Regional Innovation, Inward FDI and Industrial Structure: A Provincial and Firm Level Study of China

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Abstract

Inward foreign direct investment (FDI) is believed to be a carrier of advanced knowledge to host countries, but how regional factors might impact FDI spillover effects is still uncertain. Meanwhile, regional industrial structure, i.e. specialization and diversity, has been frequently discussed in the literature, but there is no consensus about which type of industrial structure can promote regional innovation. In this thesis, the above two streams of literature are integrated and a theoretical model is proposed in which regional FDI and industrial structure are hypothesized to have direct and interactive effects on regional innovativeness. Provincial- and firm-level panel datasets (2000-2010) were compiled for empirical analyses. The results indicate that a foreign presence is beneficial for both regional and firm innovation capability while these associations are contingent on the level of industrial structure, namely the degree of specialization and diversity. A greater level of regional specialization is less likely to facilitate regional innovators to gain positive spillovers from FDI while an increase in diversity is more likely to reinforce the positive effects of foreign presence on regional innovativeness.

As China has become the biggest FDI recipient country in the world in recent years and the Chinese industrial structure has been changing rapidly during the last few decades, an empirical study in the Chinese context would be ideal to examine the debate on the roles of industrial structure and FDI in promoting regional innovativeness. Overall, this research aims to advance the understanding about the moderating role of regional industrial structure in affecting the spillover effect of FDI on regional and firm innovation. The findings not only provide empirical evidence for the specialization versus diversity debate, but also highlight the essential role of contextual factors in facilitating regional innovativeness.

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Abbreviation

Annual Accounting Report, AAP
Business expenditure on R&D, BERD
China Statistical Database, CSD
Chinese Academy of Sciences, CAS
Chinese Communist Party, CCP
China National Petroleum Corporation, CNPC
China Stock Market Accounting Research, CSMAR
China Securities Regulatory Commission, CSRC
The Database of China Main S&T Index, DCMSTI
Government expenditure on R&D, GERD
Face-to-face, F2F
Foreign direct investment, FDI
Foreign invested enterprises, FIE
Full-time-employees, FTEs
Gross Domestic Production, GDP
Guo Tai An, GTA
High specialisation and low diversification, HSLD
High specialisation and high diversification, HSHD
High technology enterprises, HTEs
Industry, academia and research institutions, IAR
Innovation capability, IC
Information and communications technology, ICT
Intellectual Property Right, IPR
Industrial structure, IS
International Organization for Standardization, ISO
Knowledge application system, KAS
Knowledge diffusion system, KDS
Knowledge intensive business services, KIBS
Knowledge innovation system, KIS
Knowledge production function, KPF
Local Government Work Report, LGWR
Large and medium-sized enterprises, LMEs
Low specialisation and low diversification, LSLD
Low specialisation and high diversification, LSHD
Multinational enterprises, MNEs

National Bureau of Statistics of the P.R.China, NBS
National Engineering Research Centre, NERC
National innovation system, NIS
National People's Congress, NPC
New Technology Development Zone, NTDZ
Organization for Economic Co-operation and Development, OECD
Ordinary least square, OLS
Productivity Facilitation Centre, PFC
Public listed company, PLC
Regional innovation system, RIS
Research and development, R&D
Special economic zones, SEZs
State holding enterprises, SHEs
State Intellectual Property Office of the P.R.China, SIPO
Small and medium enterprises, SMEs
State owned enterprises, SOE
Technology innovation system, TIS
United States Patent and Trademark Office, USPTO
World Trade Organization, WTO

Chapter 1 Introduction

1.1 Research motivation and background

1.1.1 Research motivation

With increasing globalisation and the advent of the knowledge economy, innovation has become an increasingly attractive topic for both policy makers and business practitioners in both developed countries and emerging markets. The reason why innovation is a critical concern in practical life is because innovation becomes a new engine for promoting the competitiveness of a nation or a company (McGrath et al., 1996; Porter, 1990a). Innovation is a process in which different elements of knowledge are recombined or generated (Cohen and Levinthal, 1989), and the outcomes of innovation hope to satisfy concrete or potential market demands (Adner and Levinthal, 2001). The greater likelihood of a region or a company to innovate, the higher possibility the region or the company can establish competitiveness. Innovation capability (IC) is unevenly distributed among different nations, regions, and organisations for various reasons, such as historical development, regional endowment, and culture differences, which may impact on knowledge accumulation and capability cultivation. Regional IC (RIC) in the present research refers to the capacity of a region to generate new knowledge from the existing resources and investment in a certain geographic scope (Li, 2009).

Which factors determine a region's IC becomes an important question for both academia and practitioners. Though prior studies pointed out that research and development (R&D) expenditure and human capital are directly related to IC (Girma et al., 2009; Sterlacchini, 2008), little is known about other contextual features that may affect regional innovativeness.

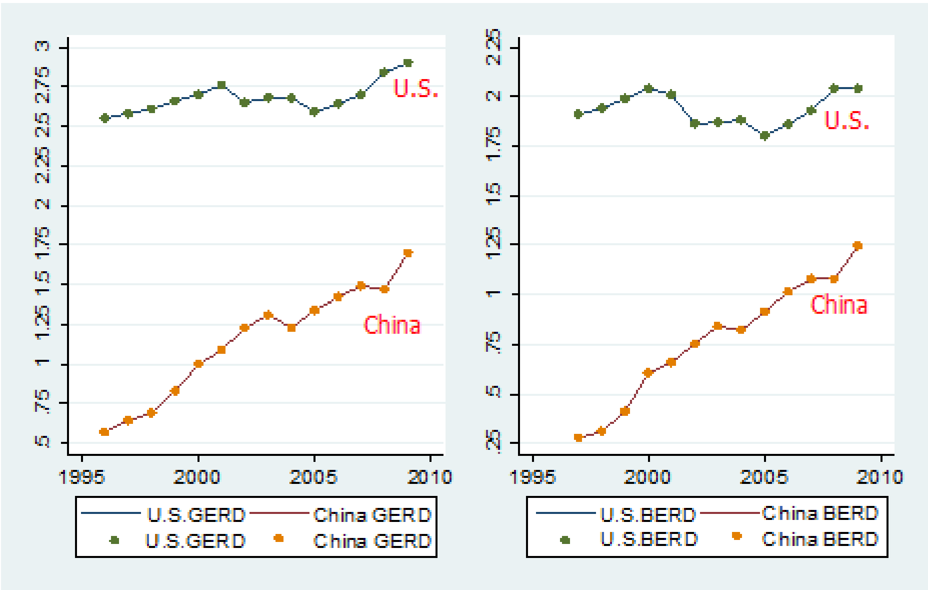
Regional discrepancy in terms of economic and innovative capabilities is a common case in emerging markets (Li et al., 2011; Prevezer et al., 2013). The notion of a regional innovation system (RIS) has emerged as a popular and territorially focused lens, which can be defined as 'the localised network of various actors and institutions in different sectors whose activities and interactions generate, absorb, and diffuse new technologies within and outside the region' (Iammarino, 2005). Prior studies mainly focussed on the structure and innovators within RISs in developed countries whilst few attempts investigated the role of regional characteristics in affecting RISs in emerging markets and how these features may affect local companies' IC.

Innovative activities in emerging markets are closely related to inward foreign direct investment (FDI) because indigenous innovators can learn from knowledge spillovers of FDI (Meyer and Sinani, 2009). Particularly, FDI spillovers occur when 'the entry or presence of multinational companies affiliates leads to productivity or efficiency benefits in the host country's local firms and the MNCs are not able to internalize the full value of these benefits' (Blomstrom & Kokko, 1998:p.249). Though a large body of prior studies investigated the impact of foreign presence on host countries' economic growth, the role of inward FDI in RISs in emerging markets is relatively unclear. Moreover, given that the high speed of economic development is usually accompanied by dynamic changing of regional industrial structure, or IS (Luo, 2003), extending the RIS theory by taking account of the effect of IS on regional innovativeness is reasonable.

Motivated by these theoretical concerns and practical demands, this thesis investigates the determinants of regional IC and local indigenous firms' IC by integrating three streams of literature – on RISs, FDI spillovers and industrial externalities – and adopting regional and firm level datasets.

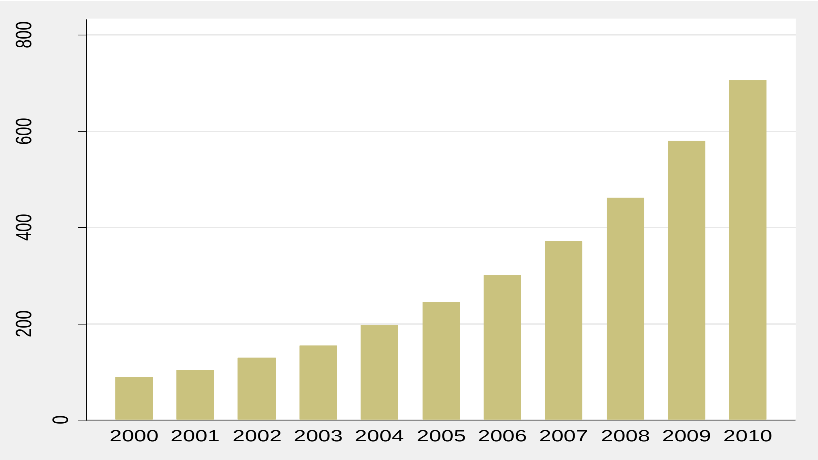
1.1.2 Research background

To complement extant literature that focuses on RISs in developed countries, this thesis concentrates on the Chinese context. The concrete reasons for choosing China as the research context are threefold. First and foremost, although the science and technology (S&T) capability of China is weaker than the United States (US), the United Kingdom (UK), and other developed countries, China is definitely an active player in catching up with developed countries in the global technology competition (Lee et al., 2011). To further comprehend this background, I provide several indicators to illustrate both R&D investment and the output of China during the past decade as follows.



