell, Griffith, and van Reenen (1999), Geroski (1990) and Nickell (1996) believe that it is competition rather than a monopoly that promotes the innovation performance of firms. Despite this, more and more recent research has found that the relationship between market structures and innovation is not simply linear. Using the data of UK companies from the 1960s to 1990s, Aghion, Bloom, Blundell, Griffith, and Howitt (2005) argue that the relationship between product market competition and innovation is an inverted U-shape.

From the abovementioned review, we can find that – unlike theories of innovation systems – the influences of a market monopoly or competition on innovation performance still remain controversial, both in theoretical and empirical terms. The results vary under different conditions in different regions with different datasets.

Although the framework and market structure are essential factors for innovation, it is firms that play a central role in innovation activities (Mortensen & Bloch, 2005). The transformation of China has changed the relationship between SOEs and private-owned enterprises. The influences of ownership on innovation performance have attracted the attention of researchers, especially those from transition countries like China. Most of the conclusions argue that SOEs exhibit lower efficiency in economic and innovation activities than other types of ownership (Jefferson et al., 2003; Jefferson, 2006), due to their unclearly defined property rights, agency

problem and lacking incentives for profitability (Demsetz, 1974; Megginson & Netter, 2001; Shleifer, 1998).

Innovation system and innovation performance:

The next three sections investigate determinants of innovation performance from the perspectives of regional, industrial and firm level, respectively. China has increased its investments in R&D in recent years. The number of full-time equivalent R&D personnel has risen from almost 0.67 million in 1998 to around 3.76 million in 2015. The expenditure has gone up from approximately 49 billion Yuan (6.8 billion euro) to 1.4 trillion Yuan (approximately 194 billion euro). On the other hand, the patent activities have also achieved great success: the number of invention patent applications rose from 13,726 to 968,251 between 1998 and 2015[3]. In this chapter, we present the influence of innovation systems on the regional innovation performance in China for the time period 1998 – 2008.

This section is based on the model of Furman, Porter, and Stern (2002) (FP&S Model), which stems from Romer's growth theory (1989), Porter's theory of national competitive strategy (1990) and Nelson's national innovation systems (1993). This model divides the determinants of innovation systems into three parts: innovation infrastructure, cluster and the linkage between these two elements. In addition, the traditional factors relevant to innovation, innovation input, such as R&D personal and expenditures, and knowledge accumulation, will be taken into consideration. As mentioned above, China's transition has changed and continues to change the whole economy deeply. Thus, based on FP&S Model, this section combines with the real-life situation of China's economy and introduces marketization reform to measure the impacts of institutional transformation. This model has been applied to the national level research of some OECD and Asian countries (Furman et al., 2002; Hu & Mathews, 2005, 2008), but we believe it is also appropriate for the exploration of the regional innovation systems of Chinese provinces because most Chinese provinces resemble an OECD country and Asia, not only because of the area and population, but the economic freedom transferred from the central government since the 1990s. Moreover, the large disparity of culture, history and habit among regions makes it necessary to investigate the innovation performance at a regional level.

We find that the innovation system contributes greatly to the increase of the innovation performance of Chinese provinces, including the openness of the region, while the expenditure on education from the government plays a key role. Indeed, a market-oriented institutional

[3] Data Source: National Bureau of Statistics of China

arrangement also raises the innovation output. However, it is surprising that the frequent engagement of banks in R&D financing cannot promote the level of innovation.

Market structure and innovation:

China's transition has changed the market structure, which influences the innovation performance of firms. The relationship between market structure and firm behavior is one of the most important fields of industrial organization. In the theoretical field, there are some controversial arguments about the relationship between market structure and firm performance. The Chicago School argues that the market structure is determined by firm performance. If a firm has high productivity and profitability, it will obtain a large market share and shape the market structure (Friedman, 1964). In contrast, using the Structure, Conduct and Performance Paradigm (SCP) as an analytical framework, the Harvard School believes that market structure influences firm performance through the channel of market conduct (Bain, 1968).

As to firm performance, the level of innovation – or, in other words, innovation performance – is considered an important indicator (Porter, 1981). At the same time, the relationship between market structure and innovation performance represents one traditional and essential research topic in the economics of innovation. There are two main assumptions in interpreting this relationship: the first one is *Schumpeter effect*, which indicates that competition has a negative effect on innovation; the second one is *escape-competition effect*, demonstrating that market competition increases the innovation of firms (Aghion et al., 2005; Castellacci, 2011).

This chapter combines the abovementioned two effects with the market competition level and explores the influence of market structures on innovation performance at firm-level. Besides focusing on the relationship between market structure and innovation, this part also takes factors of geographic disparity of regions and technological features of industries into account. We use a rich dataset of Chinese industrial enterprises between 2005 and 2007, containing over 200,000 firms.

We find that there is an inverted-U relationship between market concentration and innovation and that – more specifically – firms with a high market concentration could undertake more innovative activities in the market with a high competition level, while the effects would turn negative after a threshold is reached if the market is monopolized by a few firms. Furthermore, as to technology characteristics, it is notable that high market concentration is especially harmful for technologically advanced firms, while in low-tech industries the innovation performance of firms does not depend on market structure.

Innovation output and state ownership:

In many countries, SOEs are still the main provider of public services, though privatization is a frequently discussed topic by researchers. In post-transition countries like China, SOEs have played a critical role in the economy. Nevertheless, the institutional transformation has not only influenced the macro environment and market structure, but also the ownership structure of SOEs, in order to increase their economic performance. On the other hand, improving SOE performance is crucial for social stability and sustained growth in China.

Most previous studies argue that the economic performance of SOEs is lower than that of private companies (Shirley, 1999), which is traced to state interference in cooperate governance, resulting in market failure as well as the property rights (Alchian & Demsetz, 1972) and principle-agent problem (Laffont & Tirole, 1985). Many empirical researchers have also proven that private firms perform better than SOEs (Goldeng, Grünfeld, & Benito, 2008; Li & Xia, 2008).

Although scholars have also criticized the management problem and low efficiency of Chinese SOEs, it is surprising that they have brought some innovative achievements in strategic industries like in nuclear energy and the defense sector. The cognitive discrepancy between common academic research and Chinese reality makes it necessary to explore the performance of SOEs in more detail.

Since previous research, for the most part, does not take the specific issues of SOEs into consideration (Bozec et al., 2002), this study focuses on the relationship between innovative activities and state ownership in listed firms in China, controlling the provincial and sectoral differences. We find that, in general terms, the state ownership inhibits innovation performance of firms. However, after running separate models for different time periods, it is remarkable that SOEs generated more innovation output than other firms after the financial crisis. In addition, we find that the impact of state ownership on innovation performance depends on a number of conditions. More precisely, state control of firms has a negative impact on innovation output, in particular, in China's Northeast region and in some high-tech industries.

In the last part, *Conclusions*, we summarize all the important findings of the previous sections and outline the political implications.

2. Background

2.1 China's transition: governmental competition

2.1.1 The emergence of governmental competition

The transformation of China from a planned to a market economy is an institutional change.[4] Since 1978, China's reform has often been explained from two institutional perspectives: one is governmental reform, which suggests that the reform was implemented through institutional supply by the government. The other states that it is spontaneous institutional innovation that led to the change (Zhou, 2000). However, neither perspective truly reflects China's transformation, as the first only focuses on the role of the government, while the latter ignores the political mechanisms of the transformation.

A third direction of research that seeks to explain the transformation is governmental competition. Similar to countries in Europe and America, competition between local governments also exists in China. This is seen as an important cause of China's economic development (Zhou, 2003). Governmental competition is, to a large extent, institutional competition, especially in transformational countries like China, where the government participates in supplying and innovating institutions. The country's transformation is a process of institutional change that is regarded as a result of interaction between the internal rules of individuals and external rules of the organization (Zhou, 2000). Governmental competition can, therefore, also be seen as the discovery (Hayek, 1968) of knowledge, information and institutions.

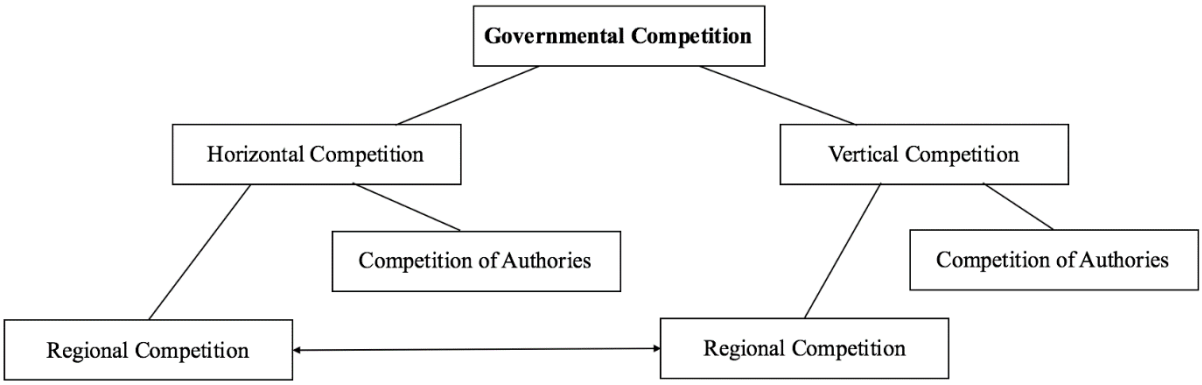
"Governmental competition" is a variation of the term "competitive governments" (Breton, 1998). In federal states, competition exists within and between local governments. Due to pressure from non-governmental actors, governments must, for instance, provide relevant products and services that are not supplied by the market to fulfill the needs of local citizens and organizations. Competition for votes and resources develops between the governments and the different authorities within the government (Breton, 1998) in order for these institutions to increase their own levels of activity. This competition mainly addresses institutional supply, such as infrastructure, technological platform, services, and tax reductions.

[4] The findings of this chapter has been published as: Kou, Kou: *"Regierungswettbewerb in China seit der Reform 1978" ("Governmental competition in China since the reform 1978"),* in: Blum, Ulrich (eds.), Economic Governance und Ordonomik, REPROCENTER GmbH, Halle, 2015. For the purpose of this thesis, this chapter has been slightly modified.

This paradigm involves two types of competition: horizontal and vertical. On the one hand, each government (authority) is in competition with its superordinate government (authority) for resources and power. On the other hand, the government also competes with other bodies at the same level.

Feng (2002) argues that governmental competition incorporates competition between governments with regards to material and immaterial resources and contains direct and indirect as well as horizontal and vertical competition. According to him, the "economic miracle" of China can be traced back to "spontaneous order" (Hayek, 1968). The initiative of civil society and market subjects led to the creation of this spontaneous order. The government recognized the results of this initiative and implemented corresponding measures throughout China. The order must fulfill two potential requirements: compatibility with personal freedom and the division of labor in relation to knowledge (Feng, 2002).

Using Breton's theory, Herrmann-Pillath (1999) establishes a new research framework with the help of evolutionary economics (see Figure 2.1). According to his theory, the government does not supply the institutional environment, the preferences of market subjects or information. Especially during the transformation, no clear institutional framework is available, and no decision-maker possesses complete information. Everyone must search for a substitutive institutional framework. This is why evolutionary economics places much value on the spreading of power and decision-making of local governments. The division of power in a federal system increases the level of competition between local governments. Vertical and horizontal competition are connected to one another, and the result of one form of competition can influence the other. For example, a local government would benefit from obtaining more resources or political support from the central government than its competitors.



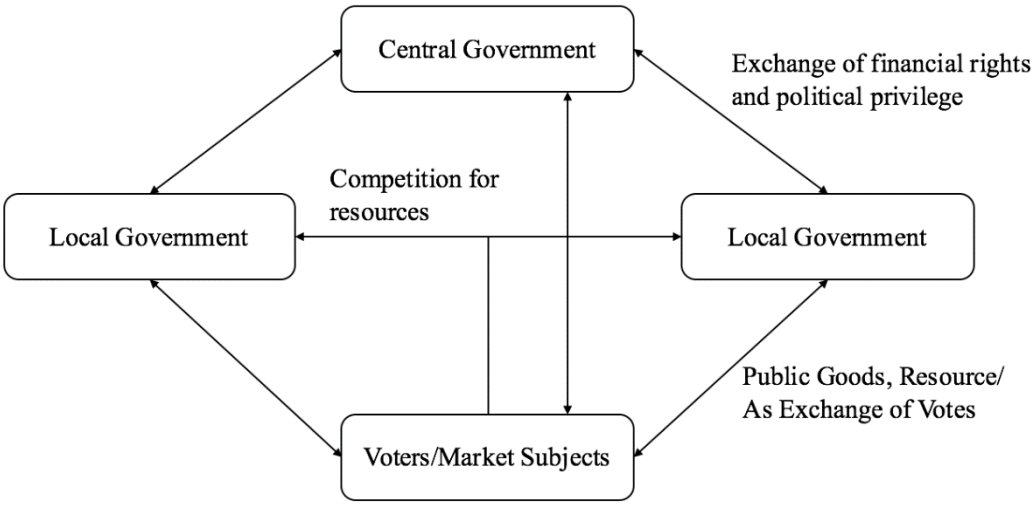


Figure 2.1: Analytical framework of governmental competition

Source: Herrmann-Pillath (1999)

Both types of competition target the resources required for economic development as well as social stability and harmony. Most of the pressure and incentives come from voters and market subjects. This section mainly focuses on governmental competition and does not consider competition between authorities.

One main type of governmental competition is institutional competition (Feng, 2002). Institutional competition emphasizes the importance of the system of internal and external rules for the level of cost and the competitiveness of a region. There exists a passive and an active institutional adjustment.

In this section, governmental competition is delineated at the level of institutional competition, because 1) China's transformation is, in general, an institutional change; 2) the governmental competition in this section is a horizontal competition between local governments, which could, in fact, be viewed as external rules; and 3) this section focuses on how local governments react to spontaneous changes in society, namely the internal rules and results that have been brought about as a consequence of decisions. The government that builds the order plays an important role as the institution supplier. In this chapter we observe the institutional competition of local governments.

Hayek's theory of social order helps us to understand the reform process from the perspective of institutional change. Hayek (1973) differentiated between two types of orders: one is spontaneous order ("kosmos"), in which the individuals follow their goals by their own means. This requires abstract rules and is described as an internal rule. The other is organization

("taxis"), which means the result of a conscious design. Concrete rules with a vertical hierarchy (Hayek, 1973) are described as external rules. Both types of rules exist in all forms of society. There are interactive relationships between individuals and internal rules, between individuals and organizations and between internal and external rules. Hayek regarded these complex connections as the driving force of social evolution. Due to the heterogeneity of individuals and the uneven distribution of knowledge, distinct possibilities exist to look for corresponding rules. The groups that introduce abstract rules are more successful (productive) than others. Other groups either accept the successful rules or are excluded (Hayek, 1973). However, the spontaneous order cannot resolve the uncertainty of institutions completely, which could be corrected by organizations. The institution supplier offers an optimum institutional arrangement for maximizing welfare.

2.1.2 Institutional governmental competition

According to the theory above, the local government is under pressure from the higher-level government, from citizens and from other local governments, which is vertical competition. In China, competition has different properties.

Figure 2.2 illustrates the structure of Chinese government institutions. As a result of the Cultural Revolution, China fell into poverty and chaos. The centrally planned economic system could not be applied as the economic guideline any more. Yet, unlike most Eastern European countries, China did not adopt shock therapy, but used an experimental approach instead. An important reason for this is that the central government had neither a clear development plan nor experience in transforming a nation. In addition, society had already started to change before the official reform policy came into force. The central government divided its power and ordered local governments to transfer more freedom to regions. The local governments obtained relative autonomy with regards to economic policies and the organization and management of civil society. Citizens now express their opinions to local governments, which, in turn, issue reports to the central government. After evaluating the "outcome" of local governments, the central government selects and appoints provincial officials.

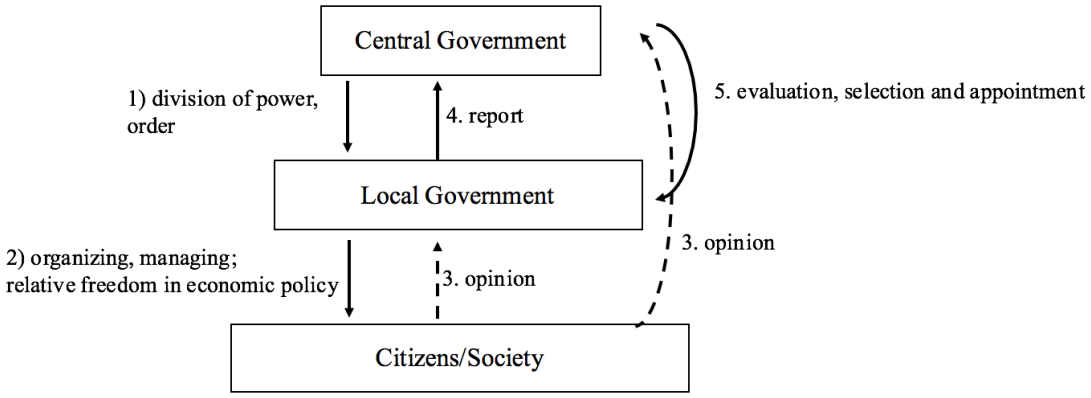


Figure 2.2: Structure of government institution in China
Source: Own Illustration

Because leaders of the local governments must be appointed by superordinates, the selection criteria have become a critical factor for the bureaucratic system. The term of office for local officials is usually limited to five years. The officials must achieve political and economic results during this period to be promoted to a higher position after or even during that term. Government officials play an important role as institutional entrepreneurs at the local level (Zhou, 2003), who create institutions that fulfill (or exceed) the local community's expectations regarding stability. In the context of the Chinese reform, the government is the organization. The inhabitants and companies are regarded as individuals. Governmental competition could be viewed as the competition of external rules.

Indeed, the main reason that the Chinese government intervened in institutional innovation at the beginning of the reform was not to maximize welfare, but rather to react to the fierce competition by external rules. These rules forced the governments to understand or imitate other successful institutions by way of different learning methods such as the exchange of officials between local governments and study trips to other countries (Zhou, 2000).

Even though internal rules play an important role in the establishment of social order (Hayek, 1973), China's reform was shaped from the beginning by the "government," due to its gradualist approach, which is characterized by continuous conflicts and compromises between internal and external rules. The critical factor in governmental competition is whether the government can establish a fair competition and market order, if a spontaneous order emerges. A successful external rule that provides the market with freedom and intervenes less in the market could, in turn, promote internal rules and is therefore the key to marketization and transformation.

However, there is also unfair competition between governments that implement state regulations and intervention with the aim of limiting competition within local regions, for instance, through protectionist measures like establishing market entry barriers or administrative monopolies. This inhibits the creation of internal rules and could lead back to a planned economy.

Competition between local institutions can lead to three types of institutions. 1) Inclusive institutions (Acemoglu & Robinson, 2012) are those in which a market-oriented economy with relatively symmetrical information is established. The government aims for institutional innovation, the economic situation becomes sound and productivity rises enormously. 2) Medium institutions are those regions with a "semi-market-oriented" and "semi-regulatory" economic system. Less importance is attached to institutional innovation, and there is partial protectionism. 3) Extractive institutions (Acemoglu & Robinson, 2012) are closed and protectionist. The government frequently intervenes in the market and exploits society and the economy. Most of the coastal provinces of China are successful examples of inclusive institutions that began reform experiments quite early and thereby introduced a market-oriented mechanism at an early stage. They are regarded as "reform pioneers". In Central China, however, medium institutions exist, in which protectionism and bureaucracy still partially influence the external order. In some western and northeastern provinces, there are still many planned economic elements in the market.

2.1.3 Transition and innovation performance

China's reform is a process of competition between local governments that compete for political and economic resources. The question is whether they can supply a reasonable institutional arrangement. According to Hayek's theory of "competition as a discovery procedure" (Hayek, 1968), market competition is a procedure of discovering knowledge, information and institutions. The government receives diffused knowledge and information from spontaneous orders, and then establishes the organization. This is the reason why governmental competition is also associated with an institutional "discovery procedure" (Hayek, 1968), which involves learning, imitation and innovation of institutions.

Since the central government divided its power, numerous spontaneous orders have appeared in regional society. Governmental competition forces local governments to choose appropriate rules. On the other hand, new awareness is disseminated to society during the innovation of external rules, which could save costs for institutional innovation (Zhou, 2000). It is important

for local governments to avoid intervening in the market too frequently. A proper external rule is a framework in which there is fair competition and an effective market mechanism.

Based on the experience of the Western world and some transitional countries, North (1990) found that institutional arrangements affect economic performance, for instance the restructuring of property rights which led to the rise of European industrial countries and the US by providing necessary incentives for economic growth (North & Thomas, 1973). As for the Chinese transition, it has also changed almost all of that country's economic circumstances. In terms of innovation systems, institutional arrangement could refer to "administrative regions" with some degree of policy making and political capacity, and also combine other different trajectories of economic and cultural factors (Cooke et al., 1997), in the context of China, at the provincial level. Institutional reform influences the behavior of the market structure and market actors including the government, firms and consumers.

At the firm level, the reforms have impacted all ownership types of firms. Firm leaders consider the state regulatory organ and state inference the most influential and complex factors affecting firm performance in China (Tan & Litsschert, 1994). Institutional changes such as restructuring property rights and establishing a market-oriented mechanism increasingly optimize governance structures and favor private firms (Nee, 1992), while large numbers of SOEs, which are criticized fiercely due to their rigid organizational systems and low economic performance, are restructured, or as described by some researchers, "privatized", which determines firm behavior in the market.

Park et al. (2006) argue that the channels of influence of institutional changes on firm performance is reflected in three forms: decentralization of control to local government, privatization of property rights and industrial policies (see Figure 2.3). As mentioned above, decentralization is the start of the reform as well as the motivation for following market-oriented measures, allowing more autonomy for local officials and managers of economic units. The protection of property rights has increased the incentives of market actors to participate in business activities including innovating and pursuing different economic objectives. On the other hand, it has changed the structure of firm ownership from the single state-owned firm to a complex and diverse ownership structure containing restructured SOEs, collectively owned enterprises and newly created private enterprises. As for the last element of industrial policy, it concentrates on political support for certain sectors, or in other word, strategical industries that facilitate industrial upgrading and diversification (Lin & Monga, 2011). These three factors influence firm behavior by optimizing resource allocation and providing information to reduce transaction and agency costs.

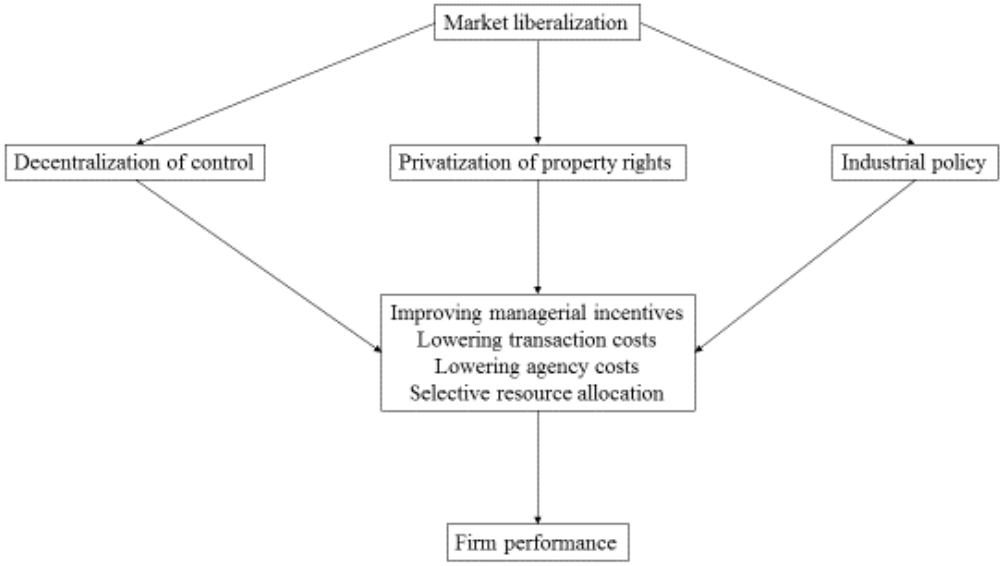


Figure 2.3: Market reform and firm performance in China
Source: Park et al. (2006)

In the following sections, we divide the influences of institutional transition into three levels: 1) innovation system, which indicates institutional and systematic changes at regional level; 2) market structure, which describes industrial factors at the industrial level and 3) reform of SOEs, which stands for the influences of reform at the firm level.

2.2 Innovation systems, market structure and state-owned enterprises

2.2.1 Innovation systems

The establishment of innovation systems is combined with systematic reforms in China and is viewed as a process of institutional change (Li, Li, & Zhang, 2000). Like its economic system, the Chinese S&T system was heavily based on the model of the Soviet Union, which was characterized by the enormous power of the government that reallocated and concentrated resources into critical sectors or research projects, such as military and space technologies. The government played a key role in innovative activities, from the establishment of S&T institutions to technology planning and conducting R&D activities.

Although China achieved progress in scientific research and high-tech industries before the 1970s, the weakness of centrally planned systems gradually became a barrier, just as it was for the whole economic system. Moreover, S&T planners could not detect the true market demand and shortages. The planned distribution of technological resources destroyed the market

allocation system and therefore could not efficiently coordinate R&D and innovation activities, which led to a discrepancy between scientific research and economic demand. As such, despite scientific achievements, the innovative efficiency still remains controversial.

The establishment of Chinese innovation systems began with a series of central government policies in the mid-1980s. In 1985, the "Decisions on the Reform of the Science and Technology System" were released, which contained three missions: supporting economic construction; developing high technologies and conducting basic research. In order to support scientific research to meet the needs of industry, the government improved the method of funding research institutes, encouraged the commercialization of S&T and rewarded individuals for participating in scientific activities. These were necessary measures to change the Soviet model, which was characterized by the separation of research from production and a high priority of S&T in political targets. In order to provide an alternative financing channel for public and applied research, the National Natural Science Foundation of China was founded in 1986.

Since the "Decisions on Accelerating S&T Development" and the "Strategy of Invigorating the Country Through Science, Technology and Education" in 1995, as well as the "Strategy of Sustainable Development" in 1999, China has decided to transfer its development path from an extensive to an S&T-driven growth model.

In 2006, the central government released the "National Medium- and Long-Term Program for Science and Technology 2006-2020," which aims to establish an innovation-oriented country by achieving "indigenous innovation." The government planned to invest intensively in crucial high-tech products and industries and promote and reward indigenous innovative technologies. The most recent central government measure, the "Outline of the National Strategy of Innovation-Driven Development" released in 2016, defined the goals of China's new development path for the next three decades. One of the highlights of the outline is that it has pledged safeguards for the implementation of the strategy with a focus on building an efficient national innovation system by 2020. It defines such a system as an ecosystem featuring close coordination and interaction among various innovation entities as well as the unimpeded flow and efficient allocation of innovation factors, and bringing about the carriers, institutional arrangements and safeguards for achieving innovation-driven development.[5] Enterprises are encouraged to invest in scientific activities and establish high-level R&D institutes. These goals are set to increase the competitiveness and innovation competence of China's universities and

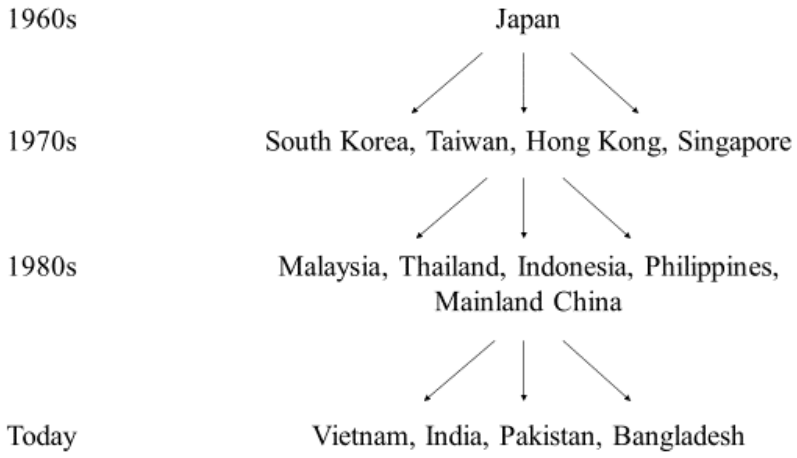
[5] http://www.china.com.cn/zhibo/zhuanti/ch-xinwen/2016-05/23/content_38515829.htm

research institutes and to promote some of them to become first-tier institutions internationally. Another target is to build an efficient technology transfer service system to optimize the commercialization process of research results.

2.2.2 Market and industrial structure

1) Change of industrial structure

Another consequence that the transformation has led to is a change of the industrial structure. As mentioned above, the transformation can be divided into two parts: opening up and reform. With respect to "opening up," one of the most important pieces of historical background is the industrial transfer in East Asia since the 1960s: the advanced economies transfer their overcapacities to underdeveloped countries through foreign investment successively, like the "pattern of flying geese". The lead country (or goose) in this pattern is Japan, the second-tier consists of the four Asian Tigers (South Korea, Taiwan, Singapore and Hong Kong). After these two groups follow Malaysia, Thailand, Indonesia, the Philippines and China (Kasahara, 2004). This development model is called the flying-geese paradigm (Akamatsu, 1962) (see Figure 2.4).