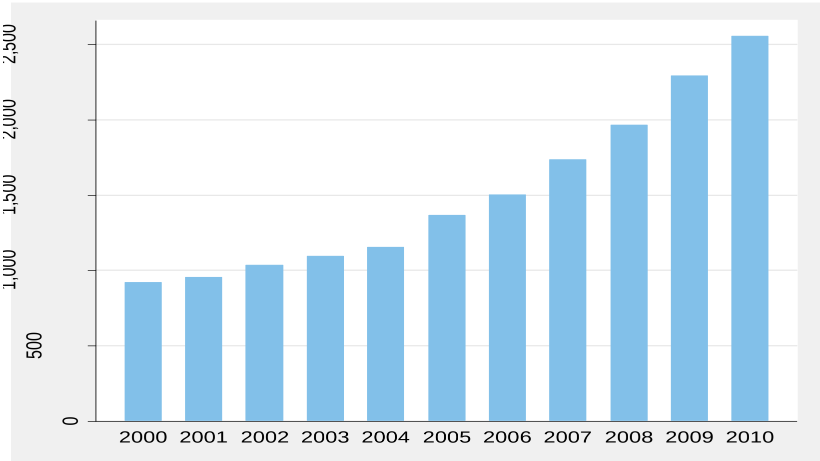
Unit: percentage
Source: compiled by the author using the data collected from OECD database.
Figure 1.1 GERD and BERD of China and U.S. (1995-2010)

Figure 1.1 above shows, from a perspective of comparison with the US, that both Chinese government expenditure on R&D (GERD) and business expenditure on R&D (BERD), have been rising rapidly since 1996 as a proportion of gross domestic product (GDP). Particularly the growth rates of Chinese GERD and BERD are higher than that of the US during 1996 to 2010, although they remain well below US levels of around 2.5% for GERD and 2% for BERD. This fact indicates that, in general terms, as a developing country, the innovation inputs have been highlighted by both Chinese policy makers and business practitioners during the last decade.



Source: compiled by the author using the data collected from the National Bureau of Statistics of P.R.Cihina (NBS).

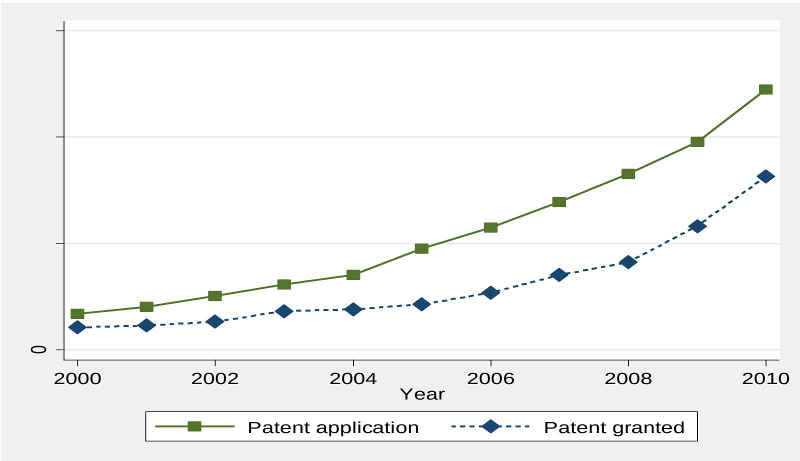
Figure 1.2 National R&D expenditure of China (2000-2010)



Source: compiled by the author using he data collected from NBS.

Figure 1.3 National R&D personnel of China (2000-2010)

Moreover, both the amount of R&D expenditure and number of R&D staff experienced substantial increases during the period of 2000 to 2010. As Figure 1.2 shows, the overall R&D expenditure of China grew dramatically from 89.57 billion RMB in 2000 to 706.26 billion RMB in 2010, an increase of nearly 788.5%. Meanwhile, human capital in terms of R&D staff increased nearly 277.0% from 922,100 full-time-employees (FTEs) in 2000 to 2,554,000 FTEs in 2010, which is presented in Figure 1.3. The consecutive R&D investment shows China's determination to transform from a '*global workshop*' to a leader of technology innovation (Abrami et al., 2014).

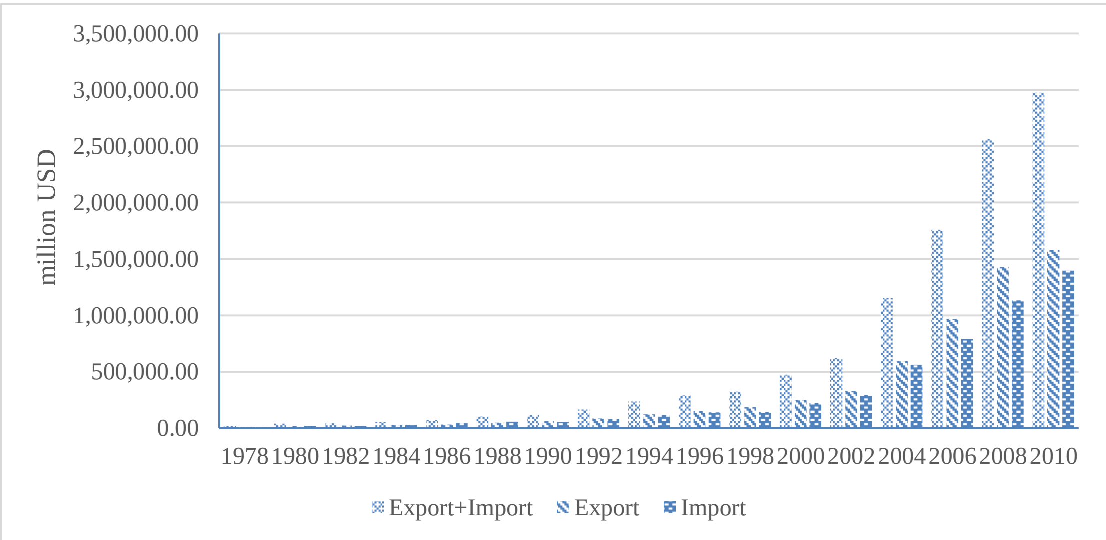


Source: compiled by author using the data collected from NBS.

Figure 1.4 National patent applications and granted patents of China (2000-2010)

On the other hand, the R&D output of China, e.g. number of patent applications and patent grants, also witnessed exponential growth during the period of 2000 to 2010. As shown in Figure 1.4, the total number of patent applications increased from 170,682 in 2000 to 1,222,286 in 2010 while the amount of granted patents increased from 105,345 in 2000 to 814,825 in 2010. Although the upward trend of R&D activities is easy to understand, little is known about the regional factors leading this upward trend.

Secondly, China has successfully attracted inward FDI during the last decade and has become the largest FDI recipient in the world since 2012. Foreign invested enterprises[1] (FIEs) accounted for nearly half of China's international trade and one quarter of its industrial output in 2011 (NBS, 2012). This provides a valuable opportunity for me to understand the role of inward FDI, which acts as an external knowledge source, in affecting regional innovativeness in developing economies. Since the Chinese government implemented the "*Reform and Opening Up*" policy (*gai ge kai fang*) in 1978, an increasing number of Chinese regions have accessed FDI. This upward trend has been even stronger since China joined the World Trade Organization (WTO) at the end of 2001, as all of the 31 regions of China have been gradually opened to foreign investors and several sectors that were originally protected by the Chinese government, e.g. telecommunication and transportation, have been gradually opened to foreign capital. I present several indicators to further illustrate the dramatic increase of foreign presence in China as follows.

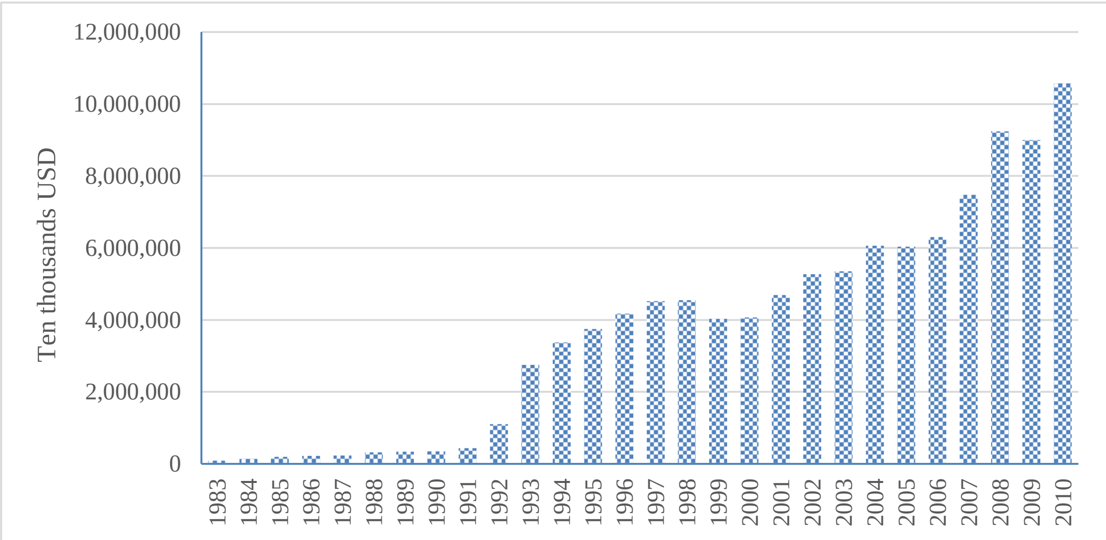


Source: Compiled by the author using data collected from NBS.

Figure 1.5 Volume of export, import and total trade volume of China (1978-2010)

[1] The criteria for assessing a foreign invested enterprise (FIE) is according to the official criteria jointly published by the National Bureau of Statistics of the P.R.C. and the State Administration for Industry & Commerce of the P.R.C. Specific information is available at http://www.gov.cn/zwgk/2011-11/17/content_1995548.htm.