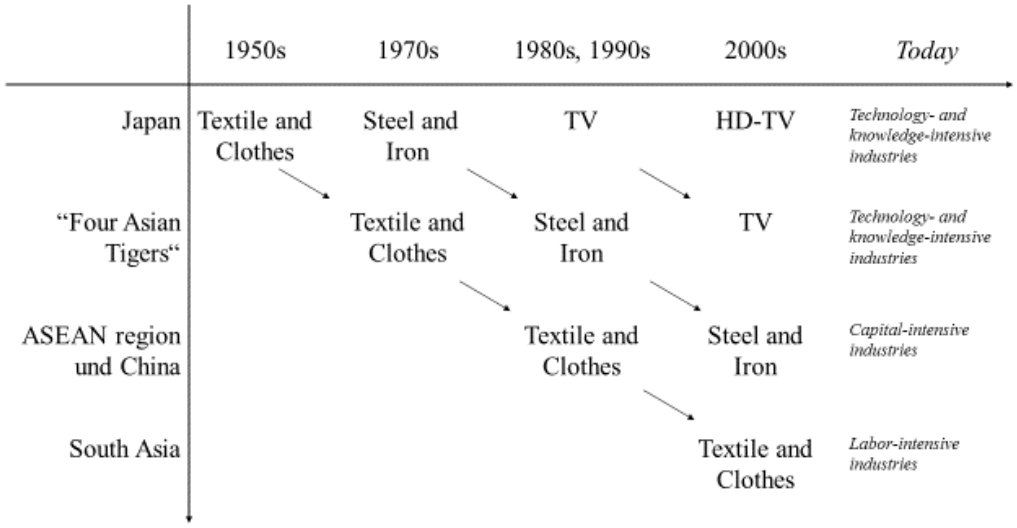


Figure 2.4: Flying-geese paradigm

This paradigm is a model for the international division of labor in East Asia based on dynamic comparative advantage, and it postulates mutual interactions between developing and advanced countries. Due to increasing labor costs, leader countries transfer their low-tech industries to lower-tier regions, so that advanced economies can shift from labor-intensive production to more capital-intensive activities.

Thanks to comparative advantages (Lin, 2012), China gained technology and know-how from advanced countries or regions such as the "four Asian Tigers" and Japan at low risk and low costs. First, in the 1980s, the textile industry was transferred to China, then after more than ten years, China began to develop capital-intensive industries such as a steel and iron sector. Nowadays, the government considers an innovation-oriented development model as its growth target. To achieve it, China needs to promote industrial upgrading to technology- and knowledge-intensive industries. At the same time, some outmoded and low technologies must be eliminated or transferred to underdeveloped regions.

2) Transformation to market-oriented industrial structure

China's market structure is characterized by state intervention. In the period of the centrally planned economy, all industries were controlled by SOEs and few private enterprises were allowed to participate in economic activities. Since the 1980s, the market structure has been liberalized by the government, and SOEs have begun to transform into a market-oriented system with elements of competition. Two of the most essential motivators are marketization reform and China's accession to the WTO.

The Chinese National Economic Research Institute has conducted a research project to develop the marketization index of China's provinces to quantify the institutional factors and reform processes of regions (see Figure 2.5).

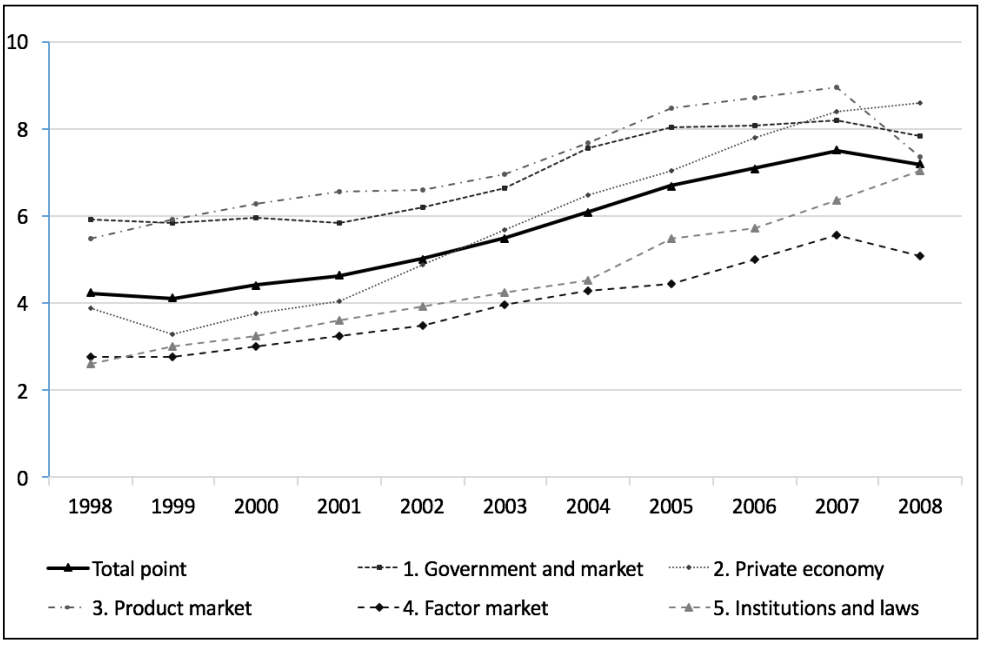


Figure 2.5: Marketization index of China

The index is measured on a scale of 0 to 10 for each province, based on its values for all components of the index (Fan, Wang, & Zhang, 2001). The higher the index is, the more market-oriented the province. The total index contains five categories: 1) the relationship between government and market, and the size of the government in the economy; 2) economic structure, mainly concerning the growth of the non-state sector and the reform of the state enterprises; 3) product market development; 4) factor-market development and 5) intermediary organization and legal frameworks.

The total index, including the first category, size of the government in the economy, has generally risen smoothly during the period. The index has only decreased since 2007, namely since the financial crisis and the central government's ensuing implementation of a stimulus policy. Nevertheless, we could conclude that the influence of the government on the market has decreased in the last decades.

The other motivator for change to the market structure was China's accession to the WTO in 2001. As preconditions to obtain WTO membership, China was obliged to accept not only the rules of the WTO's market-economy principles and its policies of fair competition and non-

discrimination, but also the market-access conditions for goods and services. The government monopoly, including, for example, the administrative entry barrier, had to be eliminated.

China's reform from a planned to a market economy, a transformation process from a state-monopolistic market to a competitive market, shaped its change of market structure. Although there are still some monopolistic activities in several sectors, many industries have changed to competitive markets. Meanwhile, like in other economies, some of the markets no longer subject to state interference have been liberalized.

In summary, high-tech, medium-tech and low-tech industries are all represented in China and the government aims to upgrade the industry structure to sustainable and technology-advanced sectors and eliminate outdated capacities. In most industries, state intervention has decreased as a result of the reforms, but market concentration still exists.

2.2.3 State-owned enterprises

Due to the institutional arrangement of the centrally planned economy at the beginning of People's Republic China, SOEs were considered a pillar of the economic system. Some SOEs evolved directly from governmental authorities and continue to belong to governments. The government invests much of its budget in SOEs.

The reform of SOEs began with China's reform and opening up policy at the end of the 1970s. The first period lasted from 1978 to 1992 and focused on breaking up the proprietary and management rights of SOEs. After this exploratory reform, the government concentrated on establishing modern enterprise systems throughout the second reform decade from 1993 to 1998. In order to support employment in the state sector and maintain social stability, the central government let the non-state enterprises grow but did not downsize the state sector. Indeed, in this period, most of the SOEs had very low productivity growth rates (Zhu, 2012) and could not have survived without support from the government such as subsidies, preferential access to credit and privileges in protected industries. The reform before the 1990s is called "reform without losers" (Lau, Qian, & Roland, 2000).

However, the lack of exit elimated market selection in the state sector and hindered further reform. Thus, in the mid-1990s, the central government reduced its commitment to stable employment in the state sector and introduced the mechanism of competition into the market. SOEs in non-state sectors had to compete with private enterprises and were allowed to go bankrupt or be privatized by companies with other forms of ownership.

Despite several series of reforms in the past decades, many previous studies have criticized the low level of economic performance of the restructured SOEs, as the internal problems of SOEs,

such as property rights and weaker incentives to profitability, impede the increases in performance and productivity as well as further reforms (Bai et al., 2006; Qian, 1996). One of the largest problems of SOEs is unclearly assigned property rights. Property rights can be viewed as an attribute of a good economy. Well-defined property rights should contain the right to use, benefit from, transfer and exchange the property. However, the property rights of most SOEs, which are owned by the government, are not defined clearly, thus making the operation of these firms inefficient. An important reason for this lack of clearly defined rights is that a mechanism for defining and enforcing liabilities when the value of the enterprise's residual profit streams is negative has not yet been established (Xiao, 1996). Clearing up SOE property rights has become the essential goal of the SOE reform.

Since the 1990s, deep structural transformation has accelerated the privatization of former state-owned firms, and, subsequently, the establishment of private firms has become formally legalized (Boeing, Mueller, & Sandner, 2016). More diversified ownership forms were introduced within the state sector. Some of the large-scale SOEs were converted into shareholding companies (Zhu, 2012). Many inefficient SOEs, especially small-scale firms and firms in competitive sectors, were shut down or privatized. From 1998 to 2014, the number of industrial large- and medium-sized SOEs decreased from 64,737 to 17,830. The share of SOEs has dropped significantly from around 40% in 1998 to under 5% in 2014 (see Table 2.1). Most of the surviving SOEs are large and operate in upstream sectors or strategical and state-monopolistic industries (Hsieh & Song, 2015).

	Number of all large and medium-sized industrial enterprises	Number of state-owned large and medium-sized industrial enterprises	Share of SOEs
2014	361,286	17,830	4.94%
2004	301,961	24,961	8.27%
1998	165,080	64,737	39.22%

Table 2.1: The number of SOEs

Sources: National Bureau of Statistics of China, Jefferson (2016)

Since China's accession to the WTO in 2001, the government has concentrated more on reforming the management of state-owned assets. In 2003, the State-owned Assets Supervision and Administration Commission of the State Council (SASAC), a special commission directly under the control of the State Council, was founded. SASAC is responsible for managing the

SOEs, including appointing top executives and approving any mergers or sales of stocks or assets, as well as drafting laws related to state-owned enterprises.

The reform has not only reduced the number of SOEs, but also increased their efficiency. Although between 1978 and 2007, the annual average total factor productivity (TFP) growth rate of non-state sectors (3.91%) was higher than that of state sectors (see Table 2.2), for 1998 to 2007, the growth rate of 5.5% in the state sector surpassed that of 3.67% in the non-state sector for the first time since the reforms (Boeing et al., 2016; Zhu, 2012).

Period	Nonstate	State
1978-2007	3.91	1.68
1978-1988	5.87	-0.36
1988-1998	2.17	0.27
1998-2007	3.67	5.50

Table 2.2: Average annual total factor productivity growth (%), nonagricultural sector

Source: Zhu (2012)

(Notes: The "state sector" includes state-owned enterprises and shareholding companies. The "nonstate sector" includes domestic private fifirms, foreign-invested firms, and collective firms.)

With their increased efficiency, the innovation performance of Chinese SOEs has also risen rapidly in recent years. Although the relative share of applications for invention patents decreased from 5.58% to 4.34% due to the increasing rate of patent applications by non-SOEs, the absolute number tripled (from 3,306 to 10,423) between 2008 and 2014 (see Figure 2.6).

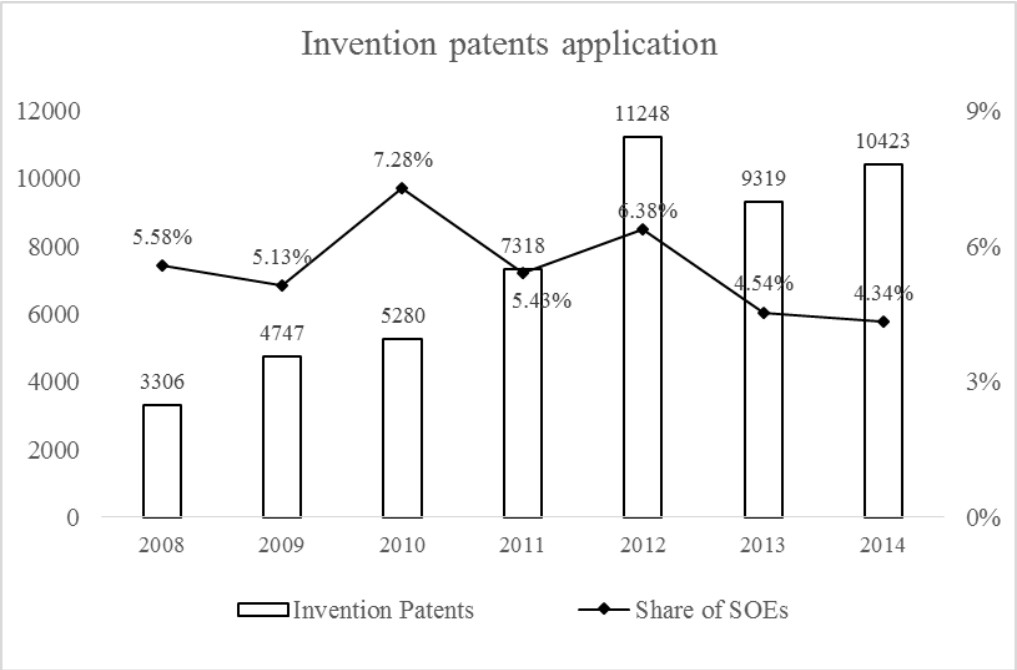


Figure 2.6: The number of invention patent application

Source: China statistical yearbook on science and technology

The reform of SOEs is, however, far from over. Scholars still criticize their problems, such as unclearly defined property rights, favored policies, monopolistic powers and subsidies from the government (Sheng & Zhao, 2012). The World Bank suggests that further reforms of SOEs should focus on eliminating barriers to market entry and exit, and increasing competition in all sectors, including strategic and pillar industries (World Bank, 2013).

3. Literature review

3.1 Overview of innovation economics

Schumpeter was the most influential pioneer and thinker of innovation research. He believed that the "source of energy" (Schumpeter, 1934) within the economic system is innovation that disrupts any equilibrium. The central point of his whole life's work is that capitalism can only be understood as an evolutionary process of continuous innovation and "creative destruction" (Freeman, 1998; Schumpeter, 1942). He defined "innovation" as new combinations of new or existing knowledge, resources and equipment, including introducing new products, new means of production, opening up new markets, the conquest of new sources and carrying out new forms of organization. This innovation activity is labeled the entrepreneurial function and contains not only potential profits, but also difficulties. Thus, Schumpeter believed that in order to overcome these difficulties and succeed in the new combinatory activities, more was required than just ordinary managerial competence. The social agents fulfilling this function are entrepreneurs (Fagerberg, 2007; Schumpeter, 1934). This is called "Schumpeter Mark I." In his book *Capitalism, Socialism and Democracy*, Schumpeter demonstrated that technical innovation is an endogenous factor for economic growth. He argued that perfect competition is not suitable for economic development, and some degree of monopoly is preferable for perfect competition. Large firms are more successful and efficient in innovation activities. This is referred to as "Schumpeter Mark II."

Mainstream economists did not accept Schumpeter's theory of innovation until the 1950s. With the rapid development of S&T after the war, the importance of innovation became an attractive research topic for the academy. Solow (1957), Arrow (1962) and Romer (1989) introduce technical progress as a crucial variate into the economic growth functions and have proven the importance of technology for economic development. Some other economists have focused mostly on innovation and have made great contributions to this area. Rothwell (1992) divides the development of theories about industrial innovation process into five stages (see Figure 3.1)

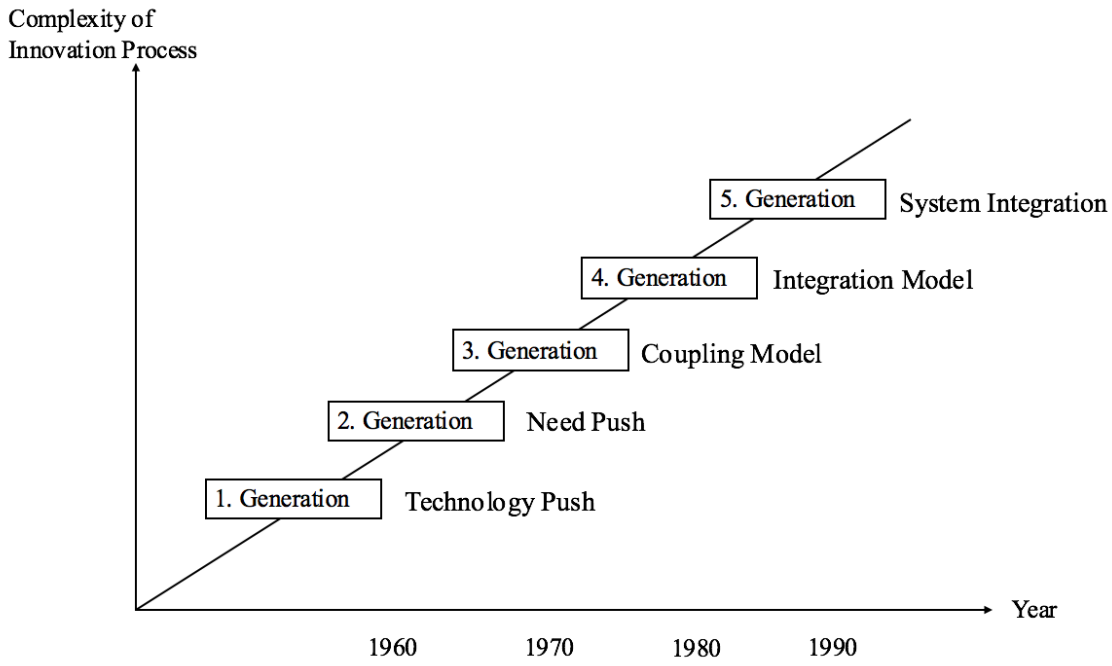


Figure 3.1: Evolution of innovation process models

Source: Wan (2013)

First generation: "technology push" model of the 1950s and mid-1960s

The 1950s and 1960s were characterized by post-war recovery. New technologies created new sectors and regenerated existing ones. During the 1950s, industrial innovation was generally considered a linear process from basic scientific research to R&D, engineering and manufacturing, ending with market activities (Carter & Williams, 1957). In this model, technology was the motive of innovation and the marketplace was a passive receptacle for R&D. Thus, it is called the "technology push" model (see Figure 3.2).

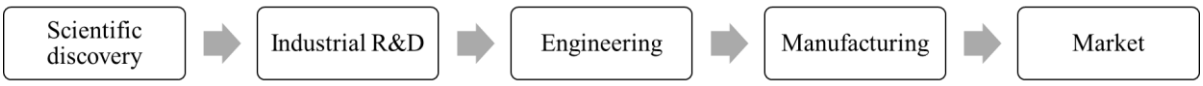


Figure 3.2: Technology push model

Source: Wan (2013)

Second generation: "need pull" model of the mid-1960s and early 1970s

In mid- and late 1960s, intense market competition led to a growing level of corporate diversification as well as mergers and acquisitions of firms. The capacities of suppliers and demand generally came into balance. Corporations began to pay more attention to market

demand. The new innovation theory, the "need pull" model (see Figure 3.3), emphasizes the role of the marketplace and considered the market the motive of industrial innovation, resulting in R&D activities (Myers & Marquis, 1969). The growth of demand pulls R&D inventions and innovations forward, and results in productivity growth.

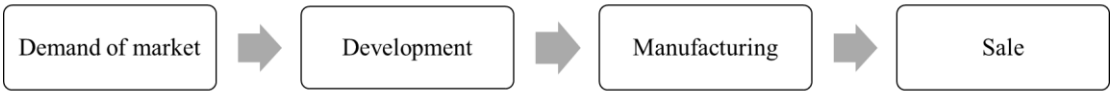


Figure 3.3: Need pull model
Source: Wan (2013)

Third generation: Coupling model of the mid-1970s and early 1980s
The economic crisis of the 1970s created stagnation, and supply capacity exceeded market demand. The innovation model returned to an approach more balanced between R&D and the market. According to the "coupling" model, industrial innovation was the result of the interaction of technology and the market, which were to be integrated into the innovation process (Mowery & Rosenberg, 1979).

Fourth more balanced: Integrated model of the early 1980s and 1990s
Rothwell and Zegveld (1985) generate a more representative model, namely the "interactive" model, which represents the confluence of technological capabilities and market demand within the framework of innovating firms. This integrated model marked a shift from considering innovation as a sequential process from technology to the market, to considering innovation as a parallel process simultaneously involving elements of R&D, design, manufacturing, management and commercial activities.

Fifth involving: Systems integration and networking model since the 1990s
During the 1990s, the strategic situation became more complex with themes coming to the fore such as a rate of technological change, integrated products, intra- and inter-firm integration and networking and manufacturing strategies. Rothwell (1992) argues that industrial innovation involves considerably more than just technological change activities, but can be accompanied by organizational factors such as organizational and commercial innovation. Organizations must be sufficiently flexible to accommodate the requirements of the emerging innovation programs.

3.2 Theories of innovation systems

In 1989, C. Freeman first defined national innovation systems in his book *Technology and Economic Performance: Lessons from Japan* (Freeman, 1989). He argues that in order to catch up to other economies, a country not only needs a market economy with free competition, but public goods from the government. The economic rise of Japan starting in the 1960s can be traced back to the rapid improvement of innovation, which includes technological as well as institutional and organizational innovation. Freeman summarizes the experience of Japan's rise and defined the national innovation system as the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies.

Innovation is viewed as a dynamic process (OECD, 1997). The systems of innovation approach studies contain the influence of external institutions and focus on the importance of the transfer and diffusion of ideas, skills, knowledge and information, which are linked in social, political and cultural networks that influence innovation activities and capabilities (Mortensen & Bloch, 2005). Market conditions and regulations, as well as policy, also influence innovation.

Lundvall (1985) introduces a user-producer perspective to innovation research. He raises critical objections to technology-push (producer-side) and demand-pull (user-side) models and argues that the user-producer interaction transmits signals from the top to the bottom of the "Black Box" (Rosenberg, 1982) and vice versa. In innovative activities, the universities are centers of scientific research, in other word, producers of science. Private firms and public agencies also participate in R&D. Between these two levels, there are many research organizations which are neither integrated in universities nor subordinated to firms, nor engaged in basic or applied research (Lundvall, 1985). Unlike traditional industries, the so-called science-based industries present their problems in a form suitable for scientific treatment, communicate in a scientific code and stimulate the scientific institutions. This linkage between science-based industry and scientific institutions establishes information channels and reflects a tendency toward a new pattern of agglomerations of industries and universities. Lundvall considers this relationship a "system" and defines as national innovation systems the elements and relationships which interact in the production, diffusion and use of new and economically useful knowledge and are either located within or rooted inside the borders of a nation state (Lundvall, 1995).

Nelson (1993) agrees with the belief that the rise of Japan in post-war years was partly due to a powerful and efficient innovation system established through the technology policy of the

Japanese government as well as strong inter-firm cooperation. These features are currently the popular models in Europe and the United States, who have designed national programs to enable their respective industries to stay ahead or catch up technologically. Such systems or networks involve key interactions between component and systems producers, upstream and downstream firms, universities and industry, and government agencies and universities and industries. Among these actors, firms are the core of innovation systems (Nelson & Winter, 1982). Besides the interactions, the national innovation systems include a set of institutions whose interactions determine the innovative performance of national firms. The institutions are supposed to establish a balance of technologies between public and private organizations.

Patel and Pavitt (1994) suggest that the notion of "national systems of innovation" covers what was ignored in earlier models of technical change: namely, deliberate "intangible" investment in technological learning activities. NIS not only involves a variety of institutions like business firms, universities, other educational and training institutions, and governments, but also considers the linkage among them and associated incentive structures and competencies. They define NIS as the national institutions, their incentive structures and their competencies that determine the rate and direction of technological learning (or the volume and composition of change-generating activities) in a country (OECD, 1997).

The OECD's study of national innovation systems focuses on flows of knowledge, which is embodied in human beings as human capital and in technology, and are considered central economic development (OECD, 1997). In today's knowledge-based economy, where the production of goods and services tends to be more knowledge- and science-intensive, innovation has become a creative and interactive process involving market and non-market institutions. A national innovation system can be constituted by the market and non-market institutions in a country that influences the direction and speed of innovation and technology diffusion (OECD, 1999).

Moreover, research on national innovation systems has been developed at a regional level. Cooke et al. (1997) argues that for conceptual and methodological reasons, many problems of innovation systems research concerning scale and complexity may be complemented by a sub-national focus. Regions evolve along different patterns through political, cultural and economic factors. Thus, the designation of regions referred to by Cooke et al. (1997) can be split into two key processes: the first is *regionalization* (Hadjimichalis, 2005), which is linked to the constraints from above by the superordinate state. The second is *regionalism* (Harvie, 2005), which involves cultural influence from below, namely so-called "social capital" (Putnam,

Leonardi, & Nanetti, 1993). These factors determine the evolutionary processes of the region, the interactions of innovative actors, learning process and the innovation process.

Cooke and Morgan (1990, 1994) claim that Baden-Württemberg in Germany is one of the leading regional innovation systems in Europe. The robustness of the economic system of this German federal state rests on networks between firms, a rich institutional system of vocational training and substantial public and private investment in innovation activities. Among them, the networks of business and government are of key importance to the development process. The authors argue that the successful lessons of Baden-Württemberg's innovation networks can be applied to less developed economies.

Porter (1998) argues that the enduring competitive advantages in a global economy lie increasingly in local things—knowledge, relationships, motivations—that distant rivals cannot match, and he emphasizes the key role of clusters, which, according to his theory of competitive strategy, dominate today's economic world map, competing with nations. Asheim and Isaksen (2002) suggest that the regional (sub-national) level and specific local and regional resources are still important in firms' efforts to obtain global competitiveness, because the resources important for innovation including labor force, specialized suppliers, learning process, technology transfer and spill-over effects are mostly linked to regions. Knowledge is "sticky" as it is partly embedded in local patterns of interaction.

Liu (2014) analyzes the theories of National Innovation System (NIS) and Regional Innovation System (RIS) and argues that the following relationships between the two innovation system levels exist: (1) NIS is the aggregation of different RIS in a country. Because the government and policy play a crucial role in shaping NIS, the structure of NIS is more like a pattern from "top to bottom." On the contrary, many RIS are formed spontaneously. (2) Compared to NIS, RIS are characterized more deeply by local culture and geographic factors. (3) Both of the systems concentrate on the importance of institutions and organizations.

3.3 Schumpeter's hypothesis: monopoly and innovation

In a static economic analysis, high concentration or, in the extreme, monopoly leads to welfare losses. This result was challenged, however, by Schumpeter (1942), who has argued that incentives to innovate are greater if an industry has a high degree of concentration. He has asserted that a firm possessing monopoly power faces less market uncertainty and can prevent imitation. Thereby, they can better recoup their R&D expenses and more easily appropriate returns from their R&D investment. Secondly, due to their large monopoly profits, firms of this

type has many resources to invest in R&D.

One of the largest bodies of literature in the field of industrial organization is devoted to the interpretation and testing of several hypotheses advanced by Joseph Schumpeter concerning innovation and industrial market structure (Levin, Cohen, & Mowery, 1985). Schumpeter's idea initiated a new research area on relationships between market monopoly and innovation. Several theoretical studies have confirmed that the relationship between these two factors may take different forms, depending on details of the strategic environment, the definition of competition intensity and the type of innovation being studied (Tishler & Milstein, 2009).

The counter-argument was presented by Arrow (1962), who stated that not monopoly, but competition is beneficial to innovation activities. This became known as the Schumpeter-Arrow debate. The reason that a monopolist's incentive to innovate is less than that of a competitive firm, is that a firm with high profits in a monopoly market has an interest in protecting the status quo and is thus less likely to introduce new disruptive technology (Shapiro, 2011).

Arrow's idea was criticized by some scholars, especially Demsetz. Demsetz (1969) challenges the assumption of complete information and augues that if an economy has no serious indivisibilities and if information is complete, as Arrow assumed, then modern analysis can describe the characteristics of an efficient long-run equilibrium. Yet, in the real world, indivisibilities are present and knowledge is costly to produce, because the latter is imperfect and information is incomplete. As such, truly efficient institutions will yield different long-run equilibrium conditions than those now used to describe the ideal norm (Demsetz, 1969). The power of monopolists and their capital ensure them to obtain necessary investment for innovation. The experience of previous success and the ability to attract professionals reduce risks in the process of innovation. Demsetz has emphasized that the power of a monopolist position is beneficial for firm innovation.

Since the debates between Arrow and Demsetz, a large number of economists have joined this discussion about the relationship between market structure and innovation. Holmes, Levine, and Schmitz (2012) develop a new theory based on Arrow's model to explain why a monopolistic industry innovates less than a competitive one. They introduce the concept of switchover disruptions: the problem that in some cases, firms must temporarily reduce ouput in order to adopt technology. The greater monopoly power is, the greater the cost of adoption will be.

Theoretical debates have stimulated empirical studies since the recent 50 years. Many scholars have contributed to testing the theories of Schumpeter with modern empirical methods, but they have obtained different results under different conditions. We could classify the research results

about the relationships between monopoly and innovation into four types:

1) No effects:

As one of the earliest scholars engaging in empirical research in the field of market structure and innovation, Scherer (1965) focuses on the relationships between inventive activity and technological opportunity, firm size, product-line diversification and monopoly power with a dataset of 448 Fortune 500 firms between 1955 and 1960. He ascertains that inventive output is not related to variations in market power. This finding raised doubts about whether the monopolistic and conglomerate corporation is as efficient as disciples of Schumpeter had supposed it to be.