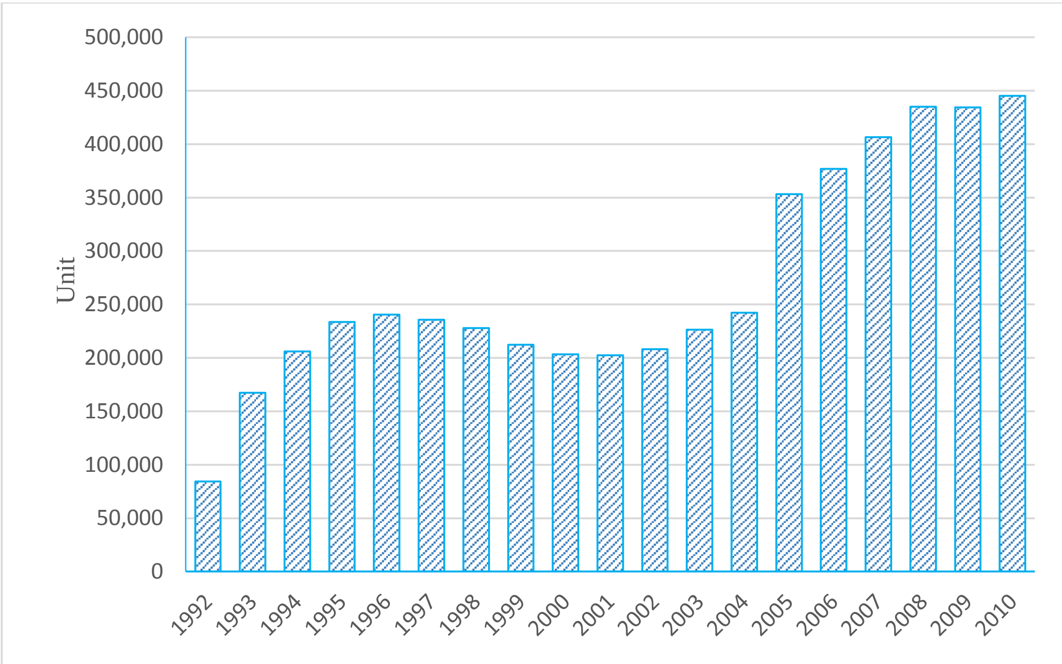
As Figure 1.5 depicts, though the general trend of the openness of China has been upward since the implementation of the "*Reform and Opening Up*" policy in 1978, international trade volume increased dramatically only in the period since China joined the WTO in 2001. For instance, international trade volume (sum of exports and imports) was merely 20.64 billion USD in 1978, and it increased to 474.29 billion USD in 2000. However, the international trade volume rocketed to 2,974 billion USD in 2010 which is 6.3 times and 144 times higher than the international trade volume in 2000 and in 1978, respectively. This fact is consistent with the argument in prior studies, for example Yang and Lin (2012), that China has become more open during the last decade, indicating that foreign investors are more willing to join in an emerging market with a high degree of foreign trade.



Source: Compiled by the author using data collected from NBS.

Figure 1.6 Inward FDI in China (1983-2010)

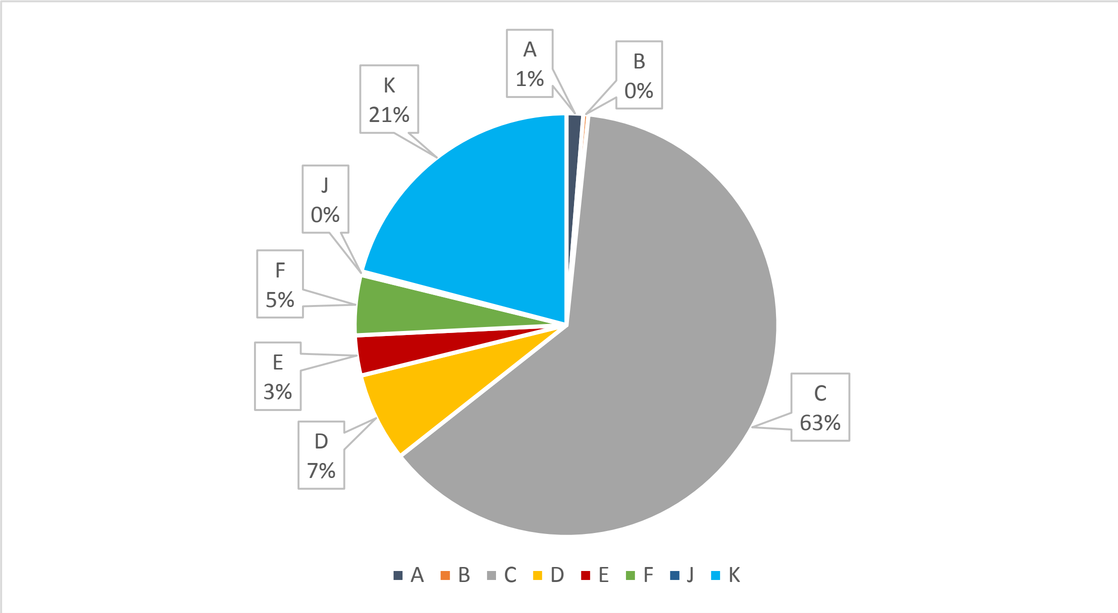
Figure 1.6 shows that there was only a very limited volume of inward FDI during the period of 1983 to 1991. This was because Chinese policy makers had tried to increase openness through a series of experiments or trials at the early stage of the opening up process, for instance several special economic zones (SEZs) were established in some coastal cities in this period (see Chapter 4 for details). Foreign investors, on the other hand, were watching and evaluating whether China is a suitable country to invest in. More importantly, it is notable that the volume of inward FDI increased gradually since China joined the WTO in 2001, indicating that China is a suitable context to investigate the role of foreign presence in affecting innovative activities.



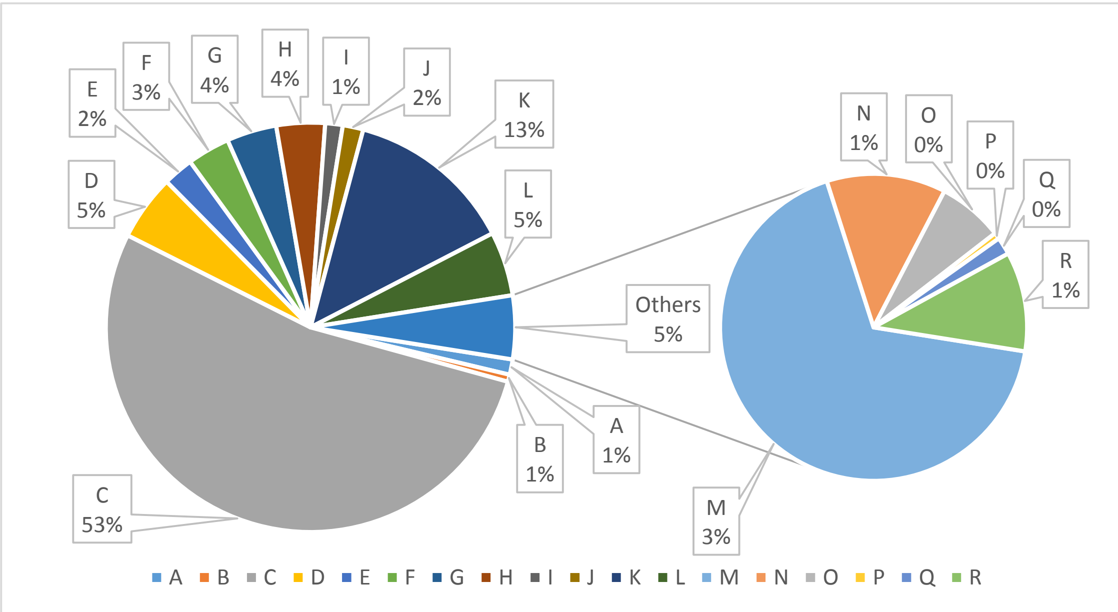
Source: Compiled by the author using data collected from NBS.

Figure 1.7 Number of foreign invested enterprise (FIE) in China (1992-2010)

I also compared the number of FIEs, as shown in Figure 1.7, with the total value of FDI, as shown in Figure 1.6, in China during the last two decades. I found that the growth rate of the number of FIEs is much smaller than the growth rate of the value of FDI, particularly in the period of 2005 to 2010. This phenomenon may be attributed to the increase in the average size of multinational enterprises' (MNEs) investments in China during the last decade. As Wang et al. (2012) pointed out, both pace and irregularity of foreign entry negatively moderate the effect of foreign presence on local firms' productivity. Thus, the foreign presence, rather than the amount itself, created a complicated process.



(plot a: 2000)



(plot b: 2010)

Source: Compiled by the author using data collected from NBS.

Notes: The share is based on the total value of FDI in each category. The general industrial categories (one digit: A-S) is in accordance with the codebook of NBS based on a national standard (GB/T 4754-2011). Specifically, A represents agriculture, forestry, animal husbandry and fishery; B represents mining; C represents manufacturing; D represents production; supply of electricity, gas and water; E represents construction; F represents transport, storage and post; G represents information, transmission, computer services and software; H represents wholesale and retail trades; I represents hotels and catering services; J represents financial intermediation; K represents real estate; L represents leasing and business services; M represents scientific research, technical services, and geological prospecting; N represents management of water conservancy, environment and public Facilities; O represents services to households and other services; P represents education; Q represents health, social security and social welfare; R represents culture, sports and entertainment.

Figure 1.8 Distribution of FDI in different industrial categories (2000, 2010)

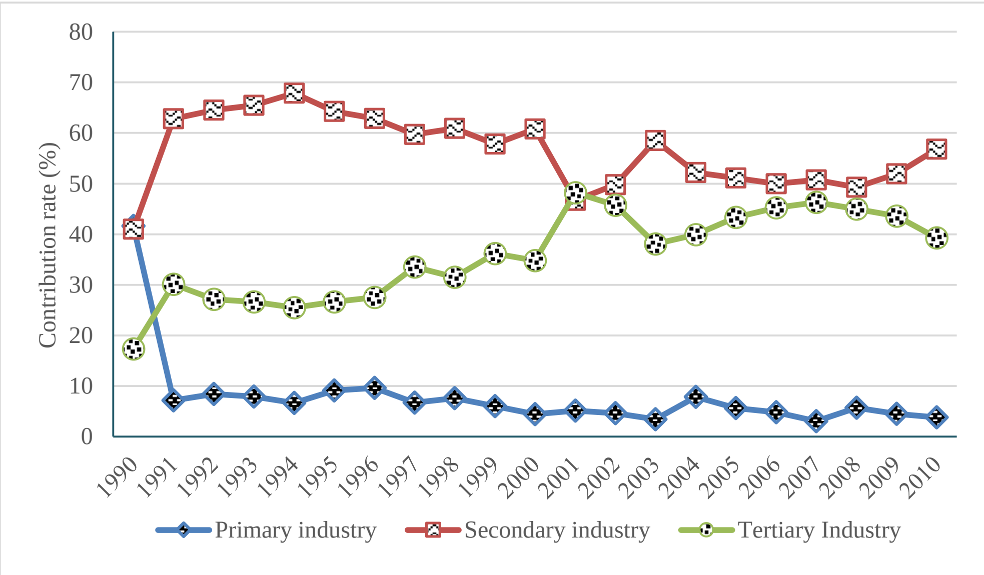
The distribution of FDI in different industrial sectors in China is illustrated using two snapshots (i.e. 2000 and 2010) in Figure 1.8 for comparison. I found that the degree of openness of the Chinese economy was limited in the year 2000 to merely eight general industries (one-digit level of the Chinese national standard GB/T 4754-2011), and found that overseas vendors invested in as many as 18 general industries in 2010, which covered most industries of the Chinese economy. In addition, I noticed that over half of foreign investment focussed on the manufacturing industry (category C) albeit its share decreased from 63% to 53%. This phenomenon implies that the manufacturing industry was the main recipient of foreign investment during our sample period (2000–2010).