2) Positive relationship:

In spite of conclusions that there is no significant tendency for inventive output with market concentration ratios in his previous research, Scherer (1967) uses a new and more comprehensive dataset of the US manufacturing industry for 1960 and extended his early analysis. He discovers that the relationship between industrial inventive and concentration is a complex one, and technological improvement increases with concentration at low levels of concentration.

Mansfield (1963) introduces industrial data regarding steel, petroleum and coal in the US from 1919 to 1958 and reveals that the relationship between market structure and innovation depends on sectoral characteristics. The sixth largest firms in the petroleum and coal industries were of about the perfect size from the point of view of maximizing the rate of innovation, while in the steel industry, much smaller firms seem to have been better in this respect.

Acs and Audretsch (1987) use two samples consisting of 172 innovative and 42 highly innovative industries and differentiate firms by size and sector. They find that large firms tend to have the relative innovative advantage in industries which are capital-intensive and concentrated, while the small firms have the relative advantage in highly innovative industries.

Kraft (1989) investigates the determinants of product innovation with data from 57 West German firms in the metal industry for the year 1979 and measures innovative activity as a percentage of new products in sales. He argues that competition has a strong negative impact on innovative activity.

3) Negative relationship:

As mentioned before, Schumpeter’s idea has been challanged by Kenneth Arrow. Based on

perfect competiton, Arrow (1962) has created a model about incentives to invest for monopolistic and competitive markets and has found that the incentive under competition always exceeds the monopolist's incentive. The only advantage of monopoly is that appropriability may be greater than under competition, but Arrow has argued that this difference is offset against the monopolist's disincentive created by his preinvention monopoly profits.
Since the problem of competition and innovation involves competition policy directly, Geroski (1990) provides implications for policy after exploring this correlation using a cross-section dataset for the UK during the 1970s. He finds almost no support in the data for popular Schumpeterian assertions about the role of actual monopoly in stimulating progressiveness. Similarly, Nickell (1996) and Blundell et al. (1999) also use the data of UK companies and argue that market competition rather than market monopoly improves innovative output.
Acs and Audretsch (1988) use the four-digit Standard Industrial Classification (SIC) released by the U.S. Small Business Administration consisting 8074 innovations and establish that the total number of innovations is negatively related to concentration and unionization.

4) Non-linear relationship:

The relationship between market structure and innovation is not always linear. Levin et al. (1985) use the data on R&D appropriability and technological opportunity collected by Levin, Klevorick, Nelson, and Winter (1984) in a survey of R&D executives in 130 industries in the US. They discover an inverted-U relationship between innovative output and concentration. However, Aghion et al. (2005) argue that the relationship between product market competition and innovation is an inverted U-shape, after developing a Schumpeterian growth model and using a panel dataset of individual UK companies covering the period 1968-1997. Their research demonstrates that although competition increases the profits from innovation, it weakens the innovation incentive of firms in some cases. According to their empirical results, the relationship between competition and innovation is an inverted U-shape. The positive impact of competition on R&D dominates when the level of competition is low, while at a higher level of competition, additional increases in competition decrease firm R&D.
As mentioned above, the results on monopoly and innovation depend on definitions of market structure in some cases. Using the Statistics Canada 1999 Survey of Innovation, Tang (2006) develops new measures of competition, arguing that firms' perceptions about their competitive environment are important for innovation and are better measures of firm-specific competition. Since this relationship cannot be summarized with simple interpretations, Tang (2006) estimates it among four types including both positive and negative correlation, depending on the specific

competition perception and specific innovation activity of firms.

Since most of these studies are built on the assumption of a product market and have not yet been empirically tested on service-sector firms, Tingvall and Karpaty (2010) use firm-level data in Sweden from Statistics Sweden between 1997 and 2005. They find an inverse U-shaped relation to hold for both small and large service-sector firms. As competition increases, small firms tend to seek more strategic alliances with competitors, while large firms tend to decrease their collaboration with competitors.

With the help of the rich set of panel data from China's large and medium-size manufacturing enterprises from 1995 to 1999, Jefferson (2006) investigates the determinants of firm-level R&D intensity, the process of knowledge production and the impact of innovation on firm performance. His research presents that R&D performers are more concentrated among SOEs and shareholding companies and the least concentrated among foreign and overseas enterprises. However, SOEs exhibit the lowest efficiency in knowledge production.

Hu (2001) uses an emprical methodology that contains a system of three equations, i.e. the production function, a private R&D equation and a government R&D equation with a a cross-sectional data set for Chinese enterprises of various ownership types. The data comes from a survey of all high-tech firms in the Haidian District of Beijing for 1995. He ascertains a strong link between private R&D and firm productivity.

Nie, Tan, and Wang (2008) use firm-level panel data from "above-scale" manufacturing firms in China between 2001 and 2005 to analyze the factors which affect Chinese firms' innovative activities. Using a four-firm concentration ratio as an indicator of market structure and advertising expenditures for market power, they argue that there is an inverted-U relationship between innovation and size or competition, and a certain size and amount of competition can increase firms' innovative activities.

Boeing et al. (2016) examine whether different R&D activities have a positive influence on TFP for firms of different ownership types and across two time periods, 2001-2006 and 2007-2011, with a dataset of Chinese listed firms. They find that privately owned enterprises (POEs) obtain higher returns from their own R&D than majority and minority SOEs.

From the studies above, we find that different scholars have reached different empirical results. The resons for this could be summarized as: 1) the variety of data samples and 2) the variety of variables, which contain two levels, firm-level and industry-level (Nie et al., 2008). In order to investigate the factors that influence the innovation of firms, one should look for a relatively comprehensive data set to measure firms' industrial and individual character.

Most of the studies on the relationship between market structure and innovation are based on industrial countries that have already established stable market-economy institutions and legal systems. Scholars thus have concentrated more on non-institutional factors including market structure and technological improvements. But in fact, for transitional countries, for instance China, which are experiencing institutional changes, the institutional factors, such as market-economy mechanisms and ownership engagement, should be considered (Wu, 2007) to make these factors become new constraints for innovation performance. It would hence improve innovation research on China if not only market structure but institutional elements were also introduced into the analytical framework to investigate relationships between institutions, innovation activities and growth of firms.

3.4 Ownership and innovation

In China, the influence of ownership should be especially taken into consideration, because a large number of manufacturing enterprises that perform R&D or innovation are SOEs or private enterprises (Nie et al., 2008).

Gary Jefferson and Albert Guangzhou Hu have contributed greatly to the research on relationships between innovation and ownership in China. Jefferson et al. (2003) use a panel of China's 22,000 large- and medium-size enterprises' data for 1994–1999, which collectively accounts for one third of the nation's total industrial output, and find considerable variation in measures of performance across ownership types in which the role of the state is steadily retreating. For SOEs, patterns of asset ownership are associated with performance. SOEs with the highest concentrations of state assets perform at the low end, whereas those with low concentrations of state-owned assets perform at the high end.

With the same dataset of China's industrial enterprises, Jefferson (2006) explores the determinants of firm-level R&D intensity, the process of knowledge production, and the impact of innovation on firm performance, using a recursive three-equation system. Across ownership types, R&D performers are more concentrated among SOEs and shareholding companies and the least concentrated among foreign and overseas enterprises. State-owned enterprises exhibit the lowest efficiency in knowledge production.

Hu and Jefferson (2009) employ a dataset that spans the population of China's large and medium-size enterprises for the period from 1995 to 2001 and assess the different hypotheses regarding the causes of the patent surge by estimating a patent's production function. As one of

their hyphotheses, they compute the marginal effects of ownership and establish that all non-state enterprises except the jointly-owned group have a higher propensity to patents than SOEs. Boeing et al. (2016) use a panel dataset of Chinese listed firms over two time periods, 2001-2006 and 2007-2011, to analyze whether different R&D activities exhibit a positive influence on TFP for firms of different ownership types. They ascertain that privately owned enterprises not only obtain higher returns from their own R&D than majority and minority SOEs but that they are also able to increase their leading position.

Besides ownership, the effect of the Party has become another indicator for the influence of state. Using survey data of private small and medium-sized enterprises (SME) in the electronics industry of the Pearl River Delta in China, Liefner, Kroll, and Peighambari (2016) examine the influence of firms' formal ties with the Communist Party of China on their patenting behavior. Different from previous studies, which argue that SMEs are less susceptible to central government influence than other Chinese firms, they reveal that state influence remains intricately connected to the patenting behavior not only of larger state-owned corporations but also of those smaller firms.

The influence of a firm's ownership on innovation has also become an important research field in China, especially since the reform of state-owned firms in the 1990s. As mentioned above, using a dataset of above-scale Chinese manufacturing firms, Nie et al. (2008) compare the influence of different types of firms on innovation. They find that SOE have a strong advantage on innovation activities, and that the comparative advantage tends to become stronger with the increase of firm size, while the innovative efficiency of SOEs is less than that of private enterprises.

With a firm-level dataset of China's industrial enterprises in 2005 and 2006, Chen and Zhu (2011) differentiate between sectors by the level of administrative barriers to entry, using the share of SOEs in an industry. They highlight that in innovation research, the institutional factors in sectors should be considered.

4. Innovation system and innovation performance

This chapter presents the influence of innovation systems on regional innovation performance in China for the period 1998-2008.[6] It places special emphasis on the effects of institutional factors, namely marketization level. The findings indicate that the innovation system contributes greatly to increasing the level of innovation. Among the factors of innovation systems, the openness of the region and government expenditure on education play key roles. Market-oriented institutional arrangements also increase innovation performance.

4.1 Introduction

China's transformation from a centrally planned system to a market-oriented economy has been a great success: Since the beginning of the "Reform and opening up policy" in 1978, China's GDP has increased by approximately 9.8% per year. With the economic boom, China's level of innovation has also been increasing rapidly, and consequently, innovation performance has already become a crucial factor for national competitiveness.

Currently, researches are paying more attention to the innovation system in innovation research. According to a report by the OECD, innovation is the result of a complex interaction between various actors and institutions. Technical change does not occur in a perfectly linear sequence, but through feedback loops within this system. The innovation system includes a network of enterprises, universities, research institutes and governments, where the flows of technology, information and knowledge among people are key to the innovative process (OECD, 1997).

Research on innovation systems was initially carried out at the national level. Patel and Pavitt (1994) have built a framework for the analysis of national innovation systems and believed that it should consider immaterial investment in technological learning. This refers to the whole institution (essentially enterprises, universities and governments), the linkage between them and their infrastructure. In empirical studies, Furman et al. (2002) investigate the innovative capacity in OECD countries, and Hu and Mathews (2005, 2008) examine the same for the four East Asian "Tiger" economies (Hong Kong, Singapore, South Korea and Taiwan) as well as China, with the help of Furman, Porter and Stern's model (FP&S). Longitudinal comparisons at the national level, however, often fall into dispute. Rosenberg and Nelson (1994) point out

[6] This chapter, *Effects of the Chinese innovation system on regional innovation performance*, is part of the research project "*Comparative research on innovation systems in China and EU*" of the Ministry of Education of China and will be published as Shi, Shiwei & Kou, Kou (2017). *Comparative research on national and regional innovation systems in China and Germany: Institution, performance and policy* (in Chinese).

that regions and industries within one country can be different. The national innovation system cannot reflect the performance of individual actors well. Asheim and Isaksen (2002) demonstrate that regional (subnational) resources and innovation activities are essential for companies to increase their global competitiveness.

In emerging countries like China, regional diversity is greater than in industrialized ones; thus, research at the national level may reflect real situations inaccurately. Moreover, many articles ignore institutional transformation factors such as marketization, which is seen as one of the most important reasons for technical progress in China (Fan et al., 2011). Thus, in this chapter, we investigate regional innovation performance in China at the provincial level and analyze the effects of innovation systems at the level of innovation output. We use a methodology introduced by Furman et al. (2002), who present an examination of the determinants of patent production in 17 OECD countries. We use the number of patents granted per Chinese province between 1998 and 2008 as an indicator for regional innovative output.

Although Furman et al. (2002) introduce their model at the national level, we believe that it is still suitable for regional innovation, as Chinese provinces can be seen as countries in terms of geographic characteristics and freedom and independence in the area of economic policy (Kou, 2015). The innovation system in this part is divided into three parts: institution and policy, namely innovation infrastructure; location and actors in clusters (cluster milieu); and the linkage between them. In innovation infrastructure, the marketization level is included, because market power could not be limited if the market lacks market entry freedom and competition (Blum, Veltins, Bauer, & Huber, 2004). Our results demonstrate that the regional innovation system, particularly its innovation infrastructure, affects innovation performance.

This chapter is organized as follows: Section 4.2 presents the theoretical basis and econometric model, Sections 4.3 and 4.4 demonstrate the dataset and research results and Section 4.5 is the conclusion.

4.2 Theoretical basis and model

This chapter is based on the FP&S model (Furman et al., 2002). The framework of the model is based on three different theories: ideas-driven endogenous growth theory (Romer, 1989), the theory of national industrial competitive advantage (Porter, 1990) and national innovation systems (Nelson, 1993). Romer's growth theory focuses on innovation input, that is to say, new input and knowledge stock, while the latter two theories focus on innovation systems.

According to the knowledge production function, knowledge production is a function of new input into R&D and the stock of knowledge. Technological progress and the accumulation of

knowledge are both the consequence of economic development and forces that promote economic development at the same time. The knowledge production function can be formulated as follows:

$$\dot{A}_t = \delta\, L_{A,t}^{\lambda} A_t^{\phi} \qquad [1]$$

where $\dot{A}_t$ stands for the output of the new knowledge and innovation in year *t*, $L_{A,t}^{\lambda}$ for human capital which is invested in R&D and A_t^{ϕ} for knowledge accumulation in year *t*.

Because the growth of knowledge stock depends on R&D professionals, the influence of the state should not be ignored. Good governance is a "good" process of decision-making and the process by which decisions are implemented (or not implemented) (Unescap, 2009). It includes participation, rule of law, transparency and a market-oriented economy. Government policy, which is relevant to the professional workforce and R&D activities in the long term, contributes to economic growth.

Porter develops the theory of national competitive strategy, namely the diamond model, which evaluates the competitiveness of industries and companies in a national cluster. In a domestic cluster, there are four important factors: 1) factor conditions including product factors such as human capital, real capital and knowledge resources, 2) competition promoting the innovation and productivity of enterprises; however, stress does not only come from local competitors, but also from international rivals, which depends on the level of openness, 3) demand conditions influencing innovation behavior, when sophisticated domestic clients pressure firms to be more efficient and create more advanced products and 4) related and supporting industries providing the fundamental infrastructure, which strengthens the knowledge spill-over effect through communication among geographically nearby industries and reduces transaction costs. Two additional factors should not be discounted: one is chance, which affects competition but is beyond the control of a firm. The other is government, which can influence each of the four determinants above (either positively or negatively). Traditional innovation policy focuses mainly on correcting market failure and maintaining competition orders through competition policy, while the innovation system theory emphasizes the interaction synthesis effect between different actors. Innovation-oriented competition in domestic clusters determines the innovation performance of firms and industries (Porter, 1990). The firms play a key role in the competition and innovation process. The government needs to provide necessary resources and a fair growth milieu for firms.

Similar to Porter, Nelson attaches great value to the impact of institutions and systems (Nelson,

1993). His national innovation system highlights the importance of state policy and specific institutions for innovation. Furman, Porter and Stern combine all the three of the theories above and divide the determinants of the national innovation environment into three categories: 1) infrastructure, innovation resources and policy, 2) the role of the industrial cluster and 3) the linkage between these two parts (Furman et al., 2002). The new national innovative capacity framework suggests not only the general innovation input formulated in the Romer function [1] but also the determinants of the innovative milieu:

$$\dot{A}_{j,t} = \delta_{j,t}\left(X_{j,t}^{INF}, Y_{j,t}^{CLUS}, Z_{j,t}^{LINK}\right) L_{j,t}^{A\lambda} A_{j,t}^{\phi} \qquad [2]$$

where $\dot{A}_{j,t}$ denotes the innovation production of region *j* in year *t*, $L_{j,t}^{A\lambda}$ the input of capital and human resources and $A_{j,t}^{\phi}$ the knowledge stock. The vector $X_{j,t}^{INF}$ is the entire innovation infrastructure, the R&D activities of the government and the openness of the region; vector $Y_{j,t}^{CLUS}$ is the cluster-specific circumstance for innovation in the region, particularly universities and research institutes and $Z_{j,t}^{LINK}$ is the linkage between the innovation infrastructure and the cluster.

Vectors $X_{j,t}^{INF}$, $Y_{j,t}^{CLUS}$ and $Z_{j,t}^{LINK}$ complement each other and play a role similar to indicators of innovation input and knowledge accumulation. These three factors are introduced in exponential form; thus, equation [2] would be rewritten into a new form, $\dot{A}_{j,t} = \delta\, X_{j,t}^{INF\,\delta_1}\, Y_{j,t}^{CLUS\,\delta_2}\, Z_{j,t}^{LINK\,\delta_3}\, L_{j,t}^{A\lambda}\, A_{j,t}^{\phi}$ (Furman & Hayes, 2004), which can be transformed into a new model via a logarithmic transformation (the natural logarithm of "*ln*" in model [3]):

$$\ln \dot{A}_{j,t} = \delta_1 \ln X_{j,t}^{INF} + \delta_2 \ln Y_{j,t}^{CLUS} + \delta_3 \ln Z_{j,t}^{LINK} + \lambda \ln L_{j,t}^{A} + \phi \ln A_{j,t} + \epsilon_{j,t} \qquad [3]$$

Furman et al. (2002) and Hu and Mathews (2005, 2008) apply model [3] to the national level for the OECD and Asian countries, yet the model could also be appropriate for the regional innovation systems on a provincial level in China for the following reasons: 1) With regard to area, population and economic volume, most Chinese provinces are as large as a country. 2) Since the reform of the late 1970s, and especially since the 1990s, the central government has given more and more freedom in terms of economic policy to local governments, who can now decide most concrete economic measures by themselves. 3) It is reasonable to analyze at a local instead of a national level, because the development stages, culture and habits are quite different

in different provinces of China (Liu & White, 2001).

Regional decentralization has shaped China's transition. In China's institutions, which are viewed as a regionally decentralized authoritarian system, the central government has control over personnel affairs, while local governments are responsible for the economy (Xu, 2011). Li (2007a) estimates the determinants for the disparity between the innovative capacities of China's provinces by analyzing the innovation subjects in innovation systems. He divides the innovation system into two parts. The first part concerns the participants in a region, including companies, universities, research institutes, the government and the interaction between these participants. The other part is institutions such as rules and the relationship between government and market. But this kind of institution is normally established at a national level, while the impact of regional institutional factors is frequently ignored. The changes of innovation participants and the differences in the innovative capacity of companies at a regional level has led to the gap in regional innovative capacity. However, reform and the division of power have induced local institutional competition in China (Cheung, 2009; Kou, 2015), which has resulted in regional institutional divergence. As such, **hypothesis 1** is that *the innovation system influences regional innovation performance in China.*

Unlike the OECD countries, China is a latecomer and has experienced massive reforms and a process of transformation to a market-oriented economy in the last decades. Marketization refers to building an order of fair competition and an economic system where the market plays a fundamental role in resource allocation. Park et al. (2006) find that the market-oriented reform, including the decentralization of control, refreshing the government-firm relationship, improving the competitive environment and defining property rights clearly, has affected the economic performance of China by shaping incentives in management and changing transaction and agency costs.

Thanks to the Chinese marketization index of the Chinese National Economic Research Institute (Fan et al., 2011), we can quantify and distinguish the important institutional factors in terms of marketization. We apply the marketization index to the innovation infrastructure parameters $X_{j,t}^{INF}$. **Hypothesis 2** is formulated as follows: *market-oriented institutions has a positive impact on China's regional innovation performance*.

In the following sections, we evaluate the extent to which the regional innovation system influences China's local innovation performance, thereby analyzing the innovation infrastructure, cluster milieu and linkages between them with the help of the model of Furman et al. (2002). We place special emphasis on the impact of the marketization level.

4.3 Data

We established a panel dataset with information on the innovation activities of 30 Chinese provinces, autonomous regions and directly controlled municipalities in mainland China (hereinafter called provinces) between 1998 and 2008,[7] which is partly comparable to that employed by Furman et al. (2002) for the OECD countries. The data used here comes from the National Bureau of Statistics of China, the China Statistical Yearbook on Science and Technology and the National Economic Research Institute (NERI) Index of Marketization.

4.3.1 Innovation output

We chose the number of patents granted as an indicator of regional innovation output. Patents are a frequently used variable for innovative activity in the literature on innovation research, and the association between these two factors is widely recognized (Griliches, 1984, 1990; Mansfield, 1986; Patel & Pavitt, 1994; Pavitt, 1988; Schmookler, 1966). Acs and Audretsch (1989) and Acs, Anselin, and Varga (2002) argue that patents provide a fairly reliable measure of innovative capacity. Because patent laws and regulations have no large differences at the provincial level in China, patents are an appropriate indicator for reflection regional levels of innovation. In this chapter, we only used the invention patent, because compared with the other two types (utility and design patents), invention patents require more high-tech and are often used as an indicator for independent intellectual property (Li, 2012).

Generally, the process from patent application to granting lasts a period of time, so we had to consider the lag between research input and patent output. Furman and Hayes (2004), Furman et al. (2002) and Hu and Mathews (2005, 2008) use a lagged variable of three years in their regression. In China, this process usually lasts three years as well (Li, 2007b). As such, we imported the number of domestic invention patents granted in year *t+3* (PATENT_GRA) and patents granted per capita in year *t+3* (in terms of population, in millions) (PATENT_POP).

Figure 4.1 and Figure 4.2 report two province-level measures of differences in the intensity of innovation across regions. Figure 4.1 presents the total number of patents granted, and Figure 4.2 provides the number per million residents between 1998 and 2008. Both of the graphs demonstrate that there are distinct trends in innovation performance among provinces. Beijing and Shanghai are the most innovative regions in China. Guangdong, Jiangsu, Zhejiang and Tianjin also could be seen as important innovation centers, while the other regions suffer from a relatively low level of innovation performance. This phenomenon also demonstrates the

[7] Due to missing values we didn't use the data of Tibet.

necessity of controlling for the individual effects of provinces in regressions.

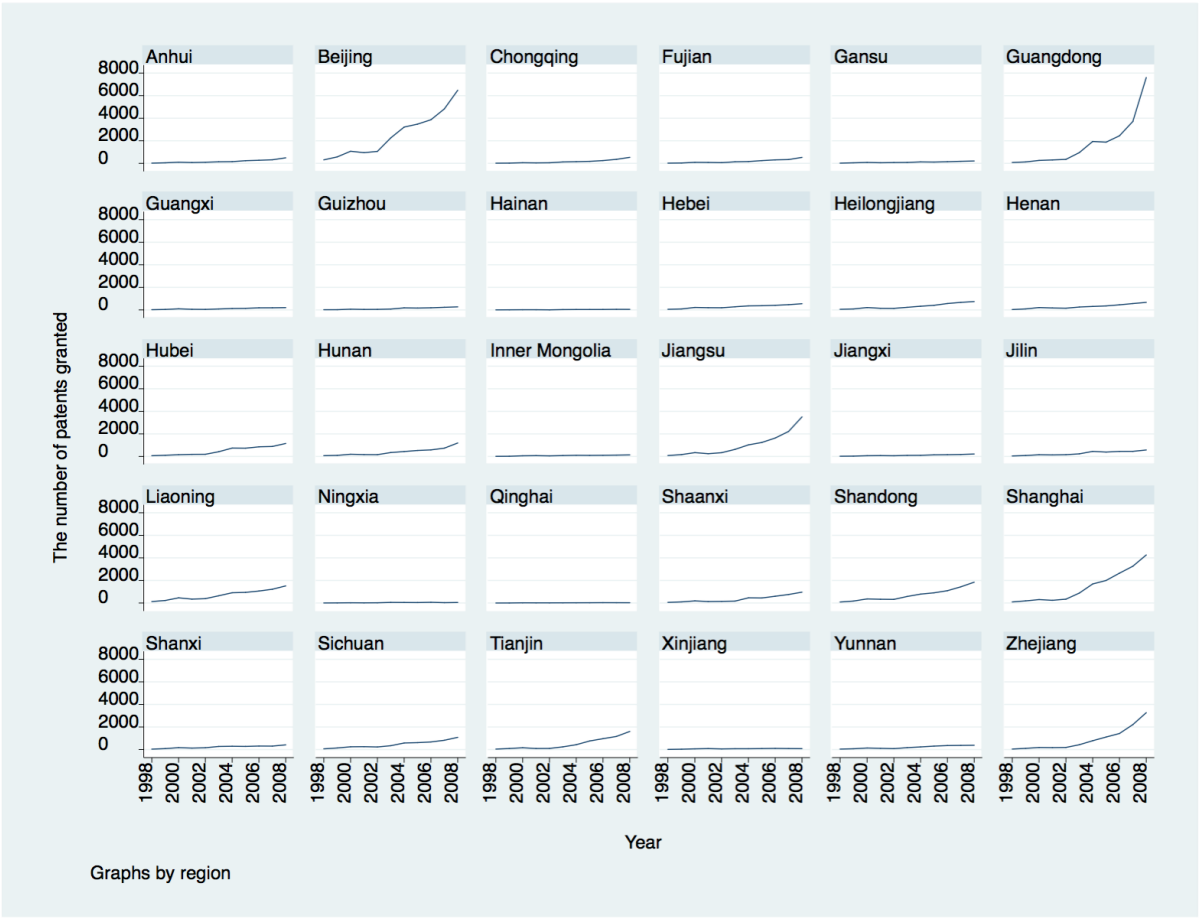


Figure 4.1: The number of patents granted 1998 to 2008

Source: National Bureau of Statistics of China

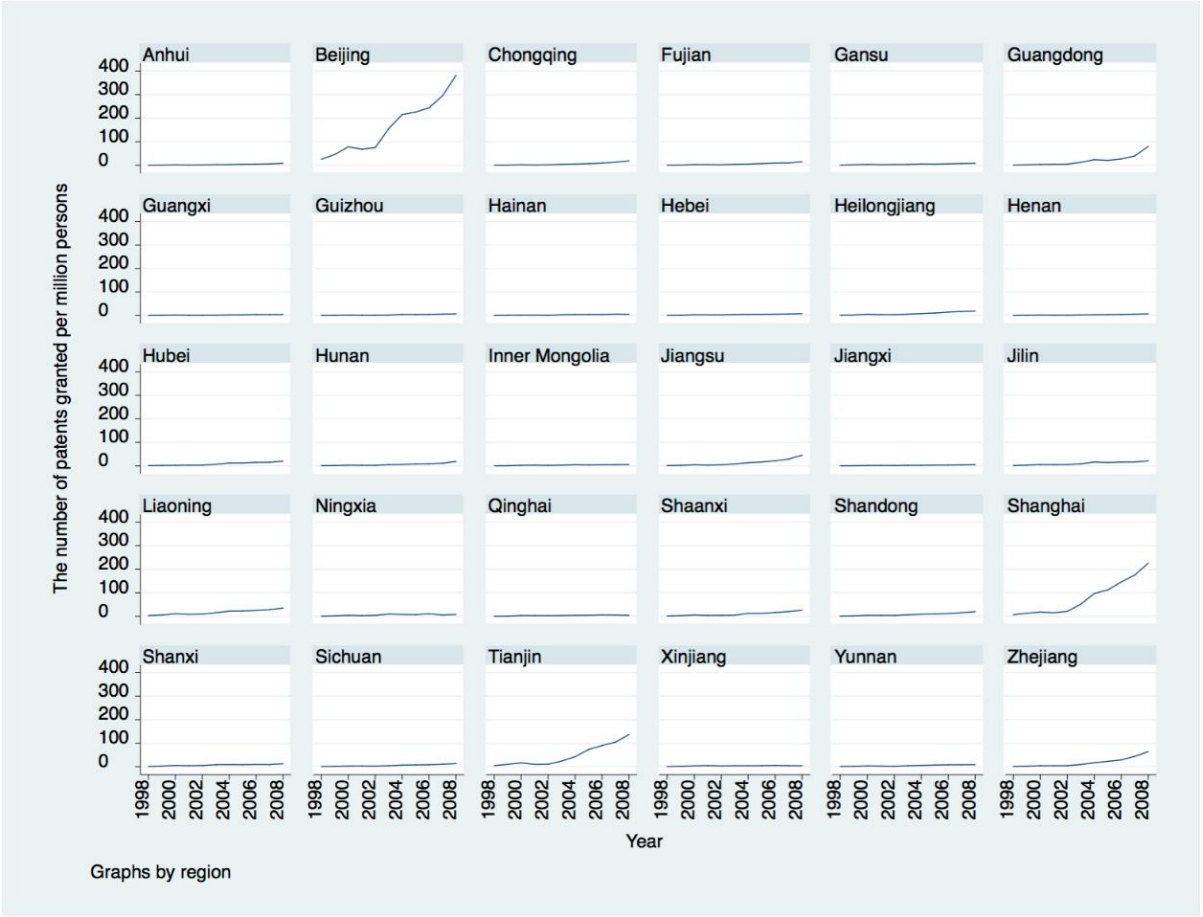


Figure 4.2: The number of patents granted per million persons 1998 to 2008
Source: National Bureau of Statistics of China

4.3.2 Traditional innovation input

According to the FP&S model, innovation input includes professional labor forces (or real capital) and knowledge stock. For labor input, we used the number of full-time equivalents of R&D personnel in a province from the China Statistical Yearbook on Science and Technology (PERSONAL), which contains all of the full-time R&D staff in research institutes, universities and enterprises. For knowledge stock, we employed the GDP per capita of the province. Per capita GDP captures the ability of a country, or in this case a province, to translate its knowledge stock into a realized state of economic development (and thus yields an aggregate control for a country's, or province's, technological sophistication) (Furman et al., 2002). Figure 4.3 demonstrates the number of R&D employees in each province between 1998 and 2008. Beijing, Guangzhou, Jiangsu and Zhejiang have invested more in R&D employees than the other provinces, which corresponds partly to the innovation output presented in Figure 4.1 and Figure 4.2.

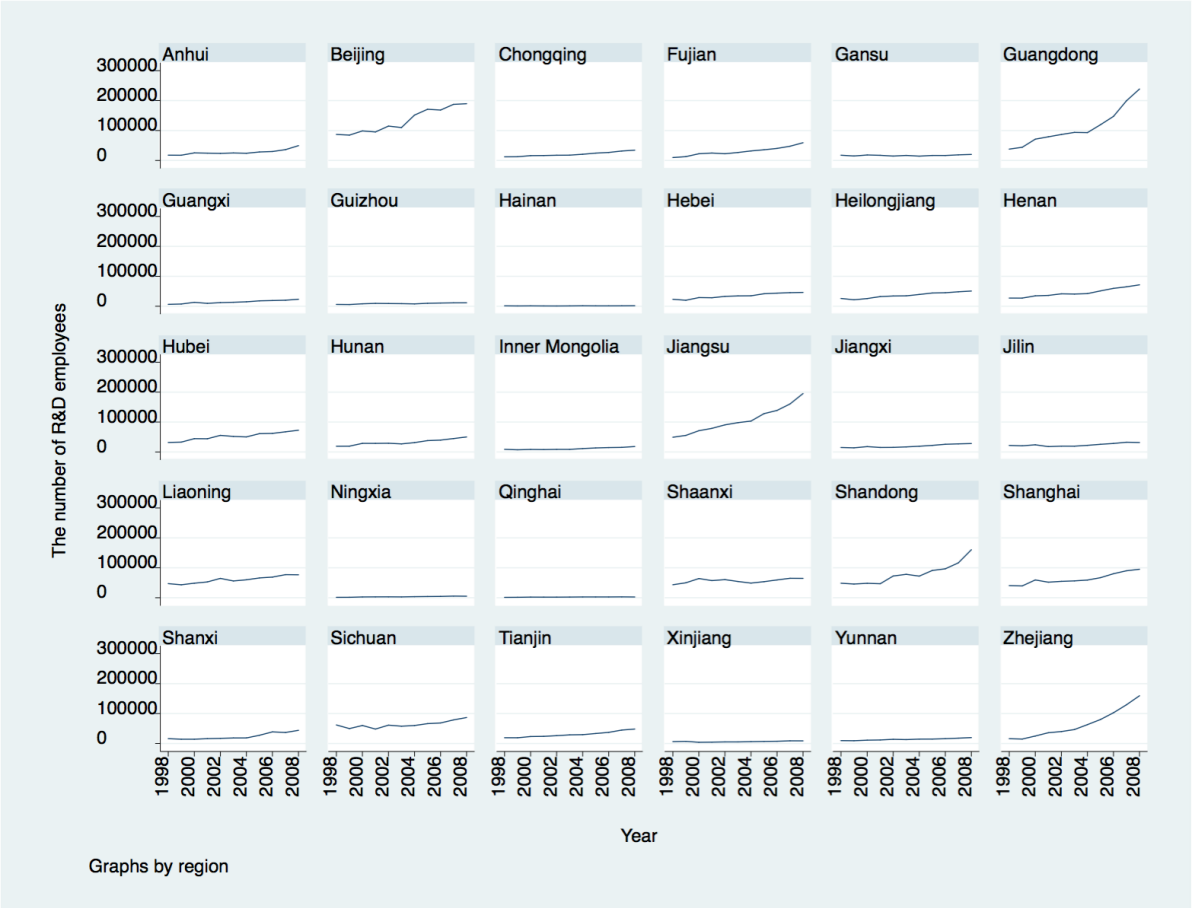


Figure 4.3: Change of R&D human capital

Source: National Bureau of Statistics of China

4.3.3 Indicators of innovation systems

Innovation infrastructure refers to factors of fundamental institutions and the role of the government. We imported the percentage of international trade volume in relation to GDP (OPENNESS) and the share of education expenditure of total government spending (ED_SHARE). Another important element is the marketization process. The experience of industrial countries has proven that the best way to modernize is to build a market-based economic system (Fan, Wang, & Zhu, 2006). The NERI Marketization Index measures the marketization levels of 31 Chinese provinces between 1997 and 2009 and demonstrates the growth process of a market-oriented economy in China. This index has been widely used by many researchers to measure regional institutional development (Chen, Firth, Gao, & Rui, 2006; Chen, Firth, & Xu, 2009; Firth, Lin, Liu, & Wong, 2009; Li, Yue, & Zhao, 2009; Wang, Wong, & Xia, 2008). The higher the point value is, the more "market-oriented" the province is. Marketization is divided into five subcategories: (1) the relationship between government and market, such as the role of markets in allocating resources; (2) the development of non-state

economy, such as industrial output of private sector; (3) the development of product markets, such as regional trade barriers; (4) the development of factor markets, such as foreign direct investment and mobility of labor; and (5) the development of intermediary organizations and the legal system, such as the protection of property rights (Chen et al., 2006). We introduced the development of intermediary organizations and the legal system (rule of law) (INTER) which encompasses the development of intermediary organizations, the protection of the rights of employees, intellectual property and the protection of the rights of consumers. In China, legislative power is exercised by the National People's Congress at the national level. The province has no power to adopt laws, but it may enact corresponding local orders and regulations and must create a fair environment for the rule of law. In order to estimate the effects of marketization reform more precisely, we added another a subcategory to this index, which contains concrete indicators of market-oriented institutions: the protection of intellectual property (IP).

Besides infrastructure, regional innovation performance also depends on the milieu of concrete clusters at a meso-level. The variable that we chose as indicator of the properties of clusters and industry structure is the share of the tertiary sector of GDP. As Porter (1990) argues, individual clusters tend to be associated with the industrial structure of local areas. We introduced the share of the tertiary sector of a province's GDP (TERTIARY) as a proxy for economic structure in a province's cluster.

For a given cluster innovation environment, innovation output may tend to increase with the strength of the common innovation infrastructure (Furman et al., 2002). Network formation and establishing new linkages might be established by affecting career patterns and incentive systems in firms and at universities (Lundvall, Johnson, Andersen, & Dalum, 2002). The connection and interaction between infrastructure and innovation-oriented clusters, as well as between R&D and production in clusters, are essential for an innovation system. This relationship can be interpreted through the behavior of institutions, such as research institutes, universities and financial institutions that fill in the blanks in the network. As such, we introduced two variables of this linkage. The first is the share of universities' R&D spending of the total R&D expenditure (UNI_RD). In latecomer countries, several fields of academic science are application-oriented, because these countries require more practical engineers for construction. This model not only influences people in industry, but also develops the scientific foundations of industrial technologies (Hu & Mathews, 2005). The second variable is the contribution of bank credit to S&T activities in a province (BANK). The bank plays a crucial role in China's economic growth and did so particularly when China was still lacking wide-

ranging financing channels decades ago. As such, we calculated the share of bank credits in total S&T funding to estimate the effect of financing channels. Table 4.1 presents the variable definitions and Table A.1 (see Appendix A) the descriptive statistics for all variables.

Variable		Definitions
	L_PATENT_GRA	Log of granted patents in the province *i* in year (*t+3*)
	L_PATENT_POP	Log of granted patents per million persons in the province *i* in year (*t+3*)
$A_{j,t}^{\phi}$	L_GDP_PC	Log of GDP per capita
$L_{j,t}^{A\lambda}$	L_PERSONAL	Log of amount of full-time equivalent of R&D personnel
$X_{j,t}^{INF}$	OPENNESS	Openness level (%): share of trade volume in GDP
$X_{j,t}^{INF}$	ED_SHARE	Share of local government's expenditures spent on education (%)
$X_{j,t}^{INF}$	INTER	Intermediary and law system
$X_{j,t}^{INF}$	IP	Strength of protection for intellectual property
$Y_{j,t}^{CLUS}$	TERTIARY	Share of tertiary sector in GDP (%)
$Z_{j,t}^{LINK}$	UNI_RD	Percentage of R&D expenditures from universities (%)
$Z_{j,t}^{LINK}$	BANK	Contributions of bank to scientific and technical activities (%)

Table 4.1: Definition of variables

4.4 Empirical results

Table 4.2 reports the empirical results of our research.[8] The dependent variable is the number of invention patents granted in province *i* in year *t + 3*. We analyzed the innovation performance in different variants through columns (1) to (4): First, we introduced only the regression with the fundamental factors of innovation input, followed by the variables of innovation systems and institutions, step by step.

According to Romer's endogenous growth theory, the volume of knowledge stock and the factor input determine innovation productivity. In column (1), we used the logarithm of GDP per capita and full-time equivalents of R&D personnel as indicators of the basic input level. According to regression results, both of the factors have positive effects on innovation performance. If GDP per capita increases by 10%, the number of patents granted rises by approximately 14.38%. If a region hires 10% more R&D staff, the number of patents granted goes up by approximately 8.74%.

[8] More details about regressions see Appendix A.

As explained above, the regional innovative capacity depends not only on innovation input, but also on the institutional milieu. Column (2) includes all variables of the innovation infrastructure. Both of the innovation infrastructure factors, OPENNESS (0.016) and ED_SHARE (0.090), have significantly positive effects. Although China's transition strategy since the late 1970s has been called the "reform and opening-up policy," "reform" and "opening-up" were in fact two separate parts, meaning that they were not simultaneously implemented. Opening-up was an engine for China's reform. Each further process of opening up brought the transition a step forward (Shi, 2009). The opening-up policy "forced" China to participate in the global division of labor and international competition. The other factor, education expenditure by local government, remains at a significant level, suggesting that policy variation plays an important role in determining innovation output. The amount of patents granted rises by approximately 0.9% if the government spends 10% more on education. Indicators of cluster circumstances were then added into the regressions. Furman et al. (2002) argue that the environment for innovation in industrial clusters is difficult to measure due to the subtlety of the concepts involved as well as the lack of systematic data. Because of the limit of data, we only used the development of tertiary sectors as indicator of industrial clusters. It is evident that TERTIARY contributes to innovation output. With the development of the economy the tertiary sector has been growing rapidly and contributed to the economic growth greatly. Provinces where the service sector is well developed are particularly innovative. One of the reasons for this could be that the tertiary sector contains a large number of industries that supply innovation activities with necessary services. Moreover, if we observe the financing channel, we find that if banks dominate the financing channel of S&T activities, the innovation output decreases.

The last factor that we observed is the influence of marketization reform. Columns (3) and (4) introduce the two marketization indicators respectively: intermediary organizations (INTER) and protection for intellectual property (IP). It is remarkable that both of these have significantly positive effects. Every additional unit of INTER and IP increases the amount of patents granted by around 0.87% and 0.44%, respectively. This proves that institutions influence innovation output in China and that a market-oriented system increases regional innovation performance.

	(1)	(2)	(3)	(4)
L_GDP_PC	1.438***	1.358***	1.121***	1.254***
	(0.186)	(0.176)	(0.193)	(0.185)
L_PERSONAL	0.874***	0.651***	0.358***	0.393***
	(0.169)	(0.149)	(0.124)	(0.130)
OPENNESS		0.016***	0.012***	0.009**
		(0.003)	(0.003)	(0.004)
ED_SHARE		0.090***	0.062**	0.061**
		(0.023)	(0.023)	(0.022)
INTER			0.087***	
			(0.020)	
IP				0.044***
				(0.014)
TERTIARY			0.071***	0.070***
			(0.010)	(0.011)
UNI_RD			0.004	0.002
			(0.007)	(0.007)
BANK			-0.013*	-0.014*
			(0.007)	(0.007)
_cons	-16.180***	-15.092***	-12.646***	-13.825***
	(1.662)	(1.446)	(1.113)	(1.186)
N	240	240	240	240
r2	0.766	0.806	0.865	0.864
r2_a	0.764	0.802	0.861	0.859

Standard errors in parentheses
* p<0.1, ** p<0.05, *** p<0.01

Table 4.2: Estimation results (granted patents as dependent variable)

In Table A.2 (see Appendix A), we replaced the dependent variable, the logarithm of the number of patents granted (L_PATENT_GRA), with the logarithm of the number of patents granted per million people (L_PATENT_POP) and estimated columns (1) to (4) once again in order to test the results' robustness. The coefficients are similar to those in Table 4.2. From columns (1) to (4) the variables L_GDP_PC and L_PERSONAL are positive and significant. We interpret this to suggest that the classic determinants of innovation are also important motors for innovation performance. The other results are also robust to the modification: OPENNESS, ED_SHARE, INTER, IP, TERTIARY and BANK.

4.5 Conclusions

In this section, we estimate the effects of innovation systems on regional innovation performance in China. For this purpose, we established a dataset across 30 provincial-level regions between 1998 and 2008. The results indicate that the traditional innovation input and innovation system contribute to increasing the level of innovation. The GDP per capita as indicator of knowledge stock plays a key role, which is identical with the results of Furman et al. (2002) and Hu and Mathews (2005, 2008). In the transition from a planned to a market economy, it is conceivable that output gains are the productive combination of existing factor stocks (Blum & Dudley, 1998). In addition, institutional arrangements also affect innovation output.

The different factors of the innovation system have different effects: innovation infrastructure, including the level of openness of a region and government expenditure on education, is necessary for innovation. As to openness, it is of importance for local firms to be active in international competition. The combination of global orientation and local strength is considered essential for China to catch up the West. However, some firms hesitate to enter foreign markets (Blum & Zhao, 2015). The provincial government should build an efficient mechanism to encourage local firms to participate in "go-out strategy"[9]. Furthermore, attracting international capital and technology to China can also help provinces to improve their innovation performance. Besides capital, human resources play an important role. Indeed, the integration of human capital and invested capital is seen as one of the factors influencing the prosperity and the education and training at work places are especially essential (List, 1841).

Another result is that the extent of bank credit does not influence innovation output. In China, the largest banks are controlled or influenced strongly by the state and would prefer to grant credit to SOEs, because SOEs' credit is "endorsed" by the government. It is evident that the frequent engagement of banks in R&D financing cannot promote the level of innovation. The reason could be that the innovation capacity of SOEs still stay at a relatively low level, although it is easier for them to obtain capital for R&D from banks than private firms.

Finally, our results suggest that institutional factors play an important role in increasing the level of innovation. A market-oriented economic structure, especially healthy intermediary organizations and protection of intellectual property, helps a region to achieve a better outcome in innovation activities.

In political terms, the findings suggest that an ideas-driven growth model is appropriate for

[9] http://english.gov.cn/news/top_news/2016/04/11/content_281475325205328.htm

innovative activities in China. The provinces should not only concentrate on training sophisticated engineers and researchers but also attempt to participate in international competition and focus on the education and training of new generations. It is necessary to continue to promote China's economic reform and transformation to a market economy. For local governments, it is beneficial to build a framework of economic fairness for the intermediary market to provide infrastructure services to innovation performers.

5. Market structure and innovation

China's transition is leading to a change in market structure, which in turn is influencing innovation activities. Using panel data from Chinese industrial firms, this chapter examines the effects of the market structure on innovation performance at the firm level. We find there is a non-linear relationship between market concentration and innovation, and the influences of market structure vary by region and industry.

5.1 Introduction

The relationship between market structure and firm behavior is one of the most important fields of industrial organization (IO). There have been many significant contributions to the research of market structure ranging from the Harvard School, the Chicago School to the various approaches of game theory, from economists, jurists to politicians. This research into market structure includes competition and monopoly, firm organization such as internal R&D, and also public policy such as economic regulation.

An attractive area of IO that has interested scholars in recent years is the relationship between market structure and innovation, a field tackled by the theoretical IO and the endogenous growth literature (Aghion et al., 2005). However, both theoretical and empirical research obtained controversial results under different preconditions with distinct datasets from different countries or regions.

Meanwhile, the relationship between market structure and innovation performance, considered a crucial element of firm behavior, represents one traditional and essential research topic in the economics of innovation (Castellacci, 2011). As the core entity of innovation activities (Mortensen & Bloch, 2005), firms play a key role in improving the innovation performance of the whole system. On the other hand, besides the firm itself, innovation activities are also influenced by market features such as competition or the monopoly level in a market. According to the Harvard School, market structure determines a firm's economic conduct, which impacts its performance (Bain, 1968) pertaining to technical efficiency and innovativeness (Porter, 1981). Aghion et al. (2005) divide market competition into two types: "neck-and-neckness" and "leader-laggard", based on the technology gap of firms. In distinct markets there can exist two different effects of market structure on innovation. First, the escape-competition effect, which

postulates that competition leads to high levels of innovation. Second, the Schumpeterian effect, which argues that a monopoly increases innovation output.

This chapter reexamines this topic from an empirical perspective and provides evidence from China's industrial enterprises. In recent decades, China has experienced a thorough change in economic institutions. The transformation from a planned economy to a market-oriented system has changed market structures that were previously shaped by the Soviet-Model. On the one hand, the state no longer interferes in many industries, and at the same time, private enterprises play a more important role in the economic system. On the other hand, state-owned enterprises (SOE) are concentrated in certain sectors, meaning barriers to market entry still exist. Meanwhile in some other industries, technologically-advanced (private) firms or market pioneers dominate markets. This recent phenomenon has re-shaped market structures in China. Moreover, China has experienced several rounds of industrial structure upgrading. This upgrading is attributable to changes in the international environment such as the industrial transfer in East Asia, China's accession to the WTO, and the diversification of indigenous demands. Indeed, this industrial structure upgrade has led to outdated and unsustainable industries being eliminated from China, or transferred to underdeveloped countries. In some cases, these industries are relocated from China's eastern provinces to western and central regions, whereas more and more technology-oriented industries are being established in China. The industrial upgrading and the diversity of technological patterns characterize the innovation activities and innovation performance of firms.

The core question of this chapter is how market structure affects innovation performance. Besides focusing on the relationship between market structure and innovation, this part also takes the geographic disparity between regions and the technological features of industries into account. Based on theories of IO and innovation economics, we investigate this research question by using panel data from Chinese industrial enterprises between 2005 and 2007.

The remainder of this chapter is organized as follows: Section 5.2 provides the conceptual background and hypotheses, Section 5.3 presents the dataset. Section 5.4 demonstrates the results and Section 5.5 concludes.

5.2 Conceptual background and hypotheses

The Harvard School and Chicago School originated two important economic theories in the IO field. The Chicago School argues that firm performance determines market structure. An enterprise can obtain large market share as it has higher productivity when competing with its rivals. The market concentration is the consequence of firm behavior and the market's

efficiency, without government interference, encourages firms to seek efficiency in their production and distribution (Friedman, 1964). In contrast, the Harvard School uses the Structure, Conduct and Performance paradigm as an analytical framework to explain the relationship among market structure, market conduct and firm performance (Bain, 1968).

According to this traditional industrial organization paradigm, market structure, defined as the economic and technical dimensions of a market that provides the context in which competition or monopoly occurs (Bain, 1972), influences the conduct, which presents the firm's choice and strategy such as price or advertising. The firm performance, for instance allocative efficiency (profitability), technical efficiency (cost minimization) and innovativeness (Porter, 1981), is then determined by market conduct. For this reason, the market structure plays a dominant role. Large-scale enterprises with high market concentration tend to increase prices and build barriers to entry in order to pursue monopoly profit. Thus, as far as the implications for economic policies are concerned, the government should focus more on market structure and use public policy to influence firm behavior (Mason, 1939), limit possible monopolistic activities and secure proper competition in markets. The Harvard School theory is considered a useful contribution to strategy formulation in a market and provides a systematic model for assessing the nature of competition in an industry (Porter, 1981).

As mentioned above, firm performance contains factors of innovation performance which describes the innovation output of innovation activities of firms. In recent years, the influence of market structure on innovation performance is considered to be an important topic in the economics of innovation. Several scholars have contributed to both theoretical and empirical research in this field. The theoretical study of the relationship between market structure and innovation represents two main arguments (Aghion et al., 2005; Castellacci, 2011; Hashmi, 2013): First, the idea itself goes as far back as Schumpeter (1942), who found that competition may decrease the monopoly rents of firms, thus reducing their incentive to innovate. This is the first argument known as the Schumpeterian effect, which demonstrates that profits will be limited at high levels of competition and thus competition reduces innovation. The second is the escape-competition effect. This theory highlights that the relationship between competition and innovation is positive because a firm needs to innovate to escape competition from rivals.

In order to combine market structure with innovation performance, we assume a market with duopolies. The market can be categorized into two types. The first is a sector in which firms compete neck-and-neck (NN) and the technological gap between competing firms is small. In contrast, in the other market, firms are technologically unequal, meaning that one firm, as the

market leader, is more technologically-advanced than the other (the laggard). Therefore, it is called the leader-laggard market (LL) (Aghion et al., 2005; Hashmi, 2013).

As regards the Schumpeterian effect, which puts forward that high competitive intensity in a market reduces the profits of a firm, monopoly would increase innovation, while considering an escape-competition effect, more competition could increase innovation. With both market structures and their effects on innovation we combine them in a four-field matrix (see Figure 5.1):

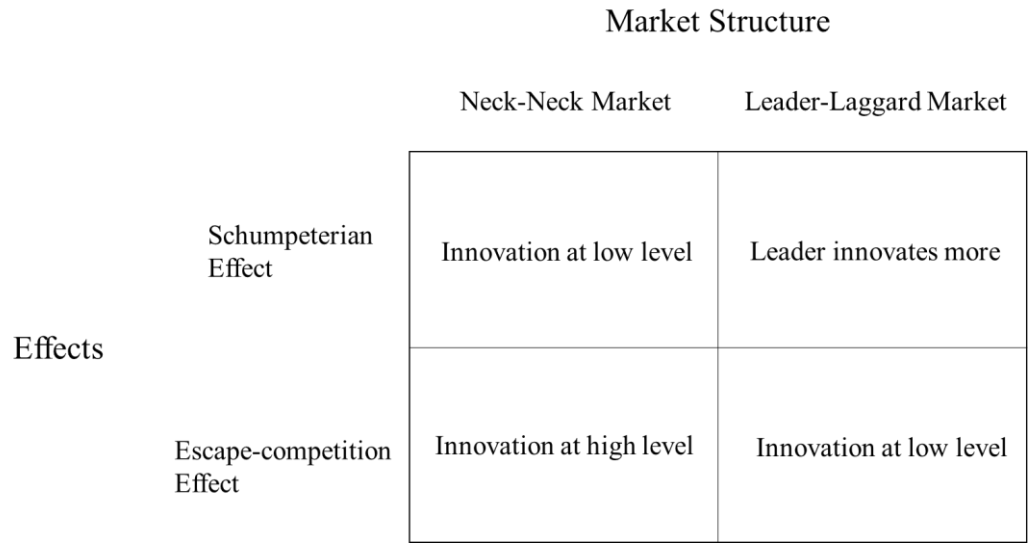


Figure 5.1: matrix of market structure and effects

With respect to the Schumpeterian effect, both of the technologically equal firms would not have high motivations to participate in innovation activities in NN market. However, in the LL market the technology-advanced firm will innovate more than the laggard counterpart. Aghion and Howitt (1992) demonstrate the Schumpeterian effect in their original Schumpeterian growth model. As for the escape-competition effect, firms in NN markets have incentives to innovate in order to escape competition from rivals. By contrast, in LL markets, where competition stays at a low level, firms do not have high motivations to invest in innovation.

Besides these two cases, the effects on the level of innovation might vary under different types of market structure. Aghion et al. (2005) argue that escape-competition effect dominates the Schumpeterian effect in the NN market, while the Schumpeterian effect dominates the escape-competition effect in the LL market. For these reasons, they believe there is a non-linear relationship between competition and innovation. In summary, as regards all circumstances touched upon above, the relationship between market structure and innovation should not be simply interpreted as a linear correlation.

The theoretical arguments can be further substantiated by empirical research. In fact, the classic works in this field were motivated by empirical investigations (Castellacci, 2011). The results of the empirical research for these two effects, however, are controversial. In some cases, it is shown that competition enhances innovation (Arrow, 1962; Geroski, 1990; Nickell, 1996), while in other cases, competition is seen to discourage innovation (Acs & Audretsch, 1987; Mansfield, 1963; Scherer, 1967). In recent years, scholars have discovered that the degree to which competition or the concentration of a market may have on a firms' innovative activities could be more complex than simply a positive or negative linear relationship. Aghion et al. (2005) point out the existence of an inverted U-shape relationship between market competition and innovation (Castellacci, 2011). Based on Cournot competition, Tingvall and Karpaty (2010) focus attention on industrial organizations and describe the optimal R&D choice of firms operating in an oligopoly market. The authors predict an inverse U-shape relationship between competition and innovation in service sectors.

So our **Hypothesis 1** is formulated as: Due to the two contradicting forces of the Schumpeterian effect and escape-competition effect, there is a non-linear relationship between market structure and innovation.

However, turning to China's current situation, it is insufficient to only investigate the market structure of China as a whole entity due to the great disparities in the country. The development periods, the innovation competence, geographic characteristics and the institutional framework vary from region to region. Due to the vast expanse of the area, these regional disparities are much larger in China than in many other countries. Moreover, regarding China's reform process in recent decades, it is worth noting how the disparity in the establishment of market-oriented institutions has risen (see Chapter 4). This disparity leads to a widening development gap and obvious distinctions in the market and industrial structure between regions. Therefore, another factor that should be taken into account is geographic location. In China's economic development, innovation performance, as well as political and institutional framework conditions vary from province to province – much more so than in many other countries. Thus, it is reasonable to assume that the innovation performance of firms would differ accordingly.

In the eastern regions for example, since the reforms, provinces have developed dynamically and have established relative market-oriented institutions. State power intervenes less frequently in markets than in other provinces. Meanwhile, many outdated industries have been eliminated or transferred to South Asian countries or western and central Chinese provinces. Provinces in eastern China, like the classic "islands of innovation", including Beijing, Shanghai and Guangdong (Kroll & Liefner, 2008; Kroll & Schiller, 2010), concentrate more on high-tech

sectors and invest more into R&D. On the other hand, regions in western and central China continue to lag behind (Kroll, 2010). For these reasons, it is reasonable to analyze to what extent these general trends with regard to the regional distribution of development as well as geographic locations influence the innovation performance of firms. Hence, we suggest as **Hypothesis 2**, that due to the disparity in the development level of the provinces, the influences of market monopoly vary from region to region.

Furthermore, the performance of firms is determined, not only by their market power, but also by their sectoral environment. China has experienced, and is experiencing, the process of industrial upgrading, which leads to low-tech industries exiting the market gradually and to technologically advanced sectors obtaining large amounts of support not only from private sectors, but also from government. The innovation performance of firms could also vary from industry to industry. In the catching-up regions in the middle and west of China, innovation activities are dominated by mature industrial sectors that have been transferred out of leading provinces. An argument for this phenomenon is that political interference demands a contribution from these provinces to the so-called "indigenous innovation" (Kroll, 2015), more precisely, to innovate through indigenous S&T and resources instead of purchasing foreign technologies and know-how. The profitability and innovation performance of firms in these low-or medium-tech industries are more dependent on their scale and the market share as there is little potential to achieve huge technological progress in these mature sectors. In addition, firms have to obtain new products or production processes through size expansion, while in high-tech or young industries, innovations, especially radical innovations, occur more frequently (Bos, Economidou, & Sanders, 2013). Jefferson et al. (2003) use panel data from China's 22,000 large-and medium-size enterprises for 1994–1999 and investigate patent applications in different sectors. They find a high concentration of patenting activity within China's manufacturing sector, and among the patent applicants, the petroleum and gas industry leads by a wide margin.

As **Hypothesis 3**, we suggest the effects of market structure on innovation of firms could be distinct in different industries. The innovation performance of firms in low-tech sectors might more depend on the their market share than those in technology-advanced industries. So the model of our analysis is formulated as:

$$INNO_{i,t} = \beta_0 + \beta_1 HHI_{j,t} + \beta_2 HHI_{j,t}^2 + \sum_{p=1}^{s} \delta_s X_{i,t} + \epsilon_{i,t}$$

where $INNO_{i,t}$ stands for innovative output of firm *i* in year *t*, *HHI* is the Herfindahl Index and HHI^2 is the quadratic term, and X is the vector for other control variables.

5.3 Data

This chapter uses a rich dataset from China's large-and-medium-sized industrial enterprises collected by China's National Bureau of Statistics since 1994. This "China Annual Survey of Industrial Firms" (Nie, Jiang, & Yang, 2012) is considered to be one of the most important and comprehensive micro-level dataset of firms in China and has been used widely by researchers[10] (Hsieh & Klenow, 2009; Hu & Jefferson, 2009; Song, Storesletten, & Zilibotti, 2011). Our dataset includes around 200,000 large- and medium-sized industrial enterprises between 2005 and 2007, containing 582,712 observations.