Although the inward FDI in China witnessed a huge increase – from 20 billion USD in 2000 to over 100 billion USD in 2010 – during the last decade, literature that focussed on the role of FDI in China was mainly based on obsolete datasets (i.e. data reflecting older time periods), for instance from the reform period (1978 to 1980) and economy transition period (1980 to 2000). I found very few studies examining the effect of foreign presence on regional innovation in China using a recent dataset (e.g. 2000 to 2010). For instance, I reviewed FDI-related studiesin the Section 2.3 in Chapter 2 and found that almost none of them focussed on foreign presence in China in the last decade. To double-check this point, I used '*FDI*', '*Innovation*', and '*China*' as keywords to search for those most related studies and the latest studies through Google Scholar Search Engine[2] in May 20th, 2014 and find that only two recent studies – Liu et al. (2014) and Jeon et al. (2013) – adopted a firm level dataset during the period from 1998 to 2008. Therefore, in this thesis, I compiled two panel datasets, one including 30 Chinese provinces and municipalities, and the other incorporating 9,291 firm-year

[2] Available at: http://scholar.google.com/

observations for 1,524 Chinese public listed companies (PLCs) during the period of 2000 to 2010, to support the empirical studies in Chapter 5 and Chapter 6.

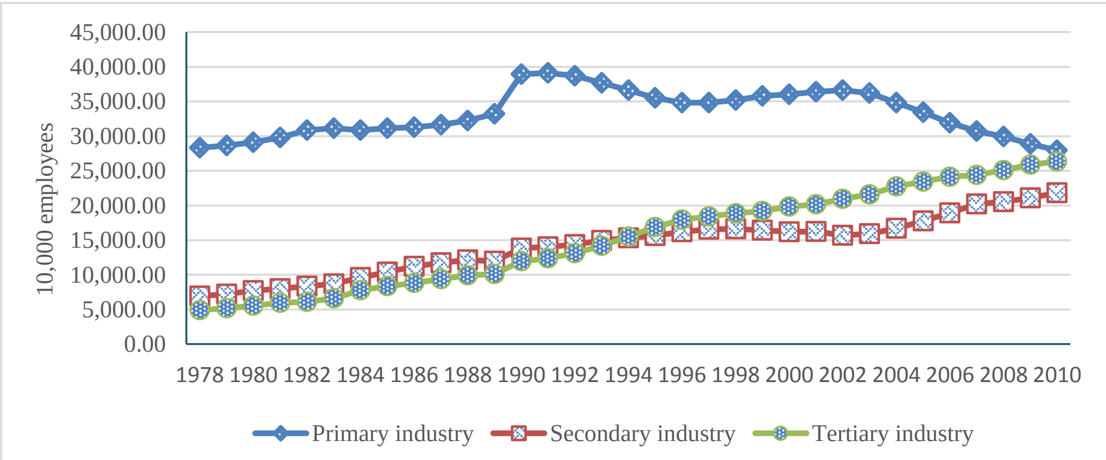
Finally, as Marshall–Arrow–Romer (MAR) externalities are associated with specialisation and Jacobs externalities are associated with diversity, the debate of MAR versus Jacobs externalities is inconclusive: the specialisation externalities view highlights that knowledge spills over from intra-sector activities while the diversity externalities viewpoint argues that a variety of regional industries provide valuable knowledge for innovation (Beaudry and Schiffauerova, 2009). The IS in China is dynamic and has changed during the last three decades, indicating that the variations of industrial portfolios in Chinese regions also changed rapidly during the last three decades. The following descriptive data analysis illustrates the dynamic changing process of the IS in China.



Source: Compiled by the author using data collected from NBS.
Note: According to the classification proposed by the NBS, the primary industry includes agriculture, forestry, herd, fishery, the secondary industry includes mining, manufacturing, electric power, heating power, gas and water production, construction, the tertiary industry, i.e., service sectors, includes sectors that do not belong to the first and second industries.

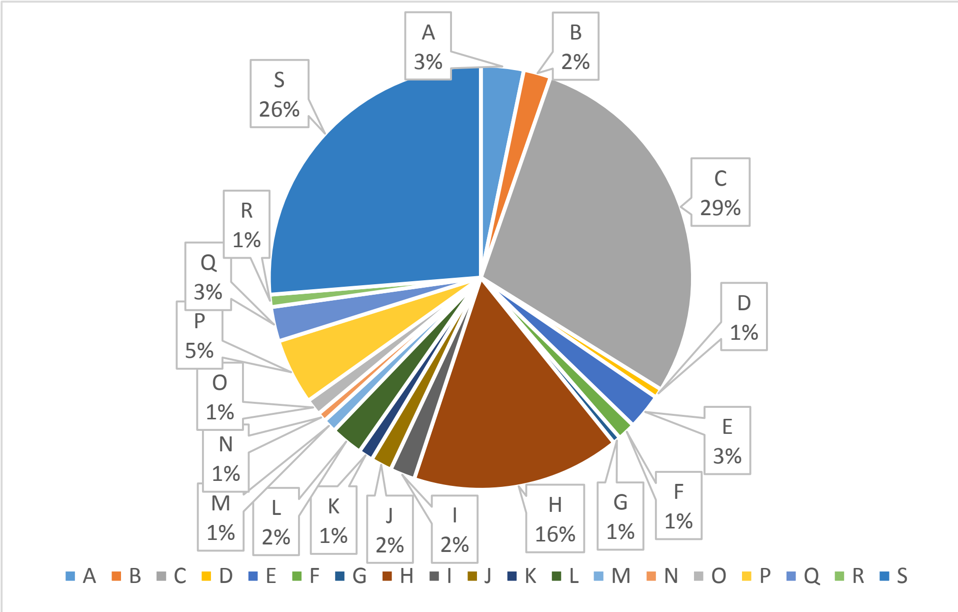
Figure 1.9 Contribution of the three types of industry to national GDP growth (1990-2010)

As shown in Figure 1.9, I investigated the contribution of the three types of industry to national GDP growth by calculating the percentage of the contribution rate, which is the added value of each industry divided by the added value of national GDP. I found that the secondary industry has been the main driver for economic development since 1991 as the contribution rate of the secondary industry fluctuated between 50% and 70% in the last two decades. Meanwhile, I noticed a huge decline of the contribution rate of the primary industry from 41.6% in 1990 to 7.1% in 1991, and since then, it stably fluctuated between 3% and 10%. The tertiary industry was found to be a new engine for economic growth as its contribution rate has exceeded 40% since 2004.

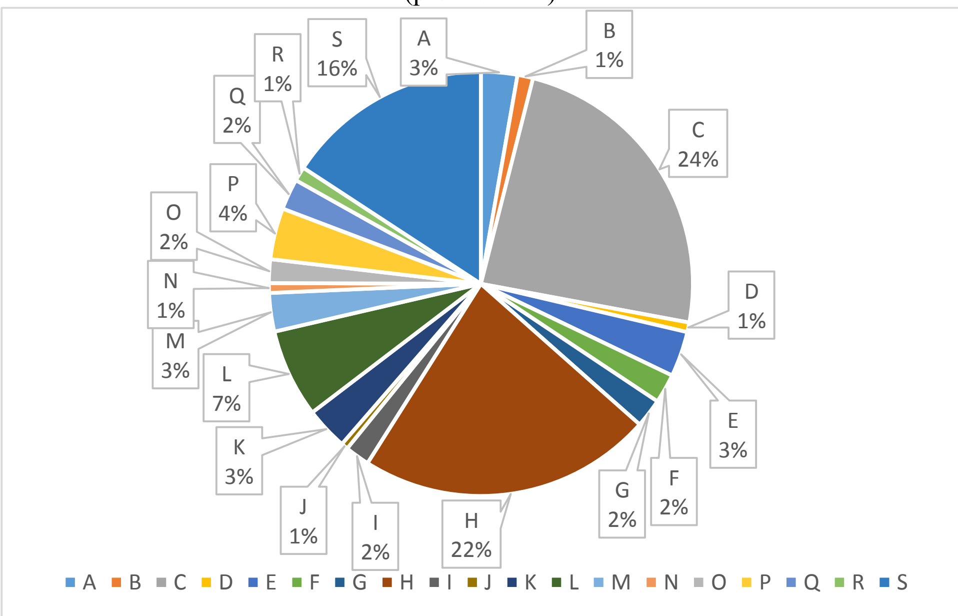


Source: Compiled by the author using data collected from NBS.
Figure 1.10 Number of employees of the three types of industry (1978-2010)

Figure 1.10 depicts the number of employees in the primary, secondary, and tertiary industries. The general trend of the number of primary industry employees is consistent with the analysis in a following section, namely that the agriculture industry was reinforced in the 1980s with a downward trend since 1990. In contrast, I noticed that the numbers in both the secondary and tertiary industries increased gradually in the last three decades. For instance, employees in the manufacturing industry increased from 69.45 million in 1978 to 218.421 million in 2010. Moreover, the number of employees in the tertiary industry has exceeded the number of those in the manufacturing industry since 1994, indicating that the tertiary industry is becoming an essential industry in China.



(plot a: 2000)



(plot b: 2010)

Source: Compiled by the author using data collected from NBS.
Notes: The general industrial categories (one digit: A-S) is in accordance with the codebook of NBS based on a national standard (GB/T 4754-2011)[3]. Specifically, A represents agriculture, forestry, animal husbandry and fishery; B represents mining; C represents manufacturing; D represents production; supply of electricity, gas and water; E represents construction; F represents transport, storage and post; G represents information, transmission, computer services and software; H represents wholesale and retail trades; I represents hotels and catering services; J represents financial

[3] For details of each general industrial category, please refer to the website http://www.stats.gov.cn/tjsj/tjbz/hyflbz/.

intermediation; K represents real estate; L represents leasing and business services; M represents scientific research, technical services, and geological prospecting; N represents management of water conservancy, environment and public Facilities; O represents services to households and other services; P represents education; Q represents health, social securities and social welfare; R represents culture, sports and entertainment; S represents public management and social organizations.