The dataset covers 482 four-digit industries over three years. If an industry includes too few companies, the Herfindahl Index would become extremely large, which, could in turn, create bias in the regression results (Chen & Zhu, 2011). Therefore, we eliminate industries containing less than 15 companies and preserve 468 four-digit industries.[11]

As an indicator for innovation performance we use new products. Schumpeter (1934) distinguished between five types of innovations: new products, new methods of production, new sources of supply, exploitation of new markets, and new ways to organize business. Kraft (1989) measures innovation as the percentage of products newly developed in sales. Jefferson (2006) also uses new products as an indicator for innovation output. So we use the percentage of newly developed products of firms in sales to measure innovation output. According to Jefferson et al. (2003) the criteria used in the dataset for measuring the variable "new products sales" is defined below:

"Products included in the category of 'new product sales' are those which are new in relation to the reporting firm's prior product mix. Products that involve the use of new principles, incorporate design improvements, utilize new materials, or embody new techniques constitute new products; existing products that are used for new functions or expand capabilities (e.g., production or speed) also constitute new products."

The reason that we give up patents, which are also widely used as indicators of innovation, is that many firm's patents have never been commercialized, or are rather only used for minor

[10] More details about this database see Nie et al. (2012)
[11] More details about regressions see Appendix B.

modifications of existing products. Indeed, some innovations are not patented at all (Kamien & Schwartz, 1982). It is particularly common, due to budget restrictions that innovations are not patented at all within small and medium sized enterprises. Since around 96.7 % of firms in the dataset have fewer than 1,000 employees, and thereby are defined as small and medium industrial enterprises in China, it is reasonable to use new products instead of patents as a method to quantify innovation performance.

The Herfindahl Index is introduced as a measure of market concentration in relation to the industry and frequently used by scholars as an indicator of market structure (Chen & Zhu, 2011). We also use the Herfindahl Index in this chapter to quantify the market concentration. The variable is defined as:

$$HHI_j = \sum_{i=1}^{n} \left(\frac{Revenue_i}{\sum_{i=1}^{n} Revenue_i} \right)^2$$

where HHI_j stands for the Herfindahl Index of industry j and $Revenue_i$ for the annual revenue of firm i. In order to avoid the potential endogeneity (simultaneous causality bias) of innovation output and market structure, we will also introduce the one-year lagged term of Herfindahl Index (Granger, 1969).

Another central Schumpeterian hypothesis refers to the relationship between firm size and innovation. Empirical studies cast doubt on a consensus in this field. Some scholars find a positive relationship between firm size and innovation activities (Link, 1980; Soete, 1979), while some found little evidence of such a relationship (Mansfield, 1964). So the number of employees of a firm will be introduced to measure the influence of firm size on innovation in China's industrial enterprises. Table 5.1 and Table B.1 (see Appendix B) demonstrate the definitions of variables and the descriptive statistics.

	Variable name	Definitions
Dependent Variables	INNO	Output value from new products/total revenue
Independent Variables	HHI	Herfindahl Index
	HHI2	Squared term of Herfindahl Index
	LABOR	Log of the number of employees
	RD	R&D spendings / revenue

Table 5.1: Definitions of variables

5.4 Empirical Results

Table 5.2 demonstrates the effects of market concentration on innovation performance with regard to three-digit and four-digit industries (Herfindahl Index)[12]. Our analysis has found that for all Chinese industrial companies in the sample, the market structure has non-linear effects on the output value of a firm's new products. More precisely, there is an inverted-U relationship between market concentration and innovation performance. At a low level of competition, firms with higher market share perform more innovatively than those which have a lower market share. After a certain threshold, the market concentration turns out to be an obstacle for innovation. Column (2) and (4) demonstrate the results with lagged effects (one year) of Herfindahl Index and also show an inverted-U relationship.

Our analysis can confirm the other Schumpeterian assumption that large-sized enterprises have more resources (including human and monetary capital) to put into innovation activities than small firms. The variable LABOR has significant positive effects on the output value of new products. Moreover, R&D investment also has significant positive effects on the innovation performance of firms.

	(1) Three-digit	(2) Three-digit (one year lag)	(3) Four-digit	(4) Four-digit (one year lag)
HHI	0.779***	0.656***	0.382***	0.347***
	(0.039)	(0.050)	(0.018)	(0.023)
HHI2	-2.576***	-1.864***	-0.717***	-0.588***
	(0.165)	(0.222)	(0.058)	(0.071)
LABOR	0.012***	0.015***	0.012***	0.015***
	(0.000)	(0.000)	(0.000)	(0.000)
RD	0.965***	2.461***	0.965***	2.456***
	(0.054)	(0.124)	(0.054)	(0.124)
_cons	-0.020***	-0.037***	-0.020***	-0.038***
	(0.001)	(0.002)	(0.001)	(0.002)

[12] The regression results in this section have obtained relative low R squared values. Nevertheless, we believe that the results are plausible, because (1) from the practical perspective some researchers who have used the same dataset have also obtained results with small R squared values, for instance Song et al. (2011) and Chen and Zhu (2011); (2) from the technical perspective the R squared value reflects the variance of unobserved and observed parts and depends on the variance of residuals, while what we investigate in the chapter is the influence of market structure on innovation performance rather than the variance of residuals. Low R squared, therefore, does not mean low explanatory power of our regression models.

N	582712	267455	582712	267455
r2_a	0.030	0.081	0.030	0.082

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 5.2: Effects of market concentration

Figure 5.2 illustrates the simulation of effects of market concentration on innovation. The thresholds of the market concentration are ca. 0.151 and 0.266 at three-digit (graph 1) and four-digit level (graph 3) respectively. Graph (2) and (4) present the curves of HHI with one-year lag. Although all results can confirm our hypothesis, we choose the Herfindal Index at a four-digit level in the following sections. We do this because firstly, the value of the dependent variable that turns to be negative after HHI is larger than around 0.8, which makes the analysis unable to correspond to reality in the interval ca. 0.8 to 1. Secondly, because so much can be observed from the dataset, it is reasonable to classify industries in more categories to avoid the situation that too many firms concentrate in too few industrial classifications. Meanwhile, we will also present empirical results with lag effects of four-digit HHI in the next parts. The graph (3) in Figure 5.2 demonstrates the optimal market concentration that promotes innovation is 0.266, while the overall trend shows that market concentration at a low level increases innovation output more than that at high level. The increasing trend on the left of the maximum point is milder than the declining trend on the right side.

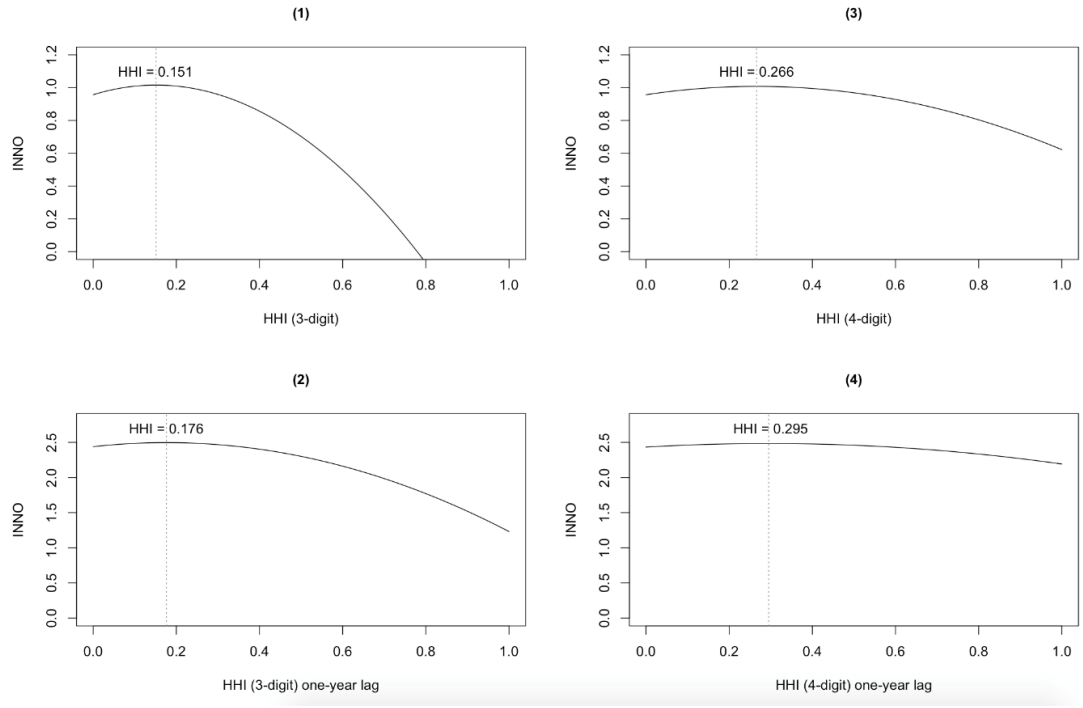


Figure 5.2: Simulation results from the model (3-digit and 4-digit level)

With respect to geographic locations in Hypothesis 2, our results have confirmed that market concentration has different effects in different regions (see Table 5.3). In eastern, central and western China, the relationship remains as an inverted U-shaped. However, it is remarkable to find that in the northeastern provinces, where the economy has fallen into financial difficulties due to structural problems, firms with high market concentration contribute to increasing the output of new products. Although their whole industrial infrastructure was established on a socialistic economic model since the beginning of People's Republic of China like other provinces, the northeastern provinces, including Heilongjiang, Jilin and Liaoning, which were viewed as one of the most important industrial bases of socialistic China before the reforms, were influenced most deeply by the planned economy and thus can be distinguished from other regions in the country.

However, since the marketization reforms, the economic structure of these northeastern provinces has been destroyed. This is partly because of the low capacity and low competitiveness of the central-planned enterprises and industries. Nowadays, there are few successful small- and medium-sized enterprises in northeast remaining. If we introduce the lagged effects of market structure in Northeast in Column (6), the effect of concentration turns to be insignificant.

Moreover, R&D investment and the size of the firms still play an essential role in innovation activities in all regions. The coefficient of R&D in the east achieves a higher level than that in other regions, which means that the innovation capital input is more important in coastal regions.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	east	east (one year lag)	mid	mid (one year lag)	northeast	northeast (one year lag)	west	west (one year lag)
HHI	0.392***	0.338***	0.370***	0.469***	0.313***	0.158	0.274***	0.297***
	(0.022)	(0.027)	(0.042)	(0.069)	(0.081)	(0.132)	(0.055)	(0.071)
HHI2	-0.738***	-0.611***	-0.724***	-0.754***	-0.338	0.201	-0.612***	-0.524***
	(0.074)	(0.080)	(0.082)	(0.169)	(0.385)	(0.714)	(0.132)	(0.139)
LABOR	0.010***	0.013***	0.011***	0.015***	0.017***	0.021***	0.020***	0.025***
	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.002)
RD	1.115***	2.672***	0.517***	1.776***	0.761***	1.395***	0.464***	1.624***
	(0.069)	(0.149)	(0.112)	(0.392)	(0.139)	(0.287)	(0.085)	(0.277)
_cons	-0.015***	-0.030***	-0.021***	-0.050***	-0.042***	-0.059***	-0.040***	-0.067***
	(0.002)	(0.002)	(0.004)	(0.006)	(0.006)	(0.008)	(0.006)	(0.008)
N	439283	210930	56551	19390	36960	15856	49918	21279
r2_a	0.041	0.098	0.014	0.054	0.019	0.031	0.017	0.052

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 5.3: Empirical results in different regions

With respect to industrial sectors, Hypothesis 3 could only be partly confirmed (see Table 5.4). In high- and medium-tech industries, there still exists an inverted-U relationship between market concentration and innovation, while in low-tech sectors, market structure has no influence. Although the influence of R&D expenditure and labor stay positive significant, R&D could make more contributions to innovation in high-tech industries than the other two, which corresponds to the reality that technologically-advanced firms depend more on R&D. Moreover, like the previous results, HHI with lagged effects demonstrates similar influences to that without time-lagged factors.

	(1) High-tech	(2) High-tech (one year lag)	(3) Mid-tech	(4) Mid-tech (one year lag)	(5) Low-tech	(6) Low-tech (one year lag)
HHI	0.784***	0.673***	0.270***	0.261***	0.026	-0.018
	(0.065)	(0.092)	(0.022)	(0.028)	(0.027)	(0.042)
HHI2	-2.078***	-1.738***	-0.509***	-0.437***	0.045	0.260
	(0.268)	(0.404)	(0.067)	(0.072)	(0.118)	(0.222)
LABOR	0.014***	0.019***	0.014***	0.017***	0.006***	0.008***
	(0.001)	(0.001)	(0.000)	(0.001)	(0.000)	(0.001)
RD	1.168***	2.176***	0.945***	2.447***	0.337***	2.480***
	(0.111)	(0.160)	(0.063)	(0.203)	(0.055)	(0.477)
_cons	-0.009**	-0.036***	-0.030***	-0.047***	-0.001	-0.013***
	(0.005)	(0.006)	(0.002)	(0.003)	(0.002)	(0.002)
N	89848	42245	290588	133246	202276	91964
r2_a	0.050	0.109	0.030	0.081	0.004	0.022

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 5.4: Empirical results in different industries

In Figure 5.3, we use the parameter values of high-tech and mid-tech industries given in Table 5.4 for new simulations. Comparing the relationships between HHI and innovation in these two industries we find strong evidence that the negative effects of market concentration are particularly obvious in technology-advanced industries: The optimum of HHI in high-tech

sectors (0.189) is smaller than that in mid-tech industries (0.265) and it is unsurprising that high-tech firms could achieve higher levels of innovation at the "peak" of the curve than their counterparts in mid-tech sectors. Furthermore, the right side of the curve in high-tech industries drops much more rapidly than that in mid-tech fields, indicating that market concentration is especially harmful for technology-oriented industries.

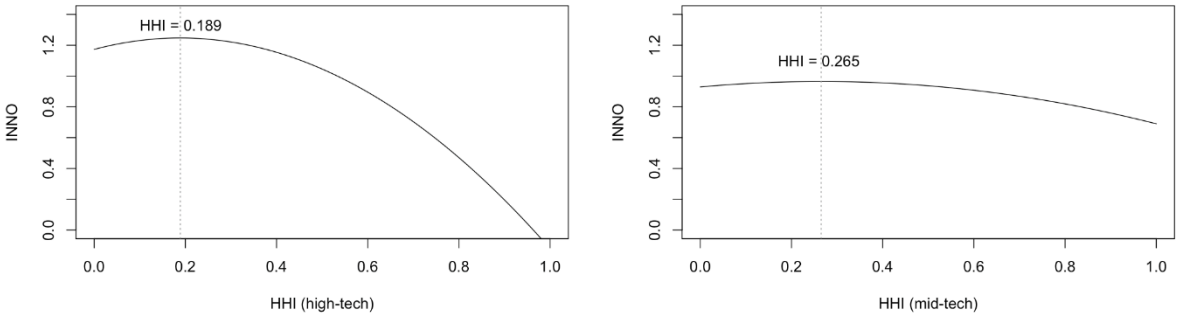


Figure 5.3: Simulation results from the model (in different industries)

5.5 Conclusions

Based on theories of industrial organization and innovation, this chapter explored the effects of market structure on innovation performance of Chinese industrial firms. In line with earlier studies, this research found that firm size and R&D expenditures are associated with the innovation output of firms. To be more precise, large enterprises produce more new products than small firms, and companies that invest more capital in R&D achieve more success in innovative activities. As far as industrial categories are concerned, R&D investment makes more of a contribution to innovation in high-tech industries than mid-tech and low-tech sectors. Most importantly, this chapter has provided new evidence from Chinese industrial firms for the long-term debate over the relationship between market structure and innovation. Our analysis has empirically confirmed that there is an inverted U relationship between market concentration and innovation performance, thus demonstrating that firms with high market concentration could undertake more innovative activities if the competition level in the market stays high. In addition, our analysis further confirms the effects would turn to negative after a certain threshold if the market is monopolized by a few firms. Despite the inverted-U relationship, it is remarkable to find that the overall trend of the curve is negative, which indicates that, in general, competition has a positive effect on innovation. Moreover, the positive effect of market concentration increases more slowly than its negative influence after it reaches the maximum of innovation. The reason that market concentration promotes innovation when concentration

stays at a low level might be that in a “radically” competitive market, where the Herfindahl Index is slightly higher than 0, firms need to obtain certain market shares to allocate enough resources to innovate.

As for technology levels, it is evident from the findings that high market concentration is particularly harmful for technologically-advanced firms. Competition plays a particularly important role in high-tech industries, while in low-tech sectors the innovation performance of firms does not depend on market structure. But from the results we realized our model may not supply appropriate variables to explain this relationship in low-tech industries. Future research investigating the effects of market structure for certain industries would be of value.

In political terms, public policy in relation to market structure greatly influences firm’s innovation performance. Our findings suggest that market concentration could not increase innovation in most cases, despite firms with high market share own more resources for innovation. The competition policy should take regional and industrial characteristics into consideration. For technology-oriented industries the government should especially focus on competition order of markets.

6. Innovation output and state ownership

China has experienced a surge in innovation output in which state-owned enterprises (SOE) play an essential role.[13] Using panel data of Chinese listed firms, this chapter examines the influence of the state ownership on innovation output at the firm level. Controlling for size, we analyze the effects of central and local government control on the number of firms' patent applications in different time periods. Doing so, standard assumptions on state ownership's inhibiting character are confirmed. However, we then qualify these finding by running separate models for different regions and sectors and find that the impact of state-control on innovation performance depends on a number of conditions. More precisely, state control of firms has a negative impact on innovation output in particular in China's Northeast region and in mid-tech sectors whereas under other circumstances it does either not matter or can even exert a positive influence.

6.1 Introduction

In many countries, SOEs are the main providers of public services such as energy, infrastructure and transport, which indicates that SOEs have an influence on everyday life of citizens and the economy. In some other countries, especially transition economies such as China, SOEs have played or are playing an important role in the market, so that their performance, not least with a view to innovation, is of great importance to broad segments of the population and to many other parts of the economy (OECD, 2015). In these countries, it is essential to ensure that the governance of SOEs is implemented effectively.

During China's economic transition, the role of SOEs has been changing with the reform of the economic system. Nonetheless, the reform of SOEs remains one of the most important issues in China's transition to a market economy. Improving SOE performance is crucial for social stability and sustained growth in China (Bai et al., 2006; Lin, Cai, & Li, 1998).

In 1980s, most SOEs were assigned a compulsory plan for input, output and employment. Until the end of that decade, some SOEs had additional capacity available for production of above-plan and were allowed to exchange a small amount of goods in the market. The surpluses of government-controlled firms made up the main source of government revenue. Due to the

[13] This chapter has been published as Kou, Kou & Kroll, Henning: *Innovation output and state ownership: Empirical evidence from China's listed firms*, Discussion Papers Innovation Systems and Policy Analysis Nr. 55, Karlsruhe: Fraunhofer ISI, 2017

distorted price system in the centrally-planned economy, SOEs became extremely profitable, even when they were not very efficient, and they served as a "cash cow" for the government and for the economy (Naughton, 2007). At that time, SOEs were seen as the pillar and the core of the whole economy.

An effort to restructure the SOEs began in 1990s. Followed by the adoption of the new Company Law in 1994 which provided a uniform legal framework for ownership reform, the government gave more freedom and autonomy to its SOEs step by step. From the mid-1990s, Chinese government began to allow SOEs to go bankrupt or be sold to private buyers and companies if they had lost their competitiveness. In this period it restructured not only the enterprises, but also the sectors dominated by SOEs, such as textile and coal industry, in which, as a consequence a large number of SOEs exited from market. SOE restructuring meant converting vaguely defined state ownership into more explicit, legally defined ownership categories, sometimes involving "privatization" (Naughton, 2007), a term that was frequently used by scholars, but avoided by the Chinese government.

In 2003, a new organization, the State-owned Assets Supervision and Administration Commission (SASAC) was formed through the consolidation of various other industry-specific ministries to take over the control of large SOEs. SASAC is responsible for managing and restructuring the remaining SOEs, including approving exchanges of stock or assets and appointing top managers, assessing and supervising firm performance, exercising ownership rights of the central government, as well as drafting legislation related to SOEs.

Up to today, SOE reform is considered a central challenge in China's transition process. Motivations for reform are found not only in economic but also in political considerations, such as the ambition to give a greater role to market forces in domestic demand through enhanced enterprise autonomy, and central government policies to promote large businesses with a view to the nation's strategic integration with the world economy (Nolan & Wang, 1999). The creation of modern, flexible, and efficient corporations is the crucial prerequisite to moving to a higher level of market economy and a more productive firm sector that is able to face international competition (Naughton, 2007). Although past SOE reforms have already brought some achievements in terms of average firm performance, detrimental effects of state ownership remain an issue in many areas. Despite reforms, it is still widely believed that China's SOEs tend to have lower performance than private or foreign enterprises in the market (Qian, 1996; Zheng et al., 2003). At the same time, their role in the market is artificially enhanced by preferential policies and unfair competition supported by both central and local governments (Sheng & Zhao, 2012). Against this background, it is the aim of this chapter to

analyze the innovation performance of Chinese enterprises in light of the influence of state ownership.

So far, most academic literature suggests that SOEs' economic performance is lower than that of private companies (Shirley, 1999; Shleifer, 1998). In the field of innovation economics there is similar evidence that SOEs operate less innovatively (Jefferson, 2006; Zhang, Zhang, & Zhao, 2003). That notwithstanding PwC's CEO Pulse survey suggests that even many top managers of private firms believe that state ownership has advantages in infrastructure related and can help to ascertain stability within and across supply chains in times of crisis (PwC, 2015). With a specific view on China, anecdotal evidence suggests that some SOEs have achieved great success in applied research and innovation, e.g. in nuclear energy, the defense sector and electricity networks but also in less obvious areas like telecommunications. This apparent discrepancy between mainstream academic research and Chinese reality makes it necessary to investigate the performance of SOEs on a broader basis and in more detail.

As many previous theoretical and empirical studies do not take the specificity of SOEs into consideration (Bozec et al., 2002), this study focuses on the relation between innovative activities and state ownership in listed firms in China, controlling for provincial and sectoral differences. Overall, the chapter aims to establish under which framework conditions state ownership will inhibit innovative activities in firms and under which others it may – contrary to general expectations – be beneficial.

The remainder of this chapter is organized as follows: Section 6.2 provides the conceptual framework and hypotheses. Section 6.3 presents the dataset and empirical method. Section 6.4 reports the results. Section 6.5 discusses them in light of the initial conceptual considerations and Section 6.6 concludes.

6.2 Conceptual Background and Hypotheses

By definition, SOEs are characterized by state ownership and/or dominant state influence on corporate governance. Depending on the specific country's legal system, public ownership rights of state can be exercised under various frameworks and through different legal structures. According to OECD (2015), the state can exercise control in different ways, from an excessive "intervenor" to an "absentee owner", with the third option of "informed and active ownership" the preferable one. At both the micro and the macro level, the challenge is to ensure that SOEs operate transparently in an accountable manner, with a high degree of professionalism and effectiveness. Despite these acknowledged differences, however, the prevailing academic

paradigm suggests that state ownership is in a generic manner harmful, favors undue interference and remains inferior to robust regulation (Megginson & Netter, 2001).

Generally, state interference in enterprise governance will result in market failures due to SOE governance systems' inability to properly attribute property rights and risk (Shirley, 1999). At the same time, state interference can enable firms to mobilize capital and resources at lower cost and unduly increase their propensity to spend and invest. Hence, a company operating under an unclear property rights regime will perform less efficiently and less profitably than private enterprises (Alchian & Demsetz, 1972; Barzel, 1989; Boardman & Vining, 1989; Demsetz, 1991; Grossman & Hart, 1986; Naughton, 1994; Weitzman & Xu, 1994).

Against this background, a system of well-defined private property rights is seen as a basic precondition to the proper functioning of a market economy and the foundation of enterprise governance. In firms with governance systems based on private property rights, owners have the rights and incentives to monitor inputs, manage and assign worker to various tasks to increase the profit of firms and benefit from it. At the same time, they bear the risk of mistakes (Demsetz, 1974; Weitzman & Xu, 1994). If no such property rights exist or a state-owned mode of governance does not hold managers accountable for their performance, firms will tend to fall short of their economic and innovative potential (Shirley, 1999; Vickers & Yarrow, 1988).

Another argument can be developed based on principle-agent theory, pointing out that in case of information problems principals will face difficulties to hold agents accountable for achieving agreed targets (Laffont & Tirole, 1985). This theory views the firm as a nexus of contracts between principal (owners) and agent (managers) (Peng et al., 2016). Routinely, agents tend to have better information than principals in a way that maximizes their own utility instead of principal's interest. In SOEs the state employs managers as agents to make decisions in the interest of the firms and – ultimately – in the public interest. However, self-interested managers will often pursue own agendas not directly related to a high level of firm performance (Peng et al., 2016). Unless there are proper corporate governance mechanisms, such rent seeking behavior is difficult to prevent in both private and public firms. Compared with e.g. related issues in share-holding corporations, however, conflicts of interest between principals and agents tend to be more fundamental in SOEs (Jensen & Meckling, 1976). Firms that are managed by bureaucrats, will not only have to deal with personal opportunism, but also with the fact that bureaucratic systems reward budget maximization and associated career benefits rather than efficiency (Buchanan, Tollison, & Tullock, 1980). Hence, the deviation of the agent's interests from the defined objective is higher and the (equally bureaucratic) principle's ability to manage that situation lower than in e.g. shareholding corporations.

Consequently, many previous studies find that private firms perform better than SOEs and that privatization is the best way to improve the performance of SOEs (Bai et al., 2006; Djankov & Murrell, 2002; Jefferson & Su, 2006; Megginson & Netter, 2001). In Norway, where SOEs play an important role, it is found that private companies perform significantly better than SOEs with regard to return on assets and costs relative to sales revenue by referring market structure (Goldeng et al., 2008). In China it is also commonly argued that SOEs are less efficient than private enterprises. The leaders of Chinese SOEs act as both managers and government officials and tend to give priority to their political career, requiring that they ascertain the security of state assets or social stability or duly perform assigned administrative tasks, while the firm could be more profitable if it operated uninhibited in the market (Li & Xia, 2008). Furthermore, institutional arrangements, include weak incentive mechanisms and government interference in corporate decision making are also viewed as a reason of SOEs' poor performance (Park et al., 2006).

With regard to measurements of firm performance, the OECD (2016) lists several performance evaluation indicators for SOEs, for instance return on investment, value added and labor productivity. In this context, it is notable that the frequently used measurement for innovation output, the number of new products, is also seen as an important indicator measuring SOEs' performance by the OECD, underlining that innovation is an essential activity for SOEs, and a relevant part of their activities.

Although many results thus suggest that private firms are more efficient than public ones, the evidence remains inconclusive, because these studies have the common limitation that they compare firms which do not have the same goals (Bozec et al., 2002). State ownership results in problems in defining the targets of the firm (Megginson & Netter, 2001). As outlined above, most of the established arguments in favor of private firms are derived more or less directly from property rights or principle-agent theory, leading on to the argument that managers of SOEs have weaker incentives for profit-maximizing behavior (Goldeng et al., 2008; Megginson & Netter, 2001; Shleifer, 1998). As mentioned above, however, many SOEs either operate in public sectors where profit maximization is a less prominent objective to start with. Taking into account that this paper's aim is to analyze innovative performance, moreover, it seems relevant that successful investment in innovation is in objective to which action guided by short-term profit maximization has often been found harmful rather than conducive.

Since the underlying motivations could thus influence the relative performance of state-owned firms, it is meaningful to compare the performance between SOEs and private enterprises with similar financial goals. Bozec et al. (2002) use the data of the large Canadian SOEs, some of

which maximize their profit as business target, and find that effectively managed SOEs can reach similar levels of economic performance like their private counterparts, measured by return on sales, return on assets and assets turn-over, when they are given the same profitability goal as privately-owned companies. According to this study, state ownership has a negative effect on performance only if the SOE has to pursue additional, unrelated goals. Moreover, privatization per se is not always an effective solution to improve the performance of firms. Omran (2004) matches privatized firms with SOEs in similar pre-privatization situations and finds that private firms do not present significant improvement in their performance changes quantified by earnings, sales and income.

Besides abovementioned clarifying objectives and motives, there are also two important areas that well-performing SOEs concentrate on and are also considered as successful experience from private enterprises: 1) focusing scarce resources on few fields with highest financial impact instead of embarking on a broad agenda that could fail for lack of resources; 2) redefining the company image and recruitment system to attract more talented people, for instance bring compensation packages closer to private-sector standards, or even the multinationals (Budiman et al., 2009). Therefore, the remedy for the performance problem of SOEs might not only be transformation of enterprises' ownership, like privatization, but identification of enterprises' objectives and goals and optimization of the cultural norm and behavior required to meet these objectives and goals (Vernon-Wortzel & Wortzel, 1989).

Thus, with regard to China, it becomes unsurprising that there are few Chinese SOEs that have been completely privatized, in the sense that the state gives up all of its shares. Usually, the central or local government retain still a substantial portion of their ownership, although the firms' governance mechanism has been reformed. In real life situation, the SOE reform in China is even not viewed as a privatization, but restructuration, or sometimes "corporatization", namely restructuring the internal corporate governance and decreasing state shares while preserving state ownership. It is found that this type of reform, corporatization without privatization, is an effective way of improving the SOEs' performance of return on assets, sales and output (Aivazian et al., 2005). Moreover, the relationship between state ownership and firm performance is believed to be an inverted U-shape. Although too frequent state interference has a negative influence, partial state ownership could increase SOE performance (Sun, Tong, & Tong, 2002). Hence, the coexistence of SOEs and private firms is by some considered a good arrangement for China, which helps maintain social stability and fulfil social outcomes (Bai et al., 2006). With a perspective on future, however, further changes in the economic governance framework may be needed to put China on a track to reach the ambitious official targets of

becoming an innovative nation by 2020, an international leader in innovation by 2030, and a world powerhouse of innovation by 2050[14]. In this process, the role of SOE may once more have to be reconsidered in an informed manner.

In general, there are a lot of empirical studies on the role and performance of SOEs based on evidence from industrial countries with developed market economy systems, but their results will not necessarily apply under other conditions. Typically, theory tends to consider the standard case in which SOEs and private firms compete on equal terms without specific institutional and political preference – which then results in a better performance of private forms.

In reality, however, the performance of SOEs and the extent to which principle-agent issues resulting from state ownership will occur is strongly associated with the political and institutional environment they operate under. In countries that follow a comprehensive strategy of reforms to improve SOE performance while at the same time still dis- playing an institutional environment and market conditions that discourage innovation in private enterprises, the situation may be reversed – with SOE becoming more productive than private firms. At the same time, privatization and corporatization are associated with politically costly reforms (Shirley, 1999) so that they may remain incomplete under circumstances in which both SOEs and private firms are inhibited by diffuse policies and an unclear institutional framework.

In an economy under transition like China, therefore, different institutional and political framework conditions in regions and sectors suggest that entirely or at least substantially different relations of performance may result, depending on the specific framework conditions. So far, some studies have been conducted a panel of China's 22,000 large- and medium-size enterprises' data, which collectively account for one third of the nation's total industrial output. Across ownership types considerable variation was found with respect to measures of innovation performance, including new product output and patents (Acs et al., 2002; Acs & Audretsch, 1988; Jefferson et al., 2003; Kraft, 1989). As mentioned above, China's SOEs have been deeply reformed by the government in the last years. In the abovementioned studies, patterns of asset ownership were found associated with performance. SOEs with the highest concentrations of state assets perform at the low end, whereas those with low concentrations of state-owned assets perform at the high end (Jefferson et al., 2003). The distribution of R&D resources shows different images in different ownership types. R&D performers are more concentrated among SOEs and shareholding companies and less concentrated among foreign

[14] Outline of China's national innovation-driven development strategy of State Council (http://news.xinhuanet.com/politics/2016-05/19/c_1118898033.htm)

and overseas enterprises. But the R&D resources of SOEs are not transferred from input to output efficiently. Although there is a high growth rate of technical efficiency for SOEs (Zhang et al., 2003), state-owned enterprises exhibit the lowest efficiency in knowledge production (Jefferson, 2006). Within the non-state sector, foreign firms have higher R&D and productive efficiency, followed by firms from Hong Kong, Macau and Taiwan, joint stock enterprises and collective-owned enterprises (Zhang et al., 2003).

Since the rapid increase of patent applications and grants in China during the last decade, the question which types of companies contribute most strongly to this trend has been repeatedly analyzed. It seems that all non-state enterprises but jointly-owned groups have a higher propensity to patent than SOEs (Hu & Jefferson, 2009). The image among listed firms is a similar one. Privately owned enterprises not only obtain higher returns from own R&D than majority and minority SOEs, they are also able to increase their leading position (Boeing et al., 2016).

Except ownership, the involvement of the Chinese Communist Party in companies has been analyzed as an indicator of the state influence in Chinese firms. Using survey data of private SME in the electronics industry of the Pearl River Delta in China, Liefner et al. (2016) examine the influence of firms' formal ties with the Chinese Communist Party on their patenting behavior. Different from previous studies which argued that SMEs were less susceptible to central government influence than other Chinese firms, they find that the state has a notable influence on the patenting behavior not only of larger state-owned corporations, but also of those smaller firms.

In summary, **Hypothesis 1** can be formulated as: In principle, i.e. on national average, state ownership has negative influences on the innovation output of firms.

However, as stated before, state-owned firms might occasionally outperform private ones, at least with regard to quantitative performance measures in their role as executors of Keynesian public investment in times of crises. In late 2008, the central government of China launched a controversial stimulus package of 4 trillion yuan (equivalent to 586 billion dollar) as an attempt to minimize the impact of the financial crisis. In the following two years, the Chinese economy recovered from the recession gradually, not least due to this stimulus plan. At the same time, however, it has caused a surge in Chinese debt among local governments (Huang & Bosler, 2014). The stimulus package was invested in key areas such as rural infrastructure and transportation, which were dominated by SOEs. The stimulus is traced to state control over its banking system and corporate sector (Deng, Morck, Wu, & Yeung, 2011). Since then, the SOEs obtained credit from state-owned banks much more easily. The average leverage ratio of state-

owned manufacturing firms increased steadily and SOEs promptly expanded their fixed assets investment due to new loans. During the recession period, SOEs expanded their credit borrowing, investment and production capacity, which generated a prompt recovery of aggregate demand. It is found that the effectiveness of China's stimulus packages is derived from the contribution of the SOEs (Wen & Wu, 2014). It remains remarkable that one of the measurements in the policy package is a new political initiative towards "indigenous innovation", which means that the government invested a large amount of capital in R&D, in order to improve the S&T development.

In summary, **Hypothesis 2** can be formulated as: (nominal) deviations from the rule outlined in Hypothesis 1 are likely to emerge as a result of SOEs role in the stimulus package that changed the political and institutional 'rules of the game'. Positive deviations in SOE performance will result from a recovery policy that emphasized the need to increase independent innovation capabilities in national high-tech industries.

Furthermore, most of the enterprises that are nominally "state-owned" are not actually controlled by the central government. Central SOEs are defined as SOEs that controlled by ministries of central government like SASAC (which manages around 100 central SOEs), Ministry of Finance and China Banking Regulatory Commission. After China embraced the development of small-scale enterprises in mid-1990s, when the central government decided only to keep control of large SOEs and to release more autonomy to small-sized SOEs, it was impossible for the central government to exercise effective oversight of assets of all types of SOEs (Naughton, 2007). In 2004 and 2005 local SASACs were set up at the provincial and municipal level. The authority to manage local SOEs was delegated to local governments, in particular local SASACs. The local government obtained the power to take part into decision-making and management of local SOEs and exerted influence on financing and accessing to production materials. Due to fiscal reforms local government officials have more incentives to pursue economic development (Oi, 1992). Local SOEs were seen as the core of local economy, so that they could obtain more financial and political supports from governments than private counterparts.

The supports that come from central and local governments to central and local SOEs are not the same. Local SOEs focus more on local market, while central SOEs possess more sources to enter new markets around China. However, most of the existing researches ignore the effects of the administrative level of enterprises and do not differentiate central and local SOEs.

So as **Hypothesis 3** we suggest that, due to the different amount of resources, competences and political power available to them central and local SOEs will perform differently with respect

to innovation. Central SOEs are still deeply influenced by assignments from the national authorities and are responsible for the fulfilment of political targets of central government. They control more resources with a view to R&D capital than local SOEs and enjoy preferential market access. A large number of national strategic technology projects are implemented in central SOEs. For that reason, we suggest that central SOEs are more innovative than local ones.

Another factor that should be taken into account is geographic location. In China economic development, innovation performance as well as political and institutional framework conditions vary from province to province – more strongly than in many other countries. With regard to the area, population and economic volume, most Chinese provinces are as large as a country. Since the reform in the late 1970s, especially since the 1990s, the central government has given provincial (and some local) governments substantial leeway in the design of economic policy. Today, most of them can decide rather autonomously about their support policy, public expenditure and, to some extent, institutional framework conditions (Gu & Lundvall, 2006). As development pathway, business culture, cultural habits as well as progress in economic transformation differ strongly among different provinces (Kou, 2015; Liu & White, 2001), it is reasonable to assume that the role and performance of SOEs would differ accordingly. In the coastal regions, for example, provinces develop dynamically and have established relative market-oriented institutions since the reforms. Amounts of SOEs have been reformed or privatized in late 1990s. In contrast, the regions in Western and Central China still keep lagging behind (Kroll, 2010). Despite the new trends, these traditional innovation centers still belong to the most innovative regions of China (Kroll & Frietsch, 2014; Tagscherer, Kroll, & Luo, 2012).

Moreover, the overall pattern of developed and less developed regions is changing in recent years. Technologically advanced industries are moving further inland while more and more regional innovation systems are developing outside the classic "islands of innovation", like Beijing, Shanghai and Guangdong (Kroll & Liefner, 2008; Kroll & Schiller, 2010).

For these reasons, it is reasonable to analyze to what extent these general trends with regard to the regional distribution of development as well as science and innovation influence the local role of SOEs in the respective innovation systems.

Hence, we suggest as **Hypothesis 4**, that due to the disparity of development levels and innovative capacity between provinces and larger statistical regions[15], state ownership may play

[15] East: Beijing, Tianjin, Hebei, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, Hainan; Northeast: Liaoning, Jilin, Heilongjiang; Central: Shanxi, Anhui, Jiangxi, Henan, Hubei, Hunan; West: Inner Mongolia, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Ti- bet, Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang.

a distinct role in different environments. In innovative regions, such as China's Eastern provinces, firms including SOEs obtain stronger and more strategically coordinated support to participate in innovative activities while, at the same time, their internal governance mechanisms have been more profoundly reformed and create less principle-agent problems. Hence, they will likely be more innovative or at least lag behind less than those in Central or Northeastern China.

Finally, the institutional and political environment and thus the role and performance of SOE is determined not only by their regional, but also by their sectoral position. SOEs dominate not only strategic industries such as natural resource, aerospace and arms industry, but also infrastructure industry. Depending on the concrete sector in which they are active, not only the intensity of private competition will differ, but also the amount of resources, competences, and preferential treatment by policy makers that SOEs can draw upon to survive in this competition. In the catching-up regions in the middle and west, innovation activities are dominated by mature industrial sectors, which have been transferred out of leading provinces. An argument for this phenomenon is that political interference demands a contribution of these provinces to the so-called "indigenous innovation" (Kroll, 2015), more precisely, to innovate through indigenous S&T and resources instead of purchasing foreign technologies and know-how. Jefferson et al. (2003) use a panel data of China's 22,000 large- and medium-size enterprises for 1994–1999 and investigate patent applications in different sectors. They find a high concentration of patenting activity within China's manufacturing sector, and among the patent applicants, the petroleum and gas industry leads by a wide margin.

As **Hypothesis 5**, we suggest that the firms in different sectors have different innovation performance. In the sectors in which the government intervenes less, market-oriented factors play a more important role and thus SOEs are more likely to hinder the increase of innovation output.

6.3 Data and methods

To obtain the companies assessment of innovation activities, this chapter established a dataset of the Chinese firms listed at the two stock exchanges of Shanghai and Shenzhen throughout the period 2003 – 2014. Information on companies is obtained from the database China Stock Market & Accounting Research (CSMAR) of GTA which is a provider of China financial market data, China industries and economic data, and the economic and financial database of

Peking University China Center for Economic Research (CCER). The provincial data is collected from National Bureau of Statistics of China.

As previously stated, due to complex ownership policy and structure and interference of state, SOEs are often less transparent and insulated from the legal framework applicable to other companies such as competition laws and government subsidy[16], which increases the difficulty of evaluating the economic performance of SOEs, since SOEs rarely aim at the maximization of profit (Rainey, 2009; Ramanadham, 1991), but specific non-commercial goals and social outcomes. In order to avoid this bias, this chapter used the data of listed firms. The reason is that in order to be a listed firm, a SOE must be restructured into a stock company through selling shares to other companies, legal entities or its own employees firstly. Then, the SOE sells part of shares (usually 1/3) to the general public investors. Thereafter, shares of the SOE are split into three parts: state, legal-entity, and tradable shares. Regardless of share type, each share enjoys the same cash flow and voting right (Wang, 2005). Firms that are publicly traded must concentrate on the interest of stakeholders, for instance profitability and firm value. Xu and Wang (1997) find that value of listed firms in China has no relation with state ownership. Even at an early stage of the country's institutional transformation, this confirmed that state ownership is not in principle an obstacle to pursuing commercial goals successfully. When public firms set themselves the target to generate profits, their performance can be comparable to that of the private counterparts (Bozec et al., 2002), and thus, these SOEs also obtain similar circumstances and motivations to participate in innovation activities like privately owned companies. The second advantage of focusing on listed firms is that due to the legal structure of stock exchanges, listed firms must provide a high degree of transparency, including disclosure of information (OECD, 2015), which makes their financial data more reliable than that of non-listed SOEs.

The patent information of CSMAR is a relatively new dataset which was published in 2015. There are still few studies applying this data to investigate the innovative performance of Chinese firms. The dataset of CSMAR includes all industries from agriculture, industry to service sectors. Because innovation activities, precisely, patenting activities, are of limited importance in some industries such as financial and the retail sector (Boeing et al., 2016), the observations from the agricultural and service sectors are excluded. The few firms that did not release the number of patents in their financial report are also eliminated. The full estimation sample is based on information for 1,625 firms including 10,203 observations. With regard to

[16] See PwC report "State-Owned Enterprises Catalysts for public value creation?" for more details.

data quality, the dataset of Chinese listed firms including CSMAR data has been found representative and of high quality in a number of studies (Fisman & Wang, 2010; Gul, Kim, & Qiu, 2010; Kato & Long, 2006; Sun & Tong, 2003), not least because the information efficiency of China's leading stock markets has increased substantially since the late 1999s (Boeing, 2016; Long, Payne, & Feng, 1999).

The dependent and independent variables are summarized in Table 6.1. The descriptive information on all variables is presented in Table C.2 (see Appendix C). As indicator of innovation output we use the number of invention patents. In China there are three categories of patents: invention, utility model and design patents. According to Article 22 of the Chinese Patent Law, an invention patent should possess prominent substantive features and indicate remarkable advancements. Invention patents are granted after a substantive and strict examination, while the other two are in a strict sense only registered, rather than examined and granted (Lei, Sun, & Wright, 2012b; Prud'homme, 2017). Compared with the other two patent types, invention patents are judged by higher standards, closest to those typically required by United States Patent and Trademark Office (USPTO) or European Patent Office (EPO) and, in the literature, therefore often used as an indicator for the independent intellectual property (Lei, Sun, & Wright, 2012a; Li, 2012). Hence, the dependent variable used in this chapter reflects exclusively invention patents.

To measure state ownership, three independent dummy variables are introduced: STATE_NAT for SOE controlled by central government, STATE_PRV for SOE controlled by provincial governments and STATE_MUN for SOE controlled by municipal governments.

As is well-known, firm size is an important general predictor of innovative capacity (Acs & Audretsch, 1987; Scherer, 1965; Schumpeter, 1942). To take into account these generic effects of firm size, and to thus compensate the use of absolute numbers in the dependent variable, the annual revenue of the firm is introduced as a further main independent variable. Further general control variables are the GDP per capita in the respective province, which measures the influence of macroeconomic environment, the interaction term of dummy variable of SOE and the number of employees, which presents to what extent the size of SOE influences innovative activities. Additionally, the model controls for Chinese firms surge in patenting by means of time dummies for each year covered by the regression.

In summary, the regression model can be written as the following equation:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \epsilon$$

where y is the number of patent applications, x_1 stands for the revenue of firms, x_2 is the vector for SOE factors, x_3 is the vector for control variables.

Variable name	Definition
L_PATENT	log of number of invention patent
L_REVENUE	log of revenue
STATE_NAT	dummy for central SOE
STATE_PRV	dummy for provincial SOE
STATE_MUN	dummy for municipal SOE
L_GDP_PC	log of GDP per capita
SOE_SIZE	interaction between SOE and log of number of employee

Table 6.1: Definition of variables

6.4 Empirical results

Table 6.2 summarizes the results of the main regression models.[17]

With a view to Hypothesis 1, the analysis finds that for all listed companies, state ownership controlled by central authorities and provincial governments has significant negative effects on the number of patent applications even if the significance of the latter is somewhat lower. Effects of municipal government ownership, to the contrary, remain insignificant (although in principle also negative).

Moreover, all other independent and control variables behave in line with expectations. Revenue is associated positively with patent output for all types of firm ownership. Large companies contribute more to innovation. If the revenue of a firm increases by 1%, the number of patent applications rises by around 0.13%. In particular, this effect is found in the 2011-2014 period, while it is not significant for the 2003-2010 period. Likewise, the negative association of average per capita income in the host province ad patent behavior seems counterintuitive only at first. Overall, however, it is not that surprising, at least for the 2003-2010 period. At that time, many of the most extensively patenting firms were located in Guangdong. Among the leading group of regions, however, Guangdong displays a comparatively low GDP per capita, due to internal disparities. Furthermore, large SOE appeared more productive in terms of patent applications on top of the general size effect from 2003-2010 while this additional effect was

[17] Details about the regressions and complete results see Appendix C

reversed during the 2011-2014 period. Apparently, many large SOEs have in some respect either become less effective in absolute terms or, with more private firms catching up, less exclusively benefit from size effects than before. Finally, the year specific dummies appropriately capture the nationwide uptake in industrial patenting in China during the 2003-2014 period of observation.

With a view to Hypothesis 2, the analysis finds that all of the three types of public control have significantly negative impacts on innovation output between 2003 and 2010 while for the 2011-2014 period, the effects for all three of them turn significantly positive. The stimulus policy of Chinese government was implemented since the end of 2008 and lasted until 2010. Acknowledging that a certain time lag should be taken into account because, in itself, the adjustment of a firm's R&D portfolio might take time and, more importantly, its full effect only emerges with delay (Boeing, 2015). Thus, Hypothesis 2 can be considered confirmed.

In contrast, Hypothesis 3 can surprisingly not be confirmed. SOEs controlled by central government do not produce more innovative output than local SOEs. To the contrary, central government control over an enterprise decreases its number of patent applications more strongly than provincial or municipal ownership. Between 2011 and 2014, when effects are positive, the positive coefficient of the dummy for central government control is lower and less significant than that of those for provincial and municipal ownership.

Concerning Hypothesis 4, Table 6.3 confirms that the role of state ownership for innovative output varies between different regions. Interestingly, no effects of state-ownership can be found in either the most or the least developed areas of the country (Eastern and Western region). In Northeast and Central China, to the contrary, all types of state ownership have negative effects on firms' tendency to apply for patents. In the North-east, affected by structural change in old industries, the coefficients are extraordinarily high and above average for provincial and municipal ownership. In this area, much of the currently state-owned industrial infrastructure was established as part of large, soviet-style combines in the 1950s and 1960s and at a later stage severely disrupted by the market reforms. Nonetheless, large SOEs perform notably better than smaller ones in that region, although industrial patenting in the Northeast does not in general depend on firm size. This situation is reversed on the developed East coast where the general effect is notable and highly significant but the one for SOE cannot be detected.

As for Hypothesis 5, Table 6.4 illustrates the effect of state-ownership on SOEs innovation output in different sectors. In low-tech industries, state ownership does not exert a negative effect on patenting behavior. In the "textile and apparel" sector, all types of state ownership lead to a significantly higher number of patent applications. In the "paper and print" sector,

these effects may not be significant, but they are still detectable as a tendency. In these sectors, firm size does not influence innovation significantly. In line with that, the additional effect of being a large SOE is significantly or as a tendency negative. The geographical distribution of highly patenting firms, in contrast, seems to differ, with more leading textile firms located in wealthier provinces while the opposite is true for the paper sector. Quite different, in contrast, is the picture for machinery and IT, representing mid-tech and high-tech sectors. In those, general size effects are notable and all types of state ownership is, in principle, negatively associated with firm level patent output. Their association with provinces with high GDP per capita levels (Beijing, Shanghai, etc.) is as a tendency high, yet insignificant. Despite these commonalities, the effects for genuinely technology-related industries like the IT sector, differ notably from that for mid-tech sectors in that the effects of central government ownership are not significantly negative and that there are positive additional effects of SOE size.

	(1) all	(2) 2003-2010	(3) 2011-2014
L_REVENUE	0.132***	0.075	0.066***
	(0.037)	(0.049)	(0.026)
STATE_NAT	-0.874**	-1.289**	0.601*
	(0.416)	(0.563)	(0.352)
STATE_PRV	-0.717*	-1.189**	0.698**
	(0.426)	(0.566)	(0.356)
STATE_MUN	-0.628	-1.102*	0.712**
	(0.411)	(0.563)	(0.352)
L_GDP_PC	-0.429*	-0.876***	0.240
	(0.232)	(0.294)	(0.371)
SOE_SIZE	0.102**	0.143**	-0.081*
	(0.051)	(0.069)	(0.045)
Year effect	+	+	+
_cons	1.105	6.750**	-2.781
	(2.382)	(2.938)	(3.985)
N	10203	4386	5817
r2	0.598	0.433	0.511
r2_a	0.597	0.431	0.511

Standard errors in parentheses
* p<0.1, ** p<0.05, *** p<0.01

Table 6.2: Basic model with year differences

	(1) east	(2) northeast	(3) mid	(4) west
L_REVENUE	0.188***	0.151	0.039	-0.005
	(0.050)	(0.162)	(0.110)	(0.085)
STATE_NAT	-0.585	-5.747*	-1.970**	-0.145
	(0.524)	(3.034)	(0.787)	(1.230)
STATE_PRV	-0.386	-8.743**	-1.897**	-0.013
	(0.537)	(3.843)	(0.833)	(1.288)
STATE_MUN	-0.380	-6.437**	-1.609**	-0.119
	(0.514)	(2.844)	(0.810)	(1.213)
L_GDP_PC	0.157	-0.640	-0.158	0.215
	(0.345)	(1.905)	(0.954)	(0.758)
SOE_SIZE	0.075	0.920**	0.222**	0.030
	(0.062)	(0.419)	(0.100)	(0.152)
Year effect	+	No effects	No effects	No effects
_cons	-5.827	2.325	0.393	-1.883
	(3.579)	(17.904)	(8.309)	(7.389)
N	6729	407	1722	1345
r2	0.627	0.629	0.580	0.511
r2_a	0.626	0.612	0.575	0.505

Standard errors in parentheses
* p<0.1, ** p<0.05, *** p<0.01

Table 6.3: Separate models for different regions

	(1) textile	(2) paper	(3) machinery	(4) IT
L_REVENUE	0.039	-0.092	0.226***	0.376
	(0.175)	(0.276)	(0.071)	(0.273)
STATE_NAT	1.688	2.259	-2.003***	-3.869
	(1.067)	(2.321)	(0.752)	(2.775)
STATE_PRV	3.057**	1.777	-2.055**	-4.494*
	(1.243)	(2.266)	(0.796)	(2.693)
STATE_MUN	2.896**	2.057	-1.432*	-4.659*
	(1.166)	(2.141)	(0.752)	(2.728)
L_GDP_PC	2.230**	-3.550**	0.101	0.852
	(1.010)	(1.564)	(0.587)	(1.266)
SOE_SIZE	-0.314**	-0.253	0.089	0.645*
	(0.139)	(0.279)	(0.100)	(0.353)
Year effects	No effects	-	-	-
_cons	-24.232**	42.432**	-3.090	-15.169

	(10.316)	(17.499)	(6.627)	(13.731)
N	286	227	1414	370
r2	0.620	0.602	0.636	0.683
r2_a	0.599	0.574	0.632	0.669

Standard errors in parentheses
* p<0.1, ** p<0.05, *** p<0.01
(Note: dummies for years 2004 and 2014 excluded during estimation for technical reasons)

Table 6.4: Separate models for different industries

6.5 Summary and discussion

Evidently, most of our findings have been found to be in line with our general assumptions while one of the assumptions could be proved to be wrong. With a view to this chapter's hypotheses, the following findings can be reported:

Firstly, there is indeed a notable influence of state ownership on the innovation performance of China's listed firms. In general terms, this underlines the mainstream assumption that state ownership inhibits innovative activities. Equally in line with previous literature, however, this finding needs to be qualified along several dimensions when more dimensions such as time, disparity of regional development and technological orientation of industries are taken into account.

Secondly, as developed in the conceptual section, the effect of state control on innovative output varies over time, depending on the evolution of a country's economic and institutional system. In line with this, this study suggests that time should be taken into consideration as a proxy for overall framework conditions before any general statements on the role of state ownership are derived. Possibly due to the effects of the fiscal recovery package or other policies aiming to boost indigenous innovation, SOEs in fact generated more innovation output than other firms during the years following the financial crisis.

Thirdly, the administrative hierarchy of SOEs in China's bureaucracy system influences patenting behavior even though in a different manner than intuition might suggest. Differing from our assumption, national SOEs do not per se become more productive in terms of output despite their prominent role in central government policy and the wealth of resources bestowed upon them. A reason might be that, in line with initial conceptual arguments, some local SOEs not only obtain more effective and targeted direct support from their provincial or municipal government, but, one the micro level, deploy more effective governance models and pursue more clearly defined strategies – profiting especially in those provinces where a market-

oriented system is already best established and management skills more broadly available. However, this paper's results equally suggest that some exceptions from this rule might apply in particular sectors, most notably in the low-tech area, but possibly also in the government-driven IT sector, where central control has no significantly negative effects and larger SOE churn out more patents than others.

Fourthly, China's provinces can be divided into four main groups based on geographic locations and development level. Among them, the Northeastern and Central provinces remain most strongly characterized by planned economy mechanisms. In these areas, the governance and management models of many traditional SOEs have hardly been reformed. Consequently, the negative impact of state ownership is found to be particularly severe in Northeast and Central China in a close to paradigmatic manner. In China's Eastern provinces, in contrast, there is no traceably negative effect of state control on patenting behavior. One possible explanation for these findings is that better SOE governance can be assumed in economically and institutionally more developed provinces.

Finally, the association of negative effects of state ownership and certain industries remains partially in line with conceptual considerations, partially surprising. While it appears logical that it is somewhat more pronounced in the market oriented machinery industry than in the government-driven, research-based IT sector, its positive role in low-tech sectors appears surprising and merits further investigation. Possibly, it could be due to the fact that many, strictly price and profit-maximization oriented firms in these sectors do not innovate at all and all firms that are in any way active in the area of innovation remain associated with the state.

6.6 Conclusions

In summary, this chapter has explored the effects of state ownership of listed firms on patent applications. In line with earlier studies, it confirmed that in the most general terms, state ownership can be considered as an obstacle to innovation.

Beyond confirming the well-known general assumptions that state-ownership and SOE management models can hinder innovative activities, the analyses developed in this chapter revealed several relevant qualifications – using data for the concrete case of China but providing a basis for generalization. Firstly, the effects of state ownership on innovation vary dynamically over time, visibly correlating with changes in political and institutional framework conditions. Secondly, stronger economic and political support for some SOE does not per se position them more favorably in comparison to others, while, thirdly, positioning them in more developed

regional innovation ecosystems might well have that effect, even with respect to private enterprises. With respect to sectoral orientation, finally, this study underlined the already established finding that mainstream assumptions on the role of state ownership for innovation may apply less in government-driven high-tech industries. Surprisingly, however, this difference was less clear than expected, but instead, larger in low-tech sectors where it remains less easy to explain.

Consequently, the most important contribution of this study is to have conceptually developed and empirically confirmed that the role of state ownership for innovative performance needs to be analyzed in its specific economic, institutional and political context, rather than on a generic level. That said, some specific findings will require further inquiry in subsequent studies to be fully understood and the precise nature of those policies and circumstances that have put SOEs ahead of private enterprises under specific circumstances remains to be uncovered.

Similar research questions than those addressed in this study could be addressed with a view to the effects a concrete innovation promotion strategies implemented by the Chinese government bringing later studies closer to the establishment of causal relations. Another further research avenue could be to explain innovation output by more detailed information on corporate governance and internal management mechanisms of specific SOEs that influences the level of principal-agent conflicts in their governance and the decision processes relevant for R&D and innovative activity. Finally, it would be worthwhile to expand the reach of the dataset to non-listed companies and additional industries.

Politically, the results underline that SOE reform remains a matter of urgency in particular in China’s northeast and should arguably concentrate on reducing political, administrative and agency costs through effective and modern corporate governance. SOEs managers should be given clear objectives and goals and operate under clear frameworks of accountability. In addition, our findings suggest that the provision of more resources to central government-level SOEs as "innovation drivers" will probably not in a general manner create much added value for the national innovation system outside very specific areas. In that light, the identified lead of SOEs under specific framework conditions should be interpreted with care. Even in the case of the research-driven IT sector, it remains, as a tendency, negative. In summary, the relative nature of all analyses presented in this paper needs to be consciously considered before drawing simplistic conclusions – not least, as the most recent changes may not yet empirically be covered.

While this study’s findings suggest that a smart reform of the SOE sector can bring concrete benefits it may at the same time simply highlight a remaining lack of attention for the needs of

requirements of private enterprises – even in China's more developed regions. That attention, however, will certainly be needed if China is to become an international leader in innovation by 2030.

7. Conclusions

Many emerging countries including China commonly use market-oriented reforms as a strategy to promote economic development (Park et al., 2006). The transition of China is considered the most influential institutional change since the founding of the People's Republic of China and has changed almost all fields of China's economy, from institutions and industrial structure to firm behavior. China, classified as "a developmental state" (Knight, 2014), which means that the government gives the highest policy priority to development and places emphasis on economic growth objectives, has achieved rapid growth. However, due to demographic changes, rising labor costs, a growing need for industrial upgrading and a much-reduced distance to the global technological frontier, the high growth phase of China is almost coming to an end. The annual growth rate has slowed from about 10% to under 7% and will likely diminish further. The side effects of unsustainable development have emerged: overcapacity in some industries, rapidly increasing public debt, and in particular, environmental pollution. On the other hand, since China has achieved economic success and fulfilled economic outcomes in the last decades, the government has clearly shifted from *growth-before-all-else* to a more comprehensive set of objectives such as sustained development and some social goals (Naughton, 2017). From the perspective of the demand side, economic growth is no longer considered the only expectation of Chinese people, who in turn appeal for environmental protection, including clean air, and request more social equity and equal legal status of market entities with various ownership types. Facing weakened global demand and domestic structural problems, China's development model has reached a growth bottleneck, identified as the middle-income trap (Gill & Kharas, 2007), which indicates a sharp deceleration in growth of a country trying to "jump" from the middle-income to high-income club. The solution is to find effective ways to embrace a shift to a more innovative economy (Wei et al., 2017). An innovation-driven development pattern has already settled upon as the target of China's government for the next decades. In fact, due to the surge of China's economy and innovation output in recent decades, the question of which factors influence China's innovation performance has become an important topic.