Figure 1.11 Distribution of the number of entities in China' industrial structure (2000, 2010)

Figure 1.11 above depicts the shares, calculated by the number of entities, of each general industrial category (one-digit level, GB/T 4754-2011) of China's IS. I provide two snapshots, i.e. '*plot a*' for 2000 and '*plot b*' for 2010, for the comparison of IS in the starting year and ending year of the sample. Obviously, the numbers of entities in the category C, which represents manufacturing, category H, which represents wholesale and retail trades, and category S, which represents public management and social organisations, are much larger than other general categories, indicating that these three industries are the most active actors in the Chinese economy. Moreover, the shares of both category C and category S decreased during the sample period, while the share of category H increased 6% in 2010 compared with a share of 16% in 2000. This difference implies that the tertiary industry has become a more attractive sector in the national IS. The dynamic changing process of the IS in the Chinese context provides me a valuable opportunity to investigate the roles of industrial specialisation and diversity in affecting regional innovativeness. Based on the above analyses, I choose China as the research context for this thesis. I hope to achieve the research objective of this thesis and extend the literature on RISs, FDI, and IS.

1.2 Research question

In order to identify those key regional features relevant to innovation, I conducted a comprehensive literature review regarding RISs, IS, and inward FDI, as shown in Chapter 2. In section 1.2.1, I document several research gaps and weaknesses in the literature. These identified research gaps define the core research question and related specific research questions of this thesis. Section 1.2.2 elaborates on how each specific question is linked together and constructs the conceptual framework for this thesis.

1.2.1 Research gap identification

As the primary focus of this thesis is the factors which affect innovative activities in a region, literature regarding RISs and IC is first reviewed in Chapter 2. I found that the majority of prior studies focussed on exploring who the main innovators in RISs are, and how the mutual relationships between various innovators, e.g. business practitioners, research facilities, universities, and policy makers, affect the structures and capabilities of RISs (Chung, 2002; Cooke, 2002b; Fleming et al., 2007). I also noticed that prior studies overwhelmingly highlight the role of internal innovators within an innovation system, but neglect potential impacts of internal structural factors on IC. The internal structural factor refers to the IS at the regional level which exerts externalities on regional innovations (Bun and Makhloufi, 2007; Gao, 2004; Henderson, 1997). Therefore, the first research gap within prior studies was identified as the following.

Research gap 1: few studies examined the role of IS in affecting IC.

Another shortcoming within the RISs literature is that most prior studies focussed on RISs in developed countries, for example the US, the UK, and European countries, while few derived evidence from emerging markets. However, findings and arguments derived from prior studies may suffer a bias when the findings and policy implications are generalised for less developed countries. Reasons behind this bias are threefold.

Firstly, both the economic and innovative capabilities of developed countries are much stronger than developing countries. The mechanism and experience derived from the RISs of developed countries may not be effective in developing countries since the latter cannot afford the highlights of innovation systems in developed countries. Secondly, compared with developed countries, emerging markets are more likely to rely on foreign knowledge spillovers because advanced knowledge embodied in FDI has become a crucial technology source for regional innovators (Fu, 2012; Kemeny, 2010; Li et al., 2013; Liu, 2002). In other words, prior RISs literature may neglect the role of foreign presence in affecting regional innovativeness because RISs theory is mainly based on the experience of developed countries. Therefore, much attention needs to be given to emerging markets, especially those with rapid development of economic and technological capabilities. I therefore identify the second research gap within prior studies as the following.

> **Research gap 2:** few studies focused on RISs in the context of emerging markets which may provide different findings to complement RISs theory.

From reviewing the stream of literature regarding FDI, especially knowledge spillover from foreign presence, it was found to highlight that the amount of FDI is not a sole determinant for the effect of foreign presence on innovative activities; regional features may act as contingent factors which moderate the impact of FDI on innovation. However, this strand of research either focuses on some physical factors, e.g. regional infrastructure (Fu, 2008), or endowment issues, such as regional human capital (absorptive capacity; (Ferragina and Mazzotta, 2013), or adopts relatively obsolete data. For example, as Table 2.3 in Chapter 2 shows, the majority of prior studies relating to

FDI in the Chinese context were mainly focussed on the reform period (1980–1990) or transition economy period (1990–2000). No specific studies focus on the later periods, for instance since China joined the WTO in 2001. Therefore, I identified the third research gap of prior studies as the following.

> **Research gap 3:** few studies investigated the regional contingent factors that moderate the association between foreign presence and IC, particularly in recent periods.

Through reviewing the literature in regard to IS – specialisation and diversity – in Chapter 2, it was also found that each of these two dimensions of IS may have a close relationship with regional innovative activities. However, prior studies cannot provide sufficient evidence for drawing a consensus for the debate of MAR versus Jacobs externalities. The majority of prior studies focussed on the effects of specialisation and diversity on regional economies, rather than exploring the impact of IS on regional innovativeness. Moreover, as pointed out by Beaudry and Schiffauerova (2009), only very few studies have focussed on IS in developing countries although variations in the regional IS in emerging countries have been significant during the last decade (Xu, 2002). Therefore, I identified the fourth research gap of prior studies as the following.

> **Research gap 4:** the debate of MAR versus Jacobs externalities is inconclusive and few studies focussed on the role of IS in affecting the association between foreign presence and IC.

Finally, the review of prior studies on innovation at firm level suggests that most existing studies treat regional features as dummy variables, rather than using specific variables to proxy various features. Recently, an increasing number of scholars contended that contextual factors are critical for understanding innovation-related research questions and that contextual factors deserve to be treated seriously in the framework of innovation research (Wang and Lin, 2013; Zahra et al., 2014). Therefore, I identified the fifth research gap within prior studies as the following.

> **Research gap 5:** few studies examined the role of contextual factors at the regional level in affecting firms' IC.

Overall, I find that the above five research gaps within prior studies are mutually connected with each other rather than isolated. In order to address these research gaps, I integrated the aforementioned results and derived the core research question of this thesis and several specific research questions to guide the direction in choosing the research method and searching data sources.

1.2.2 Research questions and objective

Based on the identified research gaps, the core research question of this thesis is:

> "*Do regional foreign presence and industrial structure (IS) affect innovation capability (IC) and, if so, how?*"

Source: Compiled by the author.

Figure 1.12 Administrative divisions of People's Republic of China (PRC)

Given that China is a huge country, currently, there are five practical (*de facto*) levels of local government: the province, prefecture, county, township, and village. As shown in Figure 1.12 above, the provincial level includes autonomous regions, provinces, municipalities, and special administrative regions. Due to the constraints of data sources and for the convenience of comparing the research results with prior studies, the '*region*' in this thesis includes autonomous regions, provinces, and municipalities. There are three main reasons for investigating regional innovation at the provincial level in China. First of all, after a series of institutional reforms beginning in the 1980s, provinces in China have become much more administratively and economically independent than earlier (Li et al., 2011). This is thanks to the '*open-door reform*' which offered regional governments in each province autonomy with the right in formulating social and economic development policies (Gu and Lundvall, 2006; Liu and White, 2001). Against this background, provinces are more likely to formulate specific plans and policies for regional technology development based on regional-specific circumstances. In addition, the regional features of each province in terms of culture, conventions, and dialect are different. These distinct features are closely related to the '*social capital*' which is regionally embedded and affects the pattern and behaviour of local innovators in a region (Li, 2009). Finally, prior studies suggest that knowledge diffusion and transfer usually are concentrated within a certain proximity (Jaffe et al., 1993). Labour mobility is an effective manner for transferring tacit knowledge (Wilson and Spoehr, 2010). China is the nation with the largest population in the world: labour mobility is constrained within the provincial scope. The '*Hukou*' system, which was generated by the central government in 1950s, is the main reason for the constraint of labour mobility (Liu, 2005b). The '*Hukou*' system can be taken as an internal visa arrangement: people have no or only limited access to housing, selling property, education, social security or food in certain locations (Bosker et al., 2012). Although this regulation has been relaxed in more and more provinces in China recently, intra-province labour mobility is more likely to happen than that of inter-province, and tacit knowledge and social capital is more likely to adhere to the regional structure (Li, 2009).

In order to comprehensively provide an answer to the core research question, I divided it into three specific research questions as follows.

Research question 1: Why are foreign direct investment and industrial structure two critical factors in a regional innovation system?

Research question 2: Do foreign presence and industrial structure (i.e., specialization and diversity) exert direct and interactive effects on ***regional*** innovation capability?

Research question 3: Do foreign presence and industrial structure (i.e., specialization and diversity) exert direct and interactive effects on the innovation capability of ***domestic firms***?

To further illustrate the logical links between the three specific research questions, I elaborated relationships between these research questions in Figure 1.13.

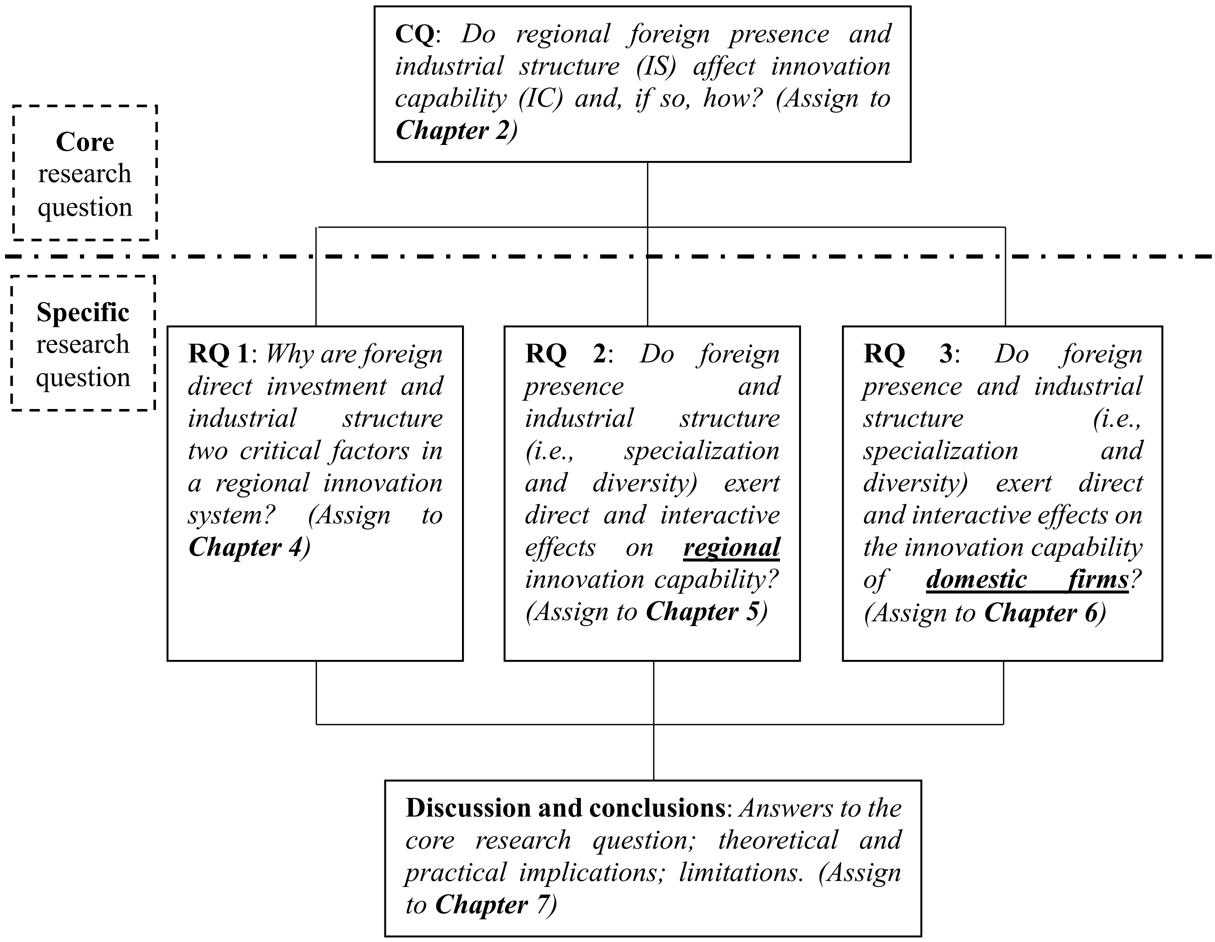
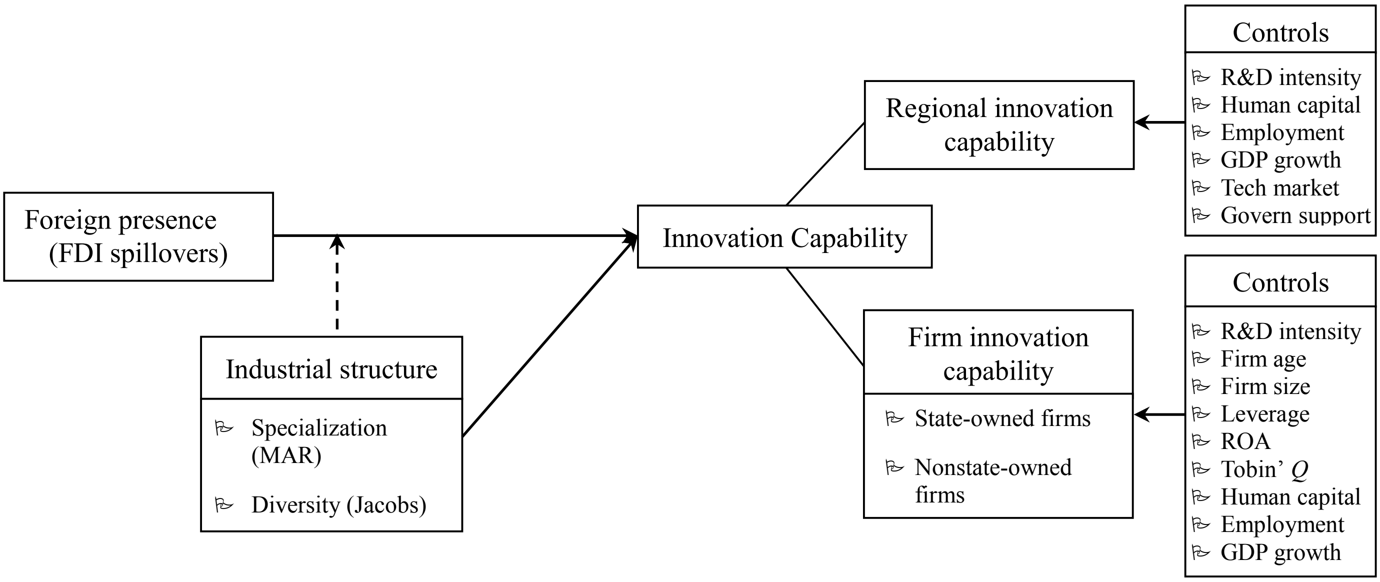


Figure 1.13 Overall research framework of this thesis

To answer the core research question, it is necessary to answer the specific questions presented in Figure 1.13. The revised framework does not include any arrows as these specific questions **contribute equally to the core research question**. Specifically, Chapter 2 is designed to derive the core research question of this thesis, Chapter 4 is designed to answer the first specific research question (RQ1), Chapter 5 is designed to answer the second research question (RQ2) and Chapter 6 is designed to answer the third research question (RQ3).

Figure 1.14 below illustrates the empirical analysis framework of this thesis. Chapter 5 and Chapter 6 will empirically test the hypothesised model at regional and firm levels, respectively. The research objective of this thesis is to address the aforementioned five research gaps and thus advance the understanding of the roles of FDI and IS in affecting IC in terms of regional and firm IC.



Notes: The arrow with solid line represents the impacts of FDI, industrial structure and controls on innovation capability, the arrow with dashed line represents moderating effect of industrial structure on the relationship between FDI and innovation capability.

Figure 1.14 Empirical analysis framework of this thesis

1.3 Outline of the thesis

Once the research questions and context for this research have been identified, the next question is how to proceed and achieve the research objective. To do so, a systematic analysis of the aforementioned specific research questions is conducted and presented in the following chapters. Specifically, I present a review of prior studies regarding the three main themes, i.e. RISs, IS, foreign presence and domestic firms with different ownership, in Chapter 2. At the very beginning of Chapter 2, the relationship between

RISs and the national innovation system (NIS) is revisited through pointing out the advantages of adopting the perspective of RISs in this research. I then review the literature focussing on regional IC through investigating which factors were suggested by previous studies as influential determinants of regional IC. In the second section of Chapter 2, I focus on the definition of specialisation and diversity as well as the debate of MAR versus Jacobs externalities. The effect of industrial specialisation and diversity on regional innovation is found to be inconclusive, with few prior studies even thinking about their moderating role in affecting IC. Finally, in the third section of Chapter 2 the role of foreign presence in affecting regional innovative activities in host countries is focussed on, including whether the impact of FDI spillovers is affected by other contextual factors. Then, I investigate the research outcome of prior studies in regard to domestic firms with different ownership, i.e. state-owned versus non-state-owned enterprises. Although ownership is believed to be a critical internal feature of firms, I found that few attempts have been made to link this factor with contextual factors that jointly impact on firms' IC.

The main objectives of Chapter 3 are twofold. The first is to select an appropriate research method according to the requirements of the specific research questions for each chapter, while the second objective is to identify the proper source and procedure for data collection. The source, procedure, and process of data collection for innovation, FDI, and IS in particular are presented in Chapter 3. I also link the research method and data source with specific research questions and specific chapters, which provides an overall research framework of this thesis.

In the first half of Chapter 4, the evolutionary path of the Chinese RISs is analysed, including IS and inward FDI based on a volume of historical documents, policies, and data. In the second half, I examine the RIS, IS and foreign presence in five Chinese regions – Beijing, Shanghai, Guangdong, Hubei, and Hunan – and conclude that both IS and inward FDI are closely related to the RISs.

In Chapter 5, I further examine the findings of Chapter 4 through developing concrete hypotheses that inward FDI and IS are determinant of regional IC. To test these hypotheses, panel regressions were conducted using a dataset of 30 regions during 2000 to 2010. The panel regression estimates support most of the predictions that inward FDI and industrial diversity have positive effects on regional innovativeness while these positive effects of FDI are moderated by the degree of specialisation and diversity.

In Chapter 6, I further examine and extend the findings of Chapter 5 through a two-step procedure. In the first step, the hypotheses of the roles of foreign presence and IS in affecting domestic firms' IC is tested using a firm level panel dataset covering the period of 2000 to 2010. Then, in the second step, I split the whole sample into two subsamples, one being state-owned firms and the other non-state-owned firms, and examine whether the effects of foreign presence and IS are varied in firms with different ownership. The findings of this chapter advance the understanding of the role of inward FDI and IS at firm level.

Chapter 7 is the final chapter of the thesis. In this chapter, the findings of each chapter are revisited and discussed comprehensively. Theoretical contributions to existing literature regarding regional innovation, IS and the role of contextual factors at firm level are delineated in this chapter. Some policy implications that policy makers and business practitioners can take lessons from are drawn. Additionally, the limitations of the thesis and avenues for future research are highlighted at the end of the chapter.

Chapter 2 Literature review

The core research question of this thesis is to investigate whether and how knowledge spillovers of inward FDI and regional industrial structure (IS) will affect regional innovation capability (IC). In this chapter, prior studies focusing on regional innovation system (RIS), industrial structure, FDI spillovers and corporate ownership, particularly their relations with innovation, are reviewed. The objective of this chapter is to review and summarize the main findings of these strands of literature and it is also expected that a systematic review of these studies serve as a solid theoretical basis for the following empirical studies in Chapter 4, Chapter 5 and Chapter 6.

2.1 The systemic view of innovation

Innovation has become an essential driver for economic development at the national, regional, sectoral and firm levels. Innovative activities are heterogeneous and complex because they include knowledge combination, recreation and diffusion (Cohen and Levinthal, 1989; Ikujiro and Hirotaka, 1995; Scott and Bruce, 1994). Systems include components, relationships among components and attributes (Carlsson et al., 2002); as Bell and Albu (1999) suggested, it is advisable to adopt systemic perspectives to understand the technological underpinnings of clusters' longer-term competitiveness. Innovation systems can be defined in various ways, such as the national innovation system (NIS), regional innovation system (RIS), sectoral innovation system (SIS) and technological innovation system (TIS), and the main function of these innovation systems is the creation, diffusion and application of knowledge (Carlsson et al., 2002). The systemic lens for observing innovative activities is appropriate for innovation research since scholars can use it to examine the role of various actors and their interactions during the innovation process. The systemic view of innovation is based on the fact that innovation processes are characterized by the growing relevance of interactive, collaborative and inter-disciplinary activities, rather than several phases that occur in a strictly proceeding sequence (Samara et al., 2012).