In this thesis, we investigate the determinants of China's innovation performance at three levels: the systematic level, market structure and ownership of SOEs. The systematic analysis focuses on the innovation of Chinese provinces, in particular innovation systems (Chapter 4), and the second and third parts concentrate on innovation of firms, in which the market structure section

explores the influences of market concentration (Chapter 5) and the latter the effects of state ownership on the innovation output of China's listed firms (Chapter 6).

The establishment of an innovation-driven path begins with a redefinition of the government's role in the innovation system, shifting away from a centrally controlled system by the government toward institutional transition and an enabling environment that supports economy-wide innovation efforts within a fair and efficient market system (World Bank, 2013). In this context, the marketization reform process that reflects the relationship between state and market, the protection mechanism of intellectual property and the roles and network of innovation actors would expedite the growth of China's innovation performance.

The distinctions and relations among these three main parts could be formulated as follows: (1) From the perspective of data, in Chapter 4 we establish a dataset of 30 Chinese provinces, which reflects the innovation performance of regional innovation systems. The dataset of Chapter 5 includes all the large and medium-sized manufacturing firms in China, demonstrating a relatively complete image of innovation activities at the firm level, whereas Chapter 6 focuses on listed firms, which are representative of the most successful firms in China. (2) As for innovation measurements, there are two frequently used indicators for innovation performance, one is patents (Acs et al., 2002) and the other is new products (Schumpeter, 1934). In order to measure the innovation output of regional systems, we have used the number of patent applications in Chapter 4, because as a measurement of the innovation of enterprises, the output of new products could not reflect the innovation activities of non-enterprise units like research institutes and universities, which, in contrast, play a key role in innovation activities in provinces. At the firm level, we use the revenue of new products as an indicator of innovative capacity in Chapter 5, while in Chapter 6, the number of patent applications is introduced. Enterprises require a large amount of capital and resources to apply for patents, so that some small firms with limited budgets have to abandon patent activities entirely. The dataset of Chapter 5 includes not only large companies, but also relatively smaller firms, thus it is reasonable to use a "less costly" method to measure their innovativeness. For this reason, it makes sense to introduce different variables to measure the innovation output of different types of firms, as the revenue of new products is more appropriate for all patterns of firms including small ones, and patents are more suitable for large successful companies.

In line with previous studies, this research confirms that classic innovation input, such as education and R&D including professionals and capital, plays an important role. With respect to the innovation performance of provinces, we find that regional innovation systems play an essential role. More precisely, the level of openness of a region and government expenditure on

education have a positive effect, while bank credit does not influence innovation output. Another factor taken into account is China's marketization reform process. Since marketization began changing institutions and systems in China, it has impacted the innovation performance of the provinces profoundly. Well established intermediary organizations and protection for intellectual property tend to be drivers for regions to improve their patent activities.

At the industrial level, we provide new evidence from the perspective of China's manufacturing firms in terms of the relationship between market structure and firms' innovation performance. We find that there is an inverted-U relationship between market concentration and innovation output measured by the value of new products, which indicates that firms with high market concentration tend to undertake more innovation activities if the intensity of competition remains high, whereas its influence turns to be negative if the market is monopolized by a few firms. However, the overall trend of the influence of market concentration is negative, which demonstrates that, in general, market concentration has negative effects on innovation. Concerning the technology level, a high level of market concentration is especially harmful for technologically advanced firms, while in low-tech sectors, firms' innovative activities are not dependent on market structure.

As for the effect of state ownership and the performance of SOEs, we find that state ownership has a significant influence on innovation output. However, this influence should be observed along more dimensions. The effect of state control on innovation varies over time, and SOEs perform better in innovation activities, which might possibly be traced back to the recovery policy since the financial crisis which aimed to stimulate indigenous innovation. Causal relationships between stimulus policy and innovation output, however, need more concrete analysis in further research. Moreover, the administrative hierarchy of SOEs is also considered, because central and local SOEs are controlled by central and local government respectively and obtain different financial and political support from governments. Despite their prominent role in central government policy, national SOEs are not much more innovative than other types of SOEs. In addition, we divide China's provinces into four groups because of the possible variation of innovation performance between regions, and find that in Northeast and Central China, the areas that were shaped the most by the centrally planned economy, state ownership is still an obstacle to increasing innovation output, whereas in Eastern provinces, there is no significantly negative effect on patent applications. With respect to technological characteristics, state ownership does not exert a negative effect in low-tech industries such as the textile and apparel sector, while in technologically advanced industries like the IT sector, it tends to hinder innovative activities.

The debate of governance approach between liberal market and state dominance has lasted a lot of years in China. We can even find out such discussions among Legalism, Confucianism and Daoism in Chinese history over two thousands years ago. However, neither absolute lasissez-faire nor centrally planned economy has been proven to be an efficient long-term way to economic prosperity. A rational governor would consistently seek balance between liberalism and state intervention, as the Chinese philosophical concept "Doctrine of the Mean", which means maintaining balance and harmonoy from directing the mind to a state of constant equilibrium. Therefore, from a historical perspective, the crossroad of governmental interference in innovation activities and liberal market mechanism is in fact an traditional question for China. Concerning years of a planned economy, a further market-oriented transition becomes a remedy for avoiding the middle income trap and finding out a sustainable growth pattern.

The focus of the next reforms should be on optimizing institution-building. Not only for non-governmental entities like firms but also for the government is it difficult to act on markets without appropriate market orders (Blum & Zhao, 2015). Nevertheless, a vital challenge faced by transitional countries including China is how to establish efficient and market-oriented institutions (Xu, 2011). If we return to the suggestions of the World Bank (2013) mentioned in previous chapters, we can find that, in political terms, most of its advice has been confirmed by our work: further reform of SOEs, further marketization including eliminating barriers to market entry and exit and increasing competition intensity in high-tech industries that contain the most strategic and pillar industries. To be precise, at the macro-level, in order to increase China's innovation performance, further reform should focus more frequently on building efficient intermediary organizations such as fund-raising institutes, since innovative activities are often associated with high risk. Bank credit alone cannot satisfy all of their requirments. On the other hand, it is necessary to improve the protection mechanism for innovators, which would entail furthering the reforms to optimize the protection of intellectual property rights. This would ensure an institutional respect for and assurence of knowledge and innovation activities. Moreover, the government should concentrate more on supplying public goods such as education and some basic R&D and separate itself from business (Acemoglu & Johnson, 2005; Rodrik, 2006), although the Chinese government is still deeply involved in market activities in some fields (Xu, 2011). Above all, it is imperative that China accelerates its marketization reforms and develop a market-based system with sound foundations in which public resources mainly finance the delivery of key public goods and services, such as institution supply and education, while a vigorous private sector plays the more important role of driving growth

(World Bank, 2013). China should reduce its misallocation of economic resources, including innovation resources, by establishing a market-oriented competitive environment for all ownership types, limiting state inference in market activities such as innovation and assuring that private firms have fair access to receiving innovation input factors (Wei et al., 2017).

At the industrial level, public policy influences firms' innovative activities in the field of market structure. Though more competition is key to improving the economic performance and innovativeness of firms (World Bank, 2013), competition policy should consider regional and industrial specifications. In Central, Eastern and Western China, market monopoly tends to be a significantly negative factor for innovation if market concentration stays at a high level. Compared with medium- and low-tech industries, the government should focus more on technology-oriented sectors to ensure an appropriate level of competition. Moreover, competitiveness and innovation performance will also be increased by measures to enhance international participation through further policies of openness and integration with the global economy (World Bank, 2013). The innovation actors, including regional systems, should be encouraged to reduce unnecessary barriers and participate more actively in international competition.

When it comes to ownership reform, the effect of "privatization" remains disputed. Indeed, many large SOEs, which have improved their governance structure, economic performance and profitability, have been "corporatized" (Aivazian et al., 2005), but are still directly monitored by the central or local government (World Bank, 2013). It is argued that in the next years a new pattern of "mixed ownership" would be employed to SOEs to replace current state ownership, which indicates that the government would decrease its intervention in markets, but meanwhile maintains its present ownership ensuring funding for social goals. The real value of state ownership would not change enormously, but incremental parts would be reformed. For example, if the scale of a SOE with 100% state ownership increases to three times through private investment, the state-owned share will be reduced to 30%, while its absolute value remains unchanged (Blum & Zhao, 2015).

To use public resources in an efficient way, the specific framework conditions should be considered. SOE reform remains an urgent mission particularly in Northeast and Central China and should evidently focus on reducing administrative and agency costs through modern corporate governance. The managers, or "agents," of SOEs should be given clear business objectives and goals rather than ambiguous political targets. In addition, public resources should be used mainly for the provision of certain sectors or the production of which results in positive

externalities (World Bank, 2013). In some other industries, especially high-tech sectors such as IT, SOEs do not always play a role as "innovation leaders."

In summary, the model of China's reforms mainly focuses on the gradual decentralization of government control and pursuing an incremental transformation from a hierarchical to a market-oriented system (Park et al., 2006). This transition path is different from those of Eastern European and some other Asian countries. The reforms have achieved rapid economic growth including a surge of innovation output in the last decades. Also, we would not deny the contributions of the government to these achievements, since in almost all countries, both in Europe and Asia, that have transformed from agrarian or planned economies to modern market-oriented ones, the government has played an important role in restructuring industries, supplying public services and institutions and facilitating firm performance (Lin & Monga, 2011). Nevertheless, the shortcomings and remaining unsolved problems of institutions and government intervention in the areas of innovation systems, market structure and firm ownership should not be ignored, since they have become newly emerging obstacles for industrial upgrading and the further increase of innovation performance. For knowledge generation and diffusion, as well as innovation, it is not sufficient to have sages. Without an appropriate environment, knowledge would not be diffused and innovation would be separated from human society. It is expected that the innovation-performance approach proposed in this thesis will help to understand the surge of innovation performance in China in the past years and contribute to finding remedies for shifting to an efficient, sustainable and environmentally friendly innovation-driven development pattern.

Appendix A

Additional information about regressions in Chapter 4:

The Hausman test shows that fixed effect model is more appropriate than random effect model. In this part fixed effect models are estimated in STATA with heteroscedasticity robust standard errors.

To test multicollinearity we used “collin” command in STATA and then obtained reasonable values of VIF (Variance Inflation Factor). All the values are lower than 6. The mean VIF of the first regression is 2.62 and that of the second regression is 2.18, which means that there is no multicollinearity problem.

The following table shows the descriptive statistics.

Variable	Obs	Mean	Std. Dev.	Min	Max
L_PATENT_GRA	240	5.579	1.313	1.792	8.936
L_PATENT_POP	240	2.064	1.158	0.100	5.946
L_GDP_PC	240	9.093	0.590	7.768	10.813
L_PERSONAL	240	9.942	1.117	6.743	12.050
OPENNESS	240	29.287	38.272	3.213	165.227
ED_SHARE	240	15.380	2.281	9.697	21.140
INTER	240	3.868	2.069	1.150	12.840
IP	240	2.621	3.835	0.010	25.130
TERTIARY	240	40.540	6.359	30.048	69.651
UNI_RD	240	10.039	5.828	0.958	30.943
BANK	240	6.920	4.773	0.000	27.210

Table A.1: Descriptive statistics

Robustness test:

	(1)	(2)	(3)	(4)
L_GDP_PC	1.406***	1.339***	1.105***	1.241***
	(0.185)	(0.178)	(0.196)	(0.188)
L_PERSONAL	0.836***	0.634***	0.333**	0.370***
	(0.164)	(0.147)	(0.126)	(0.132)
OPENNESS		0.014***	0.011***	0.008*
		(0.003)	(0.003)	(0.004)
ED_SHARE		0.085***	0.057**	0.055**
		(0.025)	(0.026)	(0.024)
INTER			0.088***	
			(0.019)	
IP				0.043***
				(0.014)
TERTIARY			0.072***	0.072***
			(0.010)	(0.011)
UNI_RD			0.004	0.002
			(0.006)	(0.006)
BANK			-0.013	-0.014*
			(0.008)	(0.007)
_cons	-19.034***	-18.145***	-15.702***	-16.932***
	(1.628)	(1.472)	(1.244)	(1.240)
N	240	240	240	240
r2	0.763	0.797	0.863	0.860
r2_a	0.761	0.794	0.858	0.856

Standard errors in parentheses
* p<0.1, ** p<0.05, *** p<0.01

Table A.2: Estimation results (granted patents per million people as dependent variable)

Appendix B

Additional information about regressions in Chapter 5:

We applied random effect models in STATA with heteroscedasticity robust standard errors.

As we are working with a panel dataset, it is important to use an appropriate panel estimation strategy from fixed-effects and random-effects. As is well known, fixed effects and random effects differ by $\frac{\sigma_\epsilon^2}{\sigma_\epsilon^2 + T\,\sigma_\alpha^2}$. As *T* (Time) gets larger, this term goes to zero, so the random-effects and fixed-effects estimators become identical. But if T is small in the panel data, then they will get considerably different results and random-effects are of great use (Beck, 2001). The fixed-effects estimator focuses on the time variation of each unit and ignores information about the cross-sectional variability. By contrast, the random-effects estimator exploits both the within and between components of the variability, and it is therefore more efficient when the time variation of the dataset is limited (Castellacci, 2011). As shown in Table B.1 in Appendix B, most of the variables in our dataset change slowly over time. So the between part of the variance is substantially larger than the within component, which makes random-effects more efficient and reliable. So, in this paper we will use random-effects to estimate.

To test multicollinearity we have used "collin" command in STATA and then obtained reasonable values of VIF (Variance Inflation Factor). All the values are lower than 3. The mean VIF of the regression with HHI2 is 1.72 and that of the regression with HHI3 is 1.56, which means that there is no multicollinearity problem.

The following table shows the descriptive statistics.

	All (N=582712)				2005 N=148064				2006 N=212085				2007 N=222563			
Variable	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
INNO	0.042	0.181	0.000	15.207	0.040	0.182	0.000	15.207	0.041	0.171	0.000	10.000	0.044	0.191	0.000	13.938
HHI_4-digit	0.017	0.029	0.001	0.682	0.020	0.033	0.002	0.682	0.015	0.028	0.001	0.633	0.015	0.028	0.001	0.551
HHI2_4-digit	0.001	0.010	0.000	0.465	0.001	0.011	0.000	0.465	0.001	0.010	0.000	0.401	0.001	0.008	0.000	0.304
HHI_3-digit	0.008	0.013	0.001	0.341	0.010	0.014	0.001	0.341	0.008	0.012	0.001	0.295	0.008	0.012	0.001	0.244
HHI2_3-digit	0.000	0.002	0.000	0.116	0.000	0.003	0.000	0.116	0.000	0.002	0.000	0.087	0.000	0.002	0.000	0.059
LABOR	4.664	1.078	2.197	12.145	4.753	1.077	2.197	11.495	4.657	1.077	2.197	11.907	4.612	1.076	2.197	12.145
RD	0.002	0.014	0.000	0.989	0.002	0.016	0.000	0.975	0.002	0.012	0.000	0.989	0.002	0.013	0.000	0.967

Table B.1: Descriptive statistics

Appendix C

Additional information about regressions in Chapter 6:

The Hausman test shows that fixed effect model is better than random effect model. In this part fixed effect models are estimated in STATA with heteroscedasticity robust standard errors.

The following table demonstrates the correlation matrix:

	L_REVENUE	L_GDP_PC	SOE_SIZE	STATE1	STATE2	STATE3
L_REVENUE	1.0000					
L_GDP_PC	0.0623	1.0000				
SOE_SIZE	0.4632	-0.2621	1.0000			
STATE1	0.2184	-0.0166	0.5011	1.0000		
STATE2	0.2014	-0.2847	0.4107	-0.1541	1.0000	
STATE3	0.0898	-0.123	0.4699	-0.1954	-0.1517	1.0000

Table C.1: Correlation matrix

This table shows the descriptive statistics:

Variable	Obs	Mean	Std. Dev.	Min	Max
L_PATENT	10,203	1.31	1.40	0	9.62
L_REVENUE	10,203	21.17	1.43	11.60	28.69
STATE_NAT	10,203	0.17	0.37	0	1
STATE_PRV	10,203	0.11	0.31	0	1
STATE_MUN	10,203	0.16	0.37	0	1
L_GDP_PC	10,203	10.61	0.60	8.22	11.56
SOE_SIZE	10,203	3.54	4.13	0	13.22

Table C.2: Descriptive statistics

Complete regression results:

	(1) all	(2) 2003-2010	(3) 2011-2014
L_REVENUE	0.132***	0.075	0.066***
	(0.037)	(0.049)	(0.026)
STATE_NAT	-0.874**	-1.289**	0.601*
	(0.416)	(0.563)	(0.352)
STATE_PRV	-0.717*	-1.189**	0.698**
	(0.426)	(0.566)	(0.356)
STATE_MUN	-0.628	-1.102*	0.712**
	(0.411)	(0.563)	(0.352)
L_GDP_PC	-0.429*	-0.876***	0.240
	(0.232)	(0.294)	(0.371)
SOE_SIZE	0.102**	0.143**	-0.081*
	(0.051)	(0.069)	(0.045)
yr2004	0.209***	0.317***	
	(0.057)	(0.065)	
yr2005	0.452***	0.630***	
	(0.093)	(0.111)	
yr2006	0.664***	0.920***	
	(0.124)	(0.151)	
yr2007	0.830***	1.201***	
	(0.164)	(0.203)	
yr2008	1.074***	1.537***	
	(0.198)	(0.246)	
yr2009	1.396***	1.906***	
	(0.215)	(0.268)	
yr2010	1.669***	2.312***	
	(0.251)	(0.314)	
yr2011	2.061***		
	(0.286)		
yr2012	2.452***		0.344***
	(0.306)		(0.034)
yr2013	2.773***		0.619***
	(0.327)		(0.067)
yr2014	3.028***		0.837***
	(0.343)		(0.093)
_cons	1.105	6.750**	-2.781
	(2.382)	(2.938)	(3.985)
N	10203	4386	5817
r2	0.598	0.433	0.511

r2_a	0.597	0.431	0.511

Standard errors in parentheses
* p<0.1, ** p<0.05, *** p<0.01

Table C.3: Basic model with year differences

	(1) east	(2) northeast	(3) mid	(4) west
L_REVENUE	0.188***	0.151	0.039	-0.005
	(0.050)	(0.162)	(0.110)	(0.085)
STATE_NAT	-0.585	-5.747*	-1.970**	-0.145
	(0.524)	(3.034)	(0.787)	(1.230)
STATE_PRV	-0.386	-8.743**	-1.897**	-0.013
	(0.537)	(3.843)	(0.833)	(1.288)
STATE_MUN	-0.380	-6.437**	-1.609**	-0.119
	(0.514)	(2.844)	(0.810)	(1.213)
L_GDP_PC	0.157	-0.640	-0.158	0.215
	(0.345)	(1.905)	(0.954)	(0.758)
SOE_SIZE	0.075	0.920**	0.222**	0.030
	(0.062)	(0.419)	(0.100)	(0.152)
yr2004	0.138*	0.154	0.181	-0.050
	(0.079)	(0.278)	(0.195)	(0.190)
yr2005	0.318**	0.350	0.354	0.071
	(0.133)	(0.579)	(0.333)	(0.283)
yr2006	0.456**	0.343	0.559	0.181
	(0.178)	(0.845)	(0.466)	(0.395)
yr2007	0.542**	0.484	0.689	0.208
	(0.228)	(1.189)	(0.648)	(0.559)
yr2008	0.760***	0.579	0.744	0.325
	(0.271)	(1.547)	(0.824)	(0.695)
yr2009	1.034***	0.854	1.142	0.546
	(0.295)	(1.750)	(0.925)	(0.751)
yr2010	1.215***	1.234	1.346	0.718
	(0.341)	(2.100)	(1.117)	(0.896)
yr2011	1.524***	1.833	1.671	0.970
	(0.386)	(2.459)	(1.293)	(1.055)
yr2012	1.867***	2.278	2.033	1.302
	(0.411)	(2.661)	(1.391)	(1.147)
yr2013	2.131***	2.655	2.338	1.550
	(0.440)	(2.803)	(1.477)	(1.232)
yr2014	2.339***	2.857	2.595*	1.764

	(0.465)	(2.897)	(1.549)	(1.297)
_cons	-5.827	2.325	0.393	-1.883
	(3.579)	(17.904)	(8.309)	(7.389)
N	6729	407	1722	1345
r2	0.627	0.629	0.580	0.511
r2_a	0.626	0.612	0.575	0.505

Standard errors in parentheses
* p<0.1, ** p<0.05, *** p<0.01

Table C.4: Separate models for different regions

	(1)	(2)	(3)	(4)
	textile	paper	machinery	IT
L_REVENUE	0.039	-0.092	0.226***	0.376
	(0.175)	(0.276)	(0.071)	(0.273)
STATE_NAT	1.688	2.259	-2.003***	-3.869
	(1.067)	(2.321)	(0.752)	(2.775)
STATE_PRV	3.057**	1.777	-2.055**	-4.494*
	(1.243)	(2.266)	(0.796)	(2.693)
STATE_MUN	2.896**	2.057	-1.432*	-4.659*
	(1.166)	(2.141)	(0.752)	(2.728)
L_GDP_PC	2.230**	-3.550**	0.101	0.852
	(1.010)	(1.564)	(0.587)	(1.266)
SOE_SIZE	-0.314**	-0.253	0.089	0.645*
	(0.139)	(0.279)	(0.100)	(0.353)
yr2005	0.653	-5.915***	-2.078***	-1.367
	(1.015)	(1.741)	(0.697)	(1.259)
yr2006	0.397	-4.951***	-2.021***	-1.503
	(0.840)	(1.581)	(0.609)	(1.119)
yr2007	0.122	-4.240***	-1.952***	-1.562*
	(0.711)	(1.272)	(0.500)	(0.868)
yr2008	0.074	-3.506***	-1.770***	-1.450**
	(0.613)	(1.004)	(0.416)	(0.661)
yr2009	0.111	-3.150***	-1.489***	-1.048*
	(0.555)	(0.894)	(0.355)	(0.567)
yr2010	-0.154	-2.168***	-1.250***	-1.043**
	(0.430)	(0.606)	(0.256)	(0.439)
yr2011	-0.198	-1.382***	-0.933***	-0.815***
	(0.279)	(0.375)	(0.161)	(0.282)
yr2012	-0.086	-0.907***	-0.518***	-0.445**
	(0.188)	(0.251)	(0.107)	(0.198)

yr2013	-0.069	-0.395***	-0.215***	-0.204**
	(0.089)	(0.119)	(0.051)	(0.097)
_cons	-24.232**	42.432**	-3.090	-15.169
	(10.316)	(17.499)	(6.627)	(13.731)
N	286	227	1414	370
r2	0.620	0.602	0.636	0.683
r2_a	0.599	0.574	0.632	0.669

Standard errors in parentheses
* p<0.1, ** p<0.05, *** p<0.01
(Note: dummies for years 2004 and 2014 excluded during estimation for technical reasons)

Table C.5: Separate models for different industries

8. References

Acemoglu, D., & Johnson, S. (2005). Unbundling institutions. *Journal of Political Economy*, *113*(5), 949–995.

Acemoglu, D., & Robinson, J. (2012). *Why nations fail: The origins of power, prosperity, and poverty*: Crown Business.

Acs, Z. J., Anselin, L., & Varga, A. (2002). Patents and innovation counts as measures of regional production of new knowledge. *Research policy*, *31*(7), 1069–1085.

Acs, Z. J., & Audretsch, D. B. (1987). Innovation, market structure, and firm size. *The review of Economics and Statistics*, 567–574.

Acs, Z. J., & Audretsch, D. B. (1988). Innovation in Large and Small Firms: An Empirical Analysis. *The American economic review*, *78*(4), 678–690.

Acs, Z. J., & Audretsch, D. B. (1989). Patents as a measure of innovative activity. *Kyklos*, *42*(2), 171–180.

Aghion, P., Bloom, N., Blundell, R., Griffith, R., & Howitt, P. (2005). Competition and innovation: An inverted U relationship. *The quarterly journal of economics*, *120*(May), 701–728. https://doi.org/10.1007/s10842-011-0123-4

Aghion, P., & Howitt, P. (1992). A Model of Growth through Creative Destruction. *Econometrica*, *60*(2), 323–351. https://doi.org/10.2307/2951599

Aivazian, V. A., Ge, Y., & Qiu, J. (2005). Can corporatization improve the performance of state-owned enterprises even without privatization? *Journal of Corporate Finance*, *11*(5), 791–808.

Akamatsu, K. (1962). A historical pattern of economic growth in developing countries. *The Developing Economies*, *1*(s1), 3–25.

Alchian, A. A., & Demsetz, H. (1972). Production, information costs, and economic organization. *The American economic review*, *62*(5), 777–795.

Arrow, K. (1962). Economic welfare and the allocation of resources for invention. *National Bureau of Economical research: The Rate and Direction of Inventive Activity: Economic and Social Factors, I*, S. 609 - 626. https://doi.org/10.1521/ijgp.2006.56.2.191

Asheim, B. T., & Isaksen, A. (2002). Regional innovation systems: the integration of local 'sticky'and global 'ubiquitous' knowledge. *The Journal of Technology Transfer*, *27*(1), 77–86.

Bai, C.-E., Lu, J., & Tao, Z. (2006). The multitask theory of state enterprise reform: empirical evidence from China. *The American economic review*, *96*(2), 353–357.

Bain, J. S. (1968). *Industrial organization*: John Wiley & Sons.

Bain, J. S. (1972). Essays on price theory and industrial organization.

Bartlett, C. A., & Ghoshal, S. (2000). Going global lessons from late movers. *Harvard Business Review*.

Barzel, Y. (1989). *Economic analysis of property rights*. *Political economy of institutions and decisions*. Cambridge, New York: Cambridge University Press.

Beck, N. (2001). Time-series–cross-section data: What have we learned in the past few years? *Annual Review of Political Science*, *4*(1), 271–293.

Blum, U. (2017a). *Grundlagen der Volkswirtschaftslehre* (1 Edition). *De Gruyter Studium*. Berlin/Boston: De Gruyter.

Blum, U. (2017b). The West against the Rest: Wie wirtschaftlich erfolgreich ist das sogenannte Abendland im Vergleich zu China? Eine kurze Einordnung. *Conference paper of SMS-Tagung ("Silk Meets Salt") in Februar 2017*.

Blum, U., & Dudley, L. (1998). Fast Convergence. Institutions and Economic Growth in the New East Germany. *Jahrbuch für Wirtschaftswissenschaften/Review of Economics*, 124–143.

Blum, U., & Dudley, L. (1999). The Two Germanies: Information Technology and Economic Divergence, 1949-1989. *Journal of Institutional and Theoretical Economics (JITE)/Zeitschrift für die gesamte Staatswissenschaft*, 710–737.

Blum, U., Veltins, M., Bauer, H., & Huber, F. (2004). Marktmacht, Kartelle und die Berechnung des Mehrerlöses. *Strategien und Trends im Handelsmanagement. H. Bauer, F. Huber ed., Vahlen, München*, 251–271.

Blum, U., & Zhao, Z. (2015). Aktulle Entwicklungen in China. In *Orientierungen zur Wirtschafts- und Gesellschaftspolitik* (pp. 36–43).

Blundell, R., Griffith, R., & van Reenen, J. (1999). Market share, market value and innovation in a panel of British manufacturing firms. *Review of Economic Studies*, *66*(3), 529–554. https://doi.org/10.1111/1467-937X.00097

Boardman, A. E., & Vining, A. R. (1989). Ownership and performance in competitive environments: A comparison of the performance of private, mixed and state-owned enterprises. *The Journal of Law & Economics*, *32*(1), 1–33.

Boeing, P. (2015). *Innovation Made in China.* Frankfurt am Main, Hochsch., Diss., 2015.

Boeing, P. (2016). The allocation and effectiveness of China's R&D subsidies-Evidence from listed firms. *Research policy*, *45*(9), 1774–1789.

Boeing, P., Mueller, E., & Sandner, P. (2016). China's R&D explosion-Analyzing productivity effects across ownership types and over time. *Research policy*, *45*(1), 159–176.

Bos, J. W. B., Economidou, C., & Sanders, M. W. (2013). Innovation over the industry life-cycle: Evidence from EU manufacturing. *Journal of Economic Behavior & Organization*, *86*, 78–91.

Bozec, R., Breton, G., & Cote, L. (2002). The performance of state–owned enterprises revisited. *Financial Accountability & Management*, *18*(4), 383–407.

Breton, A. (1998). *Competitive governments: An economic theory of politics and public finance*: Cambridge University Press.

Buchanan, J. M., Tollison, R. D., & Tullock, G. (1980). *Toward a theory of the rent-seeking society* (Vol. 4): Texas A & M Univ Pr.

Budiman, A., Lin, D., & Singham, S. (2009). Improving performance at state-owned enterprises. *McKinsey Quarterly*, 1–5.