2.1.1 Different types of innovation system

2.1.1.1 The lens of regional innovation system

The territorial attribute of innovative activities is an essential factor as knowledge is more likely to be transferred or to spill over within proximity (Braczyk et al., 1998; Breschi and Malerba, 1996; Cantwell and Iammarino, 2000; Cooke et al., 1997b; Howells, 1999; Jaffe et al., 1993; Meyer-Krahmer, 1985). Cooke (2001) argued that localized resources and institutions and the presence of an 'innovative milieu' can absorb knowledge spillovers among firms and institutions. In contrast to the assumption that innovation activities are evenly distributed, knowledge generation and new technology development tend to be spatially agglomerated (Li, 2009). Since the level and the specific sector of industrial concentration vary in different regions, an RIS is easier to implement than a sector innovation system (SIS)[4] and a national innovation system (NIS) (Chung, 2002). Regional innovation system (RIS) refers to a system 'in which firms and other organizations are systematically engaged in interactive learning through an institutional milieu characterized by embeddedness' (Cooke et al., 1998), and Iammarino (2005) added that an RIS can be defined as 'the localised network of various actors and institutions in different sectors whose activities and interactions generate, absorb, and diffuse new technologies within and outside the region'. As

[4] SIS refers to 'a set of products and the set of agents carrying out market and non-market interactions for the creation, production and sale of those products' (Malerba, 2002:p.247). See Section 2.1.1.2 for details.

Doloreux (2002) pointed out, it is difficult to make a precise distinction between an NIS and an RIS, particularly against the current background of economic globalization. The core idea of an NIS refers to the framework within which policy makers propose and implement policies to adjust the innovation process and the set of institutions that individually and collaboratively contribute to the generation and diffusion of new technologies (Metcalfe, 1996; Samara et al., 2012). In practice, some scholars have treated these ideas as different concepts, whereas others have seen an RIS as a subset of an NIS. For example, Chung (2002) argued that an RIS is an organic component of an NIS and suggested that an RIS is a reasonable perspective from which to analyse an NIS.

The concept of a national innovation system (NIS) is rooted in the evolutionary economy theorizing on socio-technical change and was introduced and elaborated by Freeman (2002), Lundvall (1992) and Nelson (1993). Based upon a review of prior studies, Sharif (2006) identified key social groups, using a self-developed term, the *epistemic community*, into which they coalesce, and traced their motivations in developing the NIS concept as a social technology. Differences in the efficiency and components of NISs are the reasons for variations in productivity growth (Nasierowski and Arcelus, 2003). As Lundvall (1992) suggested, an NIS includes key elements, which are internal firms, inter-firm relationships, the public sector, the institutional set-up of the financial sector, R&D institutions and R&D investment. Understanding the linkages among various actors in the innovation process is highlighted in the NIS approach as it is essential for a country to improve its innovative performance (Lundvall, 1992; Nelson, 1993). The popularity of the NIS approach in analysing the determinants of innovative performance in a country is closely associated with the acknowledgement that technological upgrading has become the new engine for the development of national economies, and the importance of the generation, diffusion and appropriation of knowledge has been highlighted in the economic development literature (Cooke, 2001; Patel and Pavitt, 1994).

The prior studies that followed the NIS approach can be classified into two categories. The first category of studies started from the broad definition of an NIS that embraces all innovation-related institutions that create, diffuse and exploit technologies. For instance, Hu and Mathews (2008) found that the capacity of China's NIS has improved dramatically since the 1990s, whereas the contribution from the public sector is unclear and mixed. Liu and White (2001) adopted a system-level framework to compare the structure, dynamics and performance of China's NIS under central planning and since economic reform. A recent study based on a panel data set of 87 countries in 28 years (1980–2007) found that both innovative capability and absorptive capacity are essential factors for an NIS, and the co-evolution of these two capabilities drives its development (Castellacci and Natera, 2013). The second category of prior studies is mainly based on the narrow understanding of an NIS, which focuses on actors who are directly related to the innovation processes, namely industrial enterprises, public sectors, universities and research institutions. Collaboration among different actors within the innovation process is highlighted as key to a nation's innovation capability. Early studies suggested that innovation is treated as internal activities in many firms due to self-capacity dependence and a low level of trust in external partners (Tödtling and Kaufmann, 1999), and R&D collaboration is only of relatively minor importance as a medium for knowledge spillover (Fritsch and Franke, 2004). More recently, based on the consensus that the effectiveness of an NIS is largely dependent on the interactive learning process between knowledge producers and knowledge users and on an effective institutional context, an increasing number of NIS studies are beginning to examine the interactive effects among various actors and the institutional context on a nation's innovativeness. The main objective of an NIS is therefore to maintain and promote stable cooperation between different innovators (i.e., research institutions, universities and firms) and therefore improve a nation's technological capability (Guan and Chen, 2012; Patel and Pavitt, 1994; Sharif, 2006).

The limitations of using the NIS framework to analyse the innovation process have been highlighted. For instance, Chung (2002) and Li (2009) realized that analysing the innovation capability at the national level is inappropriate since it neglects the idiosyncratic features and uneven development of the regions that compose a nation. Liu and White (2001) pointed out that there are many questions and criticisms of the analysis of innovative activities at an aggregate level, such as the national level. To identify the innovation process in a nation, some studies have begun to use a new analytical lens when analysing innovative activities. By reviewing and assessing the development of the Korean NIS, Chung (2002) found that the overall strength of Korea's NIS is weak, but there are six fast-developing RISs and seven less-developed RISs. This may also be the case in China, as the eastern regions in China are much stronger than the inland regions in terms of both economic and innovative capabilities (see Chapter 4 for further analyses).

The NIS perspective may not be appropriate for nations with a large geographic space (Edquist, 2004). China is a huge country of 9.6 million km^2, so the NIS approach is probably less appropriate because the historical, cultural and economic circumstances of each Chinese province are not the same (Li, 2009). For example, Bao et al. (2002) found that the coastal regions' returns to capital investment are higher than those of the rest of China, therefore causing the growth disparity between different regions due to more FDI and migrant labour being attracted to the region. The majority of prior studies focusing on the Chinese RIS chose the administrative provincial-level regions as the unit of analysis (Cheung and Lin, 2004; Fu, 2008; Li, 2009; Yang and Lin, 2012). More specific reasons for choosing the Chinese provincial level as the scope of the 'region' of this thesis are presented in Section 1.1 in Chapter 1.

As mentioned earlier, innovative activities are spatially concentrated because knowledge is sticky within social connections, particularly in the case of circulating tacit knowledge (Breschi and Lissoni, 2001b; Cantwell and Iammarino, 2003; Howells, 2002; Krugman, 1990; Paci and Usai, 1999), and is related to the role of knowledge spillovers as well as to the geographic concentration of production (Audretsch and Feldman, 1996). Though innovation is suggested as a partly territorial phenomenon (Doloreux and Parto, 2005), it is not easy to find a consensus on the geographical boundaries of an RIS because technology transfer has been highlighted by both intra- and inter-regional innovators (Doloreux and Shearmur, 2012; Gross, 2013; Liao and Yu, 2013). Nevertheless, it is also well established that knowledge and technical capabilities are geographically bounded and do not travel very far, giving innovation systems a regional character (Jaffe et al., 1993). Policy makers and scholars have a propensity to use the RIS framework to analyse the determinants of innovativeness in a locality (Braczyk et al., 1998; Chung, 2002; Meyer-Krahmer, 1985), because a region is more closely related to specific economic and innovative activities than a nation (Ōmae, 1995). Moreover, it is common to find uneven distributions of economic and innovative activities within a nation, and this phenomenon is especially apparent in emerging countries, such as China (Sun and Liu, 2010; Wang and Lin, 2013; Yang and Lin, 2012). Compared with an NIS, an RIS is a more accurate concept to reflect the dynamic and reflexive properties of the economic and R&D activities in a geographic scope (Ōmae, 1995). For instance, Breschi and Malerba (1996) and Florida (1995) employed the regional perspective to analyse industrial clusters and the characteristics of a learning region.

The RIS lens is appropriate when researchers are trying to examine the determinants of innovation capability in a context with huge spatial scope and discrepancies in terms of economic and/or innovative strength (Fu, 2008; Yang and Lin, 2012). Moreover, the capabilities at the regional level differ between the regions within any single nation, highlighting the importance and necessity of adopting the RIS perspective to explore the role of regional heterogeneities in innovation (Cooke et al., 1997b).

2.1.1.2 Sectoral innovation system (SIS) and technological innovation system (TIS)

A sectoral innovation system (SIS) is described as multidimensional, integrated and dynamic, which provides a useful perspective from which to examine the process of innovations in sectors. The SIS concept widely used in the literature refers to 'a set of products and the set of agents carrying out market and non-market interactions for the creation, production and sale of those products' (Malerba, 2002:p.247). Agents in SISs can be individuals or organizations. Similar to other types of innovation system, collaboration among different actors is seen as key to successful innovation. Klerkx and Leeuwis (2009) reviewed the relevant literature, focusing on the Dutch agriculture sector, and suggested that innovation intermediaries/brokers are important for innovative activities but it is difficult for innovation brokers to embed themselves into the co-operative networks.

Institutional factors are also important to the success of an SIS. By examining the innovation system of the pharmaceutical industry in Taiwan, Hu and Hung (2014) found that the intellectual property regime plays an essential role in associating innovative actors and institutions, which is closely related to the effectiveness of the SIS. As Malerba (2002) noted, the notion of an SIS complements an RIS, in which the focus is mainly on the agents and their interactions in the innovation process, and the boundary of an SIS is dynamic and transforming rather than given and static, which is different from an RIS. Additionally, the appropriate level of an SIS is largely dependent on the specific research goal, which means that the framework of an SIS can be suitable for different levels of aggregation of products (Malerba, 2002).

Though in this thesis I examine the role of the local industrial structure as a whole in innovative activities, the perspective of the SIS is not tackled. This is because the main focus of this research is on the features of different regions in one country (i.e., China) and how they affect the regional innovativeness. Based on the findings of this thesis, a further step would be to look more closely at the composition of industry by region and this is a meaningful direction for future research.

Many prior studies focusing on technological innovation systems (TISs) have followed the definition put forward by Carlsson and Stankiewicz (1991) in which TIS refers to 'a network of agents interacting in a specific economic/industrial area under a particular institutional infrastructure and involved in the generation, diffusion and utilization of technology' (p.111). For example, based on this definition, Markard and Truffer (2008) proposed a multi-level perspective of a TIS to gain a better understanding of socio-technical transformations and radical innovation processes. As Carlsson et al. (2002) noted, a TIS is characterized as disaggregated and dynamic, and many or at least several technological systems can exist in a nation, which is different from the notion of an NIS. Bergek et al. (2008) argued that TISs are socio-technical systems focusing on the generation, diffusion and application of knowledge and/or products.

In fact, the spatial border may not necessarily form the boundary of a TIS since a TIS usually focuses on generic technologies that cover several sectors, distinguishing it from other innovation systems (Bergek et al., 2008). From a relational perspective on space, Binz et al. (2014) adopted the method of social network analysis for a co-publication data set on membrane bioreactor technology and suggested that the spatial attributes of cooperation in knowledge creation vary greatly in a TIS, which means that the geographic boundary of a TIS is reflexive. Three types of interactive links are highlighted in TISs, which are input–output relationships, informal relationships and problem-solving relationships (Carlsson et al., 2002). The development of a TIS may cross national borders. For instance, Tigabu et al. (2014) analysed the development of a TIS in Rwanda between 2000 and 2011 and suggested that international assistance is very helpful for the development of a TIS of energy sectors.

Though the lens of TISs is helpful for examining the dynamic features and evolution of technological development, I adopt the RIS approach in my thesis due to the main focus of this research being the relationships between regional features and innovation capability rather than the process of generation, diffusion and utilization of technology. However, it is meaningful to expand the findings and arguments of this thesis by adopting the lens of TISs in the next step and examining the socio-technical transformations and different types of innovation (e.g., incremental innovation and radical innovation) in future studies.

2.1.2 Actors and their relationships in RSIs

An increasing number of studies focusing on RISs have emerged since the beginning of the 1990s, and the majority of them have focused on analysing the region itself and the relationship between RISs and NISs (Chung, 2002). Similar to an NIS, an RIS is essentially a social system that involves interactive activities among various actors (private and public sectors), and these activities are embedded in a systemic pattern that reinforces the localized learning capabilities of a region (Doloreux, 2002). As Lundvall (1992) suggested, (regional) innovation cannot be understood as an isolated activity; it is in fact a socially and territorially shaped interactive learning process because innovation is a kind of uncertain and risky activity that requires immense R&D resources and investments, so it is becoming more difficult for a single innovator to generate and exploit R&D opportunities effectively.

Interactive learning is deemed to be the central idea of an RIS and learning is closely related to innovation (Doloreux, 2002). Specifically, interactive learning refers to ‘an interactive process of knowledge generation shared by innovator actors (firms, institutions) and shaped by institutional routines and social conventions’ (Doloreux, 2002:p.249). Within an RIS, different sets of actors, for example firms, universities and research institutions, are directly related to the activities of knowledge generation, diffusion and appropriation and the interactive relationships between these innovators are essential for the innovative performance of the region. Taking enterprises as an example, they are more likely to operate in a dense network of formal and informal ties with various actors in an RIS (Lall, 1993).

A general consensus of the RIS literature suggests that regional innovation performance is more likely to improve when local firms are encouraged to interact with various local supportive organizations (e.g., customers, universities, research institutions, etc.) to conduct innovative activities (Doloreux & Parto, 2005). Focusing on the role of the regional location of firms, Iammarino et al (2012) examined different forms of collaboration and found that firms' technological capabilities are closely related to vertical cooperation, horizontal cooperation and cooperation with business groups. Similarly, from the standpoint of evolutionary economics, Cooke et al (1997a) contended that institutional learning, financial capacity and productive culture are important to systematic innovation, and systematic learning and interactive innovation are critical for RISs. Using the official statistics of 30 Chinese regions (provinces), Zhao et al (2014) found that interactive R&D activities in RISs are closely related to private firms, public universities and research institutions, and governmental intervention. Hajek et al (2014) explored the pattern of individual components of European RISs and found a similar level of diversity in the components of these RISs because of the strong interactive activities among different actors within the RISs.

Evidence from US counties suggests that private research and development transfers regional spatial externalities both directly and indirectly between university research and high-technology innovative activity (Anselin et al, 1997). A comparison of the components of RISs in US and European countries suggested that the innovation gap between Europe and the US is mainly due to the market failure in terms of excess reliance on public intervention, and stronger institutional and organizational support from the private sector along with public innovation support is critical for Europe's RIS (Cooke, 2001). The higher education sector is another important actor in RISs. Drawing on data on new universities and regional patenting in Italy, Cowan and Zinovyeva (2013) found that new universities can bring new patent applications, for example a new school leads approximately 7% of the increase in patent numbers and this is mainly due to universities' ability to provide the regional innovation process with high-quality scientific research. Prior studies have also illustrated the knowledge flow from universities to industries and pointed out that regions with strong universities play a more important role in RISs (Hong, 2008). In addition, Varsakelis (2001) indicated that several institutional factors, for example culture and tradition, openness and patent protection, of the regional environment are closely related to R&D investment. Bebczuk (2002) highlighted the role of the national government in allocating resources to innovative activities. The increase in R&D intensity is a way to protect the intellectual property of novel knowledge created by various regional innovators, and usually R&D investment is higher in developed regions (Lederman & Maloney, 2003).

Additionally, the distance among innovators is closely related to the interactive activities within the innovation process. Using data on academic papers in the Chinese Science Citation Database, Liang and Zhu (2002) found that geographic distance is an influential factor of inter-regional R&D collaborations in China. Focusing on 51 NUTS-I regions in Europe, Tappeiner et al (2008) suggested that the reason for the autocorrelation shown by patent applications is the proximity of the spatial location of R&D input factors in the knowledge production process.

2.1.3 Innovation capability of RSIs

Innovation performance or capability is different not only among nations but also in sub-national regions, like states or provinces (Acs et al., 2002; Evangelista et al., 2001; Fritsch, 2002). At national level, the public R&D expenditure is essential for facilitating national innovative capacity, and a latecomer country is able to close the gap with developed countries by allocating more resources for building national innovative capacity (Hu and Mathews, 2005). In the framework of national innovation capability (NIC), three mindsets are frequently referenced as theoretical supports. Specifically, they are the endogenous growth theory developed by Romer (1990) and Jones (1995), the interactive effect between private sector and national industrial clusters argued by Porter (1990b), and the NIS theory in which interactions between various innovators are highlighted (Freeman, 1987; Lundvall, 1992; Nelson, 1993). The NIC focuses on overall sources of innovation in the system. Furman et al. (2002) firstly used a dataset of 17 OECD countries and subsequently enlarged the sample into 29 OECD countries in a later study (Furman and Hayes, 2004) to support the NIC framework. Hu and Mathews (2005) validate their conclusions using data of four “East Asian tigers”. At regional level, the capability of generating new knowledge and absorb external technology is essential for a region to earn competitiveness. Originating from the concept of national innovation capacity (NIC), regional innovation capability (RIC) refers to the capacity of a region to generate new knowledge from existing resources and investment in a certain geographic scope (Li, 2009). RIC is believed to be an essential component of national competitiveness as well as a critical force to promote a region’s long run economic performance (Krammer, 2009).

The determinant of RIC is an attractive topic in extant literature. Early studies suggest that regional innovation is attributed to R&D investment as it is the main input in the knowledge production process (Griliches, 1990). Using a panel data of industries across 12 OECD countries, Griffith et al. (2004) found that R&D expenditure is very important for innovation, while human capital is also essential for productivity growth but has limited effect on trade. Intensified R&D investment means there are more resources for innovative activities and usually the intensification of R&D input will bring a growth of innovation output, such as patentable inventions (Hu and Jefferson, 2009). Prior studies find that the elasticity of the number of patents against R&D investment is less than 1 (Cheung and Lin, 2004; Cincera, 1997; Fu, 2008; Hausman et al., 1984; Hu and Jefferson, 2009; Yang and Lin, 2012), hence the contribution of R&D intensity to innovative activities should be moderate. Meanwhile, R&D personnel is believed as another source of innovative activities, especially it is closely related to the absorptive capacity (Cohen and Levinthal, 1990a). From the perspective of the nature of knowledge, both codified and tacit knowledge are crucial determinants of regional innovation capacity and tacit knowledge is the basis for sustained regional competitive advantage, and collective learning is a main way of improving regional innovation capacity (Lawson and Lorenz, 1999). As suggested by Lall (1993), only linking technological development with formal R&D is not correct. Knowledge source is an influential factor of RIC. Focusing on the European regional innovation system, Barrutia et al. (2014) suggest that the effect of both formal knowledge source and informal knowledge source on innovation performance is complex and nonlinear and a balance between formal and informal knowledge source is essential to amplify their positive effect on regional innovation.

In fact, various factors may influence on the RIC. Governance factors such as political rights, civil liberties, institutional corruption, and education are considered as influential factors for innovation capability (Varsakelis, 2006). Institutional factors are closely related to RIC as well. For instance, evidence from the patenting activities in some Latin American and Caribbean countries shows that the increasing foreign applications for the U.S. patents in these countries is closely related to local institutional/political stability (Waguespack et al., 2005). Using the data of 197 NUTS-II regions of 12 countries, Sterlacchini (2008) found that the equal growth among EU regions cannot be guaranteed by simply investing more public and private resources in domains of knowledge and education but rely on some other factors. Focusing on some OECD countries duirng the period of 1998 to 2004, Usai (2011) suggested that highly inventive regions are propensity to be clustered, and human capital and R&D expenditure directly affect regional inventive performance.

External knowledge source also plays an important role in facilitating RIC, particularly for those regions in developing countries. Cheung and Lin (2004) suggest that positive effect of FDI spillover on regional patent applications is found, and such positive effect is the strongest for external design patent, highlighting the FDI spillovers' '*demonstration effect*'. The type and quality of FDI inflows