Carter, C. F., & Williams, B. R. (1957). Industry and technical progress.

Castellacci, F. (2011). How does competition affect the relationship between innovation and productivity? Estimation of a CDM model for Norway. *Economics of Innovation and New Technology*, *20*(7), 637–658.

Chen, G., Firth, M., Gao, D. N., & Rui, O. M. (2006). Ownership structure, corporate governance, and fraud: Evidence from China. *Journal of Corporate Finance*, *12*(3), 424–448. https://doi.org/10.1016/j.jcorpfin.2005.09.002

Chen, G., Firth, M., & Xu, L. (2009). Does the type of ownership control matter? Evidence from China's listed companies. *Journal of Banking & Finance*, *33*(1), 171–181.

Chen, L., & Zhu, W. (2011). Innovation, market structure and administrative entry barriers. *China Economic Quarterly*, *10*(2), 653–674.

Cheung, S. N. S. (2009). *The 30th Anniversary of China's Economic Reform*: CITIC Press.

Coase, R. H. (1937). The nature of the firm. *economica*, *4*(16), 386–405.

Cooke, P., & Morgan, K. (1990). *Learning through networking: Regional innovation and the lessons of Baden-Württemberg*: Regional Industrial Research Cardiff.

Cooke, P., & Morgan, K. (1994). The regional innovation system in Baden-Württemberg. *International Journal of Technology Management*, *9*, 394–429.

Cooke, P., Uranga, M. G., & Etxebarria, G. (1997). Regional innovation systems: Institutional and organizational dimensions. *Research policy*, *26*, 475–491.

Demsetz, H. (1969). Information and efficiency: another viewpoint. *The Journal of Law & Economics*, *12*(1), 1–22.

Demsetz, H. (1974). Toward a theory of property rights. In *Classic Papers in Natural Resource Economics* (pp. 163–177). Springer.

Demsetz, H. (1991). *The organization of economic activity*. Oxford: Blackwell.

Deng, Y., Morck, R., Wu, J., & Yeung, B. (2011). *Monetary and fiscal stimuli, ownership structure, and China's housing market*. National Bureau of Economic Research.

Djankov, S., & Murrell, P. (2002). Enterprise restructuring in transition: A quantitative survey. *Journal of economic literature*, *40*(3), 739–792.

Fagerberg, J. (2007). A guide to Schumpeter. *Confluence: Interdisciplinary Communications*, *2008*, 20–22.

Fan, G., Wang, X., & Zhang, L. (2001). Annual report 2000: Marketization index for China's provinces.

Fan, G., Wang, X., & Zhu, H. (2006). *NERI INDEX of marketization of China's provinces 2006 report*.

Fan, G., Wang, X., & Zhu, H. (2011). *NERI INDEX of Marketization of China's Provinces 2011 Report (in Chinese)*: Economic and Science Press.

Feng, X. (2002). An Analytic Framework for the Chinese Intergovernmental Competition Theory (in Chinese). *Discussion Paper of Unirule Institute of Economics*.

Ferguson, N. (2012). *Civilization: The West and the rest*: Penguin.

Firth, M., Lin, C., Liu, P., & Wong, S. M. L. (2009). Inside the black box: Bank credit allocation in China's private sector. *Journal of Banking & Finance*, *33*(6), 1144–1155.

Fisman, R., & Wang, Y. (2010). Trading favors within Chinese business groups. *The American economic review*, *100*(2), 429–433.

Freeman, C. (1989). *Technology policy and economic performance*: Pinter Publishers Great Britain.

Freeman, C. (1998). *Schumpeter's business cycles reviseted*: Fondazione Carivit.

Friedman, M. (1964). *Capitalism and freedom*: JSTOR.

Furman, J. L., & Hayes, R. (2004). Catching up or standing still? National innovative productivity among 'follower' countries, 1978-1999. *Research policy*, *33*(9), 1329–1354. https://doi.org/10.1016/j.respol.2004.09.006

Furman, J. L., Porter, M. E., & Stern, S. (2002). The determinants of national innovative capacity. *Research policy*, *31*(6), 899–933.

Geroski, P. A. (1990). Innovation, technological opportunity, and market structure. *Oxford economic papers*, *42*(3), 586–602.

Gill, I. S., & Kharas, H. J. (2007). *An East Asian Renaissance: Ideas for Economic Growth*: World Bank Publications.

Goldeng, E., Grünfeld, L. A., & Benito, G. R. G. (2008). The performance differential between private and state owned enterprises: The roles of ownership, management and market structure. *Journal of Management Studies*, *45*(7), 1244–1273.

Granger, C. W. J. (1969). Investigating Causal Relations by Econometric Models and Cross-spectral Methods. *Econometrica*, *37*(3), 424. https://doi.org/10.2307/1912791

Griliches, Z. (1984). *R&D, Patents and Productivity* (Vol. 21). Retrieved from http://www.sciencedirect.com/science/article/pii/S0264275104000939

Griliches, Z. (1990). *Patent Statistics as Economic Indicators: A Survey* (Vol. 28). Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=19291971&site=ehost-live

Grossman, S. J., & Hart, O. D. (1986). The costs and benefits of ownership: A theory of vertical and lateral integration. *The Journal of Political Economy*, 691–719.

Gu, S., & Lundvall, B.-Å. (2006). *China's innovation system and the move toward harmonious growth and endogenous innovation*. *DRUID working paper: Vol. 2006,7*. Göttingen, Aalborg: Niedersächsische Staats- und Universitätsbibliothek; DRUID.

Gul, F. A., Kim, J.-B., & Qiu, A. A. (2010). Ownership concentration, foreign shareholding, audit quality, and stock price synchronicity: Evidence from China. *Journal of financial economics*, *95*(3), 425–442.

Hadjimichalis, C. (2005). *Uneven development and regionalism: state, territory and class in southern Europe*: Routledge.

Harvie, C. (2005). *The rise of regional Europe*: Routledge.

Hashmi, A. R. (2013). Competition and innovation: the inverted-U relationship revisited. *Review of Economics and Statistics*, *95*(5), 1653–1668.

Hayek, F. A. (1973). *Law, legislation and liberty: a new statement of the liberal principles of justice and political economy, v. 1: Rules and order*: London: Routledge.

Hayek, F. A. (1968). *Der Wettbewerb als Entdeckungsverfahren*: Institut für Weltwirtschaft an der Universität.

Herrmann-Pillath, C. (1999). *Die fiskalische und regionale Dimension des systemischen Wandels großer Länder: Regierungswettbewerb in China und Rußland*: Univ. Witten, Herdecke, Fak. für Wirtschaftswiss.

Holmes, T. J., Levine, D. K., & Schmitz, J. A. (2012). Monopoly and the incentive to innovate when adoption involves switchover disruptions. *American Economic Journal: Microeconomics, 4*(3), 1–33. https://doi.org/10.1257/mic.4.3.1

Hsieh, C.-T., & Klenow, P. J. (2009). Misallocation and manufacturing TFP in China and India. *The quarterly journal of economics, 124*(4), 1403–1448.

Hsieh, C.-T., & Song, Z. M. (2015). *Grasp the large, let go of the small: The transformation of the state sector in China.*

Hu, A. G. (2001). Ownership, government R&D, private R&D, and productivity in Chinese industry. *Journal of Comparative Economics, 29*(1), 136–157. https://doi.org/10.1006/jcec.2000.1704

Hu, A. G., & Jefferson, G. (2009). A great wall of patents: What is behind China's recent patent explosion? *Journal of Development Economics, 90*(1), 57–68.

Hu, M.-C., & Mathews, J. a. (2005). National innovative capacity in East Asia. *Research policy, 34*(9), 1322–1349.

Hu, M.-C., & Mathews, J. a. (2008). China's national innovative capacity. *Research policy, 37*(9), 1465–1479.

Huang, Y., & Bosler, C. (2014). *China's debt dilemma: deleveraging while generating growth*: Carnegie Endowment for International Peace, September.

Hung, S.-C., & Whittington, R. (2011). Agency in national innovation systems: Institutional entrepreneurship and the professionalization of Taiwanese IT. *Research policy, 40*(4), 526–538.

Jaspers, K. (2014). *The Origin and Goal of History (Routledge Revivals)*: Routledge.

Jefferson, G. (2006). R and D Performance in Chinese Industry. *Economics of Innovation and New Technology*.

Jefferson, G. (2016). *State-Owned Enterprise in China: Reform, Performance, and Prospects.*

Jefferson, G., Hu, A. G., Guan, X., & Yu, X. (2003). Ownership, performance, and innovation in China's large- and medium-size industrial enterprise sector. *China Economic Review, 14*(1), 89–113.

Jefferson, G. H., & Su, J. (2006). Privatization and restructuring in China: Evidence from shareholding ownership, 1995–2001. *Journal of Comparative Economics, 34*(1), 146–166.

Jensen, M. C., & Meckling, W. H. (1976). Theory of the firm: Managerial behavior, agency costs and ownership structure. *Journal of financial economics, 3*(4), 305–360.

Jones, E. (2003). *The European miracle: environments, economies and geopolitics in the history of Europe and Asia*: Cambridge University Press.

Kamien, M. I., & Schwartz, N. L. (1982). *Market structure and innovation*: Cambridge University Press.

Kasahara, S. (2004). The Flying Geese Paradigm: A critical study of its application to East Asian regional development.

Kato, T., & Long, C. (2006). Executive turnover and firm performance in China. *The American economic review, 96*(2), 363–367.

Knight, J. B. (2014). China as a developmental state. *The World Economy*, *37*(10), 1335–1347.

Kou, K. (2015). Auswirkungen des chinesischen Innovationsmilieus auf das regionale Wachstumspotenzial. In U. Blum (Ed.), *Cultural heritage and green economy. Technology, industrial growth, mobility ; Beijing Humboldt Forum* (Vol. 4, pp. 41–61). Halle (Saale): Martin-Luther-Univ.

Koyre, A. (1943). Galileo and the Scientific Revolution of the Seventeenth Century. *The Philosophical Review*, *52*(4), 333. https://doi.org/10.2307/2180668

Kraft, K. (1989). Market structure, firm characteristics and innovative activity. *The Journal of Industrial Economics*, 329–336.

Kroll, H. (2010). *Indicator-based reporting on the chinese innovation system 2010: The regional dimension of science and innovation in China*. *Fraunhofer ISI discussion papers innovation system and policy analysis: Vol. 2011,25*. Karlsruhe: Fraunhofer ISI.

Kroll, H. (2015). *Exploring pathways of regional technological development in China through patent analysis.*

Kroll, H., & Frietsch, R. (2014). Regional Structures and Trends in China's Innovation System: An Indicator-Based Account of the Last Decade's Developments. *Innovation and Regional Development in China. London: Routledge*, 41–72.

Kroll, H., & Liefner, I. (2008). Spin-off enterprises as a means of technology commercialisation in a transforming economy—Evidence from three universities in China. *Technovation*, *28*(5), 298–313.

Kroll, H., & Schiller, D. (2010). Establishing an interface between public sector applied research and the Chinese enterprise sector: Preparing for 2020. *Technovation*, *30*(2), 117–129.

Laffont, J.-J., & Tirole, J. (1985). *Using cost observation to regulate firms. Technical report / Institute for Mathematical Studies in the Social Sciences, Stanford University: no. 477*. Stanford, Calif.: Institute for Mathematical Studies in the Social Sciences, Stanford University.

Landes, D. S. (1999). *The wealth and poverty of nations: Why some are so rich and some so poor* (1st Norton paperback ed.). New York: W.W. Norton & Co.

Lau, L. J., Qian, Y., & Roland, G. (2000). Reform without losers: an interpretation of China's dual‐track approach to transition. *Journal of Political Economy*, *108*(1), 120–143.

Lei, Z., Sun, Z., & Wright, B. (2012a). *Are Chinese Patent Applications Politically Driven? Evidence from China's Domestic Patent Applications*. In Patent Statistics for Decision Makers Conference, OECD, Paris.

Lei, Z., Sun, Z., & Wright, B. (2012b). Patent subsidy and patent filing in China. *University of California, Berkeley, mimeo*.

Levin, R., Cohen, W. M., & Mowery, D. C. (1985). R & D appropriability, opportunity, and market structure: new evidence on some Schumpeterian hypotheses. *The American economic review*, *75*(2), 20–24.

Levin, R., Klevorick, A., Nelson, R. R., & Winter, S. (1984). Survey research on R&D appropriability and technological opportunity. *Unpublished manuscript. Yale University, New Haven, CT*.

Li, K., Yue, H., & Zhao, L. (2009). Ownership, institutions, and capital structure: Evidence from China. *Journal of Comparative Economics*, *37*(3), 471–490.

Li, S., Li, S., & Zhang, W. (2000). The road to capitalism: Competition and institutional change in China. *Journal of Comparative Economics*, *28*(2), 269–292.

Li, S., & Xia, J. (2008). The roles and performance of state firms and non-state firms in China's economic transition. *World Development*, *36*(1), 39–54.

Li, X. (2007a). An empirical analysis of the change of chinese regional innovation capability: Based on the view of innovation system (in Chinese). *Management World*.

Li, X. (2007b). An empirical analysis of the effect of institutional factors on regional innovation performance (in Chinese). *The Journal of Quantitative & Technical Economics*, *24*(8), 13–24.

Li, X. (2012). *Behind the recent surge of Chinese patenting: An institutional view* (No. 1). *Research policy*, *41*.

Liefner, I., Kroll, H., & Peighambari, A. (2016). Research-driven or party-promoted? Factors affecting patent applications of private small and medium-sized enterprises in China's Pearl River Delta. *Science and Public Policy*, scw002.

Lin, J. Y. (1995). The Needham puzzle: Why the industrial revolution did not originate in China. *Economic development and cultural change*, *43*(2), 269–292.

Lin, J. Y. (2012). *New structural economics: A framework for rethinking development and policy*: World Bank Publications.

Lin, J. Y., Cai, F., & Li, Z. (1998). *Competition, policy burdens, and state-owned enterprise reform*. Estados Unidos: American Economic Review.

Lin, J. Y., Cai, F., & Li, Z. (2003). *The China miracle: Development strategy and economic reform*: Chinese University Press.

Lin, J. Y., & Monga, C. (2011). Growth Identification and Facilitation: The Role of the State in the Process of Dynamic Growth. *Development Policy Review*, *29*(3), 264–290.

Link, A. N. (1980). Firm size and efficient entrepreneurial activity: A reformulation of the Schumpeter hypothesis. *The Journal of Political Economy*, 771–782.

List, F. (1841). *Das nationale System der politischen Ökonomie*. Stuttgart & Tübingen: J. G. Cotta.

Liu, X. (2014). *Economics of technological innovation*. Beijing: Tsinghua University Press.

Liu, X., & White, S. (2001). Comparing innovation systems: a framework and application to China's transitional context. *Research policy*, *30*(7), 1091–1114.

Long, D. M., Payne, J. D., & Feng, C. (1999). Information transmission in the Shanghai equity market. *Journal of Financial Research*, *22*(1), 29–45.

Lundvall, B.-Å. (1985). *Product innovation and user-producer interaction, industrial development"*.

Lundvall, B.-Å. (1995). National systems of innovation: towards a theory of innovation and interactive learning. *London*. Retrieved from http://orton.catie.ac.cr/cgi-bin/wxis.exe/?IsisScript=CIENL.xis&method=post&formato=2&cantidad=1&expresion=mfn=002923\npapers2://publication/uuid/719EE451-FB79-47D0-8E30-F2FD6674D753

Lundvall, B.-Å., Johnson, B., Andersen, E. S., & Dalum, B. (2002). National systems of production, innovation and competence building. *Research policy*, *31*(2), 213–231. https://doi.org/10.1016/S0048-7333(01)00137-8

Maddison, A. (2010). Statistics on world population, GDP and per capita GDP, 1-2008 AD. *Historical Statistics*, 1–36.

Mansfield, E. (1963). Size of firm, market structure, and innovation. *The Journal of Political Economy*, 556–576.

Mansfield, E. (1964). *Industrial research and development expenditures: Determinants, prospects, and relation to size of firm and inventive output*. *Cowles Foundation paper: no. 216*. New Haven, Conn.: Cowles Foundation for Research in Economics at Yale University.

Mansfield, E. (1986). Patents and Innovation: An Empirical Study. *Management Science*, *32*(2), 173–181. https://doi.org/10.1287/mnsc.32.2.173

Mason, E. S. (1939). Price and production policies of large-scale enterprise. *The American economic review*, *29*(1), 61–74.

Megginson, W. L., & Netter, J. M. (2001). From state to market: A survey of empirical studies on privatization. *Journal of economic literature*, *39*(2), 321–389.

Mortensen, P. S., & Bloch, C. W. (2005). *Oslo Manual-Guidelines for collecting and interpreting innovation data*: Organisation for Economic Cooporation and Development, OECD.

Mowery, D., & Rosenberg, N. (1979). The influence of market demand upon innovation: a critical review of some recent empirical studies. *Research policy*, *8*(2), 102–153.

Myers, S., & Marquis, D. G. (1969). Successful industrial innovations. A study of factors underlying innovation in selected firms.

Naughton, B. (1994). Chinese institutional innovation and privatization from below. *The American economic review*, *84*(2), 266–270.

Naughton, B. (2007). *The Chinese economy: Transitions and growth*. Cambridge, Mass.: MIT Press.

Naughton, B. (2017). Is China Socialist? *The Journal of Economic Perspectives*, *31*(1), 3–24.

Nee, V. (1992). Organizational dynamics of market transition: Hybrid forms, property rights, and mixed economy in China. *Administrative science quarterly*, 1–27.

Needham, J. (1969). *The grand titration: Science and society in East and West*: University of Toronto Press. Retrieved from https://books.google.de/books?id=OwRgAAAAMAAJ

Nelson, R. R. (1993). *National Innovation Systems: A Comparative Analysis*: Oxford University Press.

Nelson, R. R., & Winter, S. G. (1982). *An evolutionary theory of economic change*. Cambridge, Mass.: Belknap Press of Harvard University Press.

Nickell, S. J. (1996). Competition and Corporate Performance. *The Journal of Political Economy*, *104*(4), 724–746. https://doi.org/10.1086/262040

Nie, H., Jiang, T., & Yang, R. (2012). A Review and Reflection on the Use and Abuse of Chinese Industrial Enterprises Database. *The Journal of World Econom, 5*.

Nie, H., Tan, S., & Wang, Y. (2008). Innovation, Firm Size and Market Competition: From the Evidence of Firm-level Panel Data in China (in Chinese). *School of Economics, Renmin University of China Working Paper Series*.

Nolan, P., & Wang, X. (1999). Beyond privatization: Institutional innovation and growth in China's large state-owned enterprises. *World Development*, *27*(1), 169–200.

North, D. C. (1990). *Institutions, institutional change and economic performance*: Cambridge University Press.

North, D. C. (1992). *Transaction costs, institutions, and economic performance*: ICS Press San Francisco, CA.

North, D. C., & Thomas, R. P. (1973). *The rise of the western world: A new economic history*: Cambridge University Press.

OECD. (1997). National innovation systems. Retrieved from http://www.oecd.org/science/inno/2101733.pdf

OECD. (1999). *Managing National Innovation Systems* (Vol. 26). Retrieved from http://new.sourceoecd.org/9264170383

OECD. (2015). OECD Guidelines on corporate governance of state-owned enterprises 2015 Edition.

OECD. (2016). State-Owned Enterprises in Asia: National Practices for Performance Evaluation and Management.

Oi, J. C. (1992). Fiscal reform and the economic foundations of local state corporatism in China. *World Politics*, *45*(01), 99–126.

Omran, M. (2004). The performance of state-owned enterprises and newly privatized firms: does privatization really matter? *World Development*, *32*(6), 1019–1041.

Park, S. H., Li, S., & David, K. T. (2006). Market liberalization and firm performance during China's economic transition. *Journal of International Business Studies*, *37*(1), 127–147.

Patel, P., & Pavitt, K. (1994). National innovation systems: why they are important, and how they might be measured and compared. *Economics of Innovation and New Technology*, *3*(1), 77–95.

Pavitt, K. (1988). Uses and abuses of patent statistics. In *Handbook of Quantitative Studies of Science and Technology* (pp. 509–536). https://doi.org/10.1016/B978-0-444-70537-2.50021-0

Peng, M. W., Bruton, G. D., Stan, C. V., & Huang, Y. (2016). Theories of the (state-owned) firm. *Asia Pacific Journal of Management*, *33*(2), 293–317.

Pomeranz, K. (2000). *The Great Divergence: China, Europe, and the Making of the Modern World Economy*: Princeton University Press.

Porter, M. E. (1998). Clusters and the new economics of competition. *Harvard Business Review*, *76*(6), 77–90. https://doi.org/10.1042/BJ20111451

Porter, M. E. (1981). The contributions of industrial organization to strategic management. *Academy of management review*, *6*(4), 609–620.

Porter, M. E. (1990). The Competitive Advantage of Nations. *Harvard Business Review*, *68*, 73–93. Retrieved from http://esc-web.lib.cbs.dk/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=9005210820&login.asp&site=ehost-live&scope=site

Prud'homme, D. (2017). Utility model patent regime "strength" and technological development: Experiences of China and other East Asian latecomers. *China Economic Review*, *42*, 50–73. https://doi.org/10.1016/j.chieco.2016.11.007

Putnam, R. D., Leonardi, R., & Nanetti, R. (1993). *Making democracy work.*

PwC. (2015). *State-Owned Enterprises: Catalysts for public value creation?*

Qian, Y. (1996). Enterprise reform in China: Agency problems and political control. *Economics of Transition*, *4*(2), 427–447.

Rainey, H. G. (2009). *Understanding and managing public organizations*: John Wiley & Sons.

Rajan, R. G. (2011). *Fault lines: How hidden fractures still threaten the world economy*: Princeton University Press.

Ramanadham, V. V. (1991). *The economics of public enterprise*: Taylor & Francis.

Rodrik, D. (2006). Goodbye Washington consensus, hello Washington confusion? A review of the World Bank's economic growth in the 1990s: learning from a decade of reform. *Journal of economic literature*, *44*(4), 973–987.

Romer, P. (1989). *Endogenous technological change.*

Rosenberg, N. (1982). *Inside the Black Box: Technology and Economics* (Vol. 1). Retrieved from http://www.amazon.com/Inside-Black-Box-Technology-Economics/dp/0521273676

Rosenberg, N., & Nelson, R. R. (1994). American universities and technical advance in industry. *Research policy*, *23*(3), 323–348.

Rothwell, R. (1992). Successful industrial innovation: critical factors for the 1990s. *R&D Management*, *22*(3), 221–240.

Rothwell, R., & Zegveld, W. (1985). *Reindustrialization and technology*: ME Sharpe.

Scherer, F. M. (1965). Firm size, market structure, opportunity, and the output of patented inventions. *The American economic review*, *55*(5), 1097–1125.

Scherer, F. M. (1967). Market structure and the employment of scientists and engineers. *The American economic review*, *57*(3), 524–531.

Schmookler, J. (1966). *Invention and Economic Growth*. Cambridge, MA.

Schumpeter, J. (1942). *Capitalism, Socialism, and Democracy*. New York: Harper and Row.

Schumpeter, J. A. (1934). *The Theory of Economic Development.*

Shapiro, C. (2011). Competition and Innovation: Did Arrow Hit the Bull's Eye? In *The rate and direction of inventive activity revisited* (pp. 361–404). University of Chicago Press.

Sheng, H., & Zhao, N. (2012). *China's state-owned enterprises: Nature, performance and reform*: World Scientific.

Shi, S. (2009). *Auswirkungen des Beitritts Chinas zur WTO auf die Wettbewerbspolitik in China: Eine institutionenöknomische Betrachtung.*

Shin, N., Kraemer, K. L., & Dedrick, J. (2012). Value capture in the global electronics industry: Empirical evidence for the "smiling curve" concept. *Industry and Innovation*, *19*(2), 89–107.

Shirley, M. M. (1999). Bureaucrats in business: The roles of privatization versus corporatization in state-owned enterprise reform. *World Development*, *27*(1), 115–136.

Shleifer, A. (1998). State versus private ownership. *The Journal of Economic Perspectives*, *12*(4), 133–150.

Soete, L. L. G. (1979). Firm size and inventive activity: The evidence reconsidered. *European Economic Review*, *12*(4), 319–340.

Solow, R. M. (1957). Technical change and the aggregate production function. *The review of Economics and Statistics*, 312–320.

Song, Z., Storesletten, K., & Zilibotti, F. (2011). Growing like china. *American Economic Review*, *101*(1), 196–233.

Sun, Q., & Tong, W. H. S. (2003). China share issue privatization: the extent of its success. *Journal of financial economics*, *70*(2), 183–222.

Sun, Q., Tong, W. H. S., & Tong, J. (2002). How does government ownership affect firm performance? Evidence from China's privatization experience. *Journal of Business Finance & Accounting*, *29*(1 ‐ 2), 1 ‐ 27.

Tagscherer, U., Kroll, H., & Luo, X. (2012). Regional Innovation Systems in China-An Analysis of Industry-Science Linkages in Bohai Bay Area. *Technological Entrepreneurship in China. Cheltenham: Edward Elgar*, 16–40.

Tan, J., & Litsschert, R. J. (1994). Environment ‐ strategy relationship and its performance implications: An empirical study of the Chinese electronics industry. *Strategic management journal*, *15*(1), 1–20.

Tang, J. (2006). Competition and innovation behaviour. *Research policy*, *35*(1), 68–82. https://doi.org/10.1016/j.respol.2005.08.004

Tingvall, P. G., & Karpaty, P. (2010). Service-sector competition, innovation and R&D. *Economics of Innovation and New Technology*, *20*(1), 63–88. https://doi.org/10.1080/10438590903073675

Tishler, A., & Milstein, I. (2009). R&D wars and the effects of innovation on the success and survivability of firms in oligopoly markets. *International Journal of Industrial Organization*, *27*(4), 519–531.

Unescap. (2009). What is Good Governance ? *United Nations Economic and social Comission for Asia and the Pacific*, 1–3.

van der Hoeven, R., & Sziraczki, G. (1997). *Lessons from privatization: labour issues in developing and transitional countries*: International Labour Organization.

Vernon-Wortzel, H., & Wortzel, L. H. (1989). Privatization: Not the only answer. *World Development*, *17*(5), 633–641.

Vickers, J., & Yarrow, G. K. (1988). *Privatization: an economic analysis*. *MIT Press series on the regulation of economic activity: Vol. 18*. Cambridge, MA: The MIT Press.

Vining, A. R., & Boardman, A. E. (1992). Ownership versus competition: Efficiency in public enterprise. *Public choice*, *73*(2), 205–239.

Wan, J. (2013). *The economics of innovation*. Beijing: Intecllectual property publishing house (in Chinese).

Wang, C. (2005). Ownership and operating performance of Chinese IPOs. *Journal of Banking & Finance*, *29*(7), 1835–1856.

Wang, Q., Wong, T.-J., & Xia, L. (2008). State ownership, the institutional environment, and auditor choice: Evidence from China. *Journal of Accounting and Economics*, *46*(1), 112–134.

Weber, M. (1905). *Die protestantische Ethik und der Geist des Kapitalismus*. *Wort-Schätze*. Gütersloh: Verlagshaus Gerd Mohn.

Wei, S.-J., Xie, Z., & Zhang, X. (2017). From "Made in China" to "Innovated in China": Necessity, Prospect, and Challenges. *Journal of Economic Perspectives*, *31*(1), 49–70. https://doi.org/10.1257/jep.31.1.49

Weitzman, M. L., & Xu, C. (1994). Chinese township-village enterprises as vaguely defined cooperatives. *Journal of Comparative Economics*, *18*(2), 121–145.

Wen, Y., & Wu, J. (2014). Withstanding great recession like China. *FRB of St. Louis Working Paper No*.

World Bank. (2013). *China 2030: building a Modern, Harmonious, and Creative Society*. Washington, DC: World Bank Publications. Retrieved from http://documents.worldbank.org/curated/en/781101468239669951/China-2030-building-a-modern-harmonious-and-creative-society

Wu, Y. (2007). Firm Size, Market Concentration and Innovation: A Survey. *Economic Research Journal*.

Xiao, G. (1996). *Clarification of SOE Property Rights.*

Xu, C. (2011). The fundamental institutions of China's reforms and development. *Journal of economic literature*, *49*(4), 1076–1151.

Xu, X., & Wang, Y. (1997). *Ownership structure, corporate governance, and corporate performance: The case of Chinese stock companies*: World Bank Publications.

Zhang, A., Zhang, Y., & Zhao, R. (2003). A study of the R&D efficiency and productivity of Chinese firms. *Journal of Comparative Economics*, *31*(3), 444–464.

Zheng, J., Liu, X., & Bigsten, A. (2003). Efficiency, technical progress, and best practice in Chinese state enterprises (1980–1994). *Journal of Comparative Economics, 31*(1), 134–152.

Zhou, Y. (2000). The Institutional Change of China in an Evolutionary Perspective (in Chinese). *Economic Research Journal*, *5*, 3–11.

Zhou, Y. (2003). Local Government Competition and Economic Growth (in Chinese). *Journal of Renmin University of China*, *1*, 97–103.

Zhu, X. (2012). Understanding China's growth: Past, present, and future. *The Journal of Economic Perspectives*, *26*(4), 103–124.

Eidesstattliche Erklärung

Hiermit erkläre ich, dass ich die Dissertation selbst und ohne unerlaubte fremde Hilfe angefertigt und außer den im Literaturverzeichnis sowie in den Anmerkungen genannten Hilfsmitteln keine weiteren benutzt habe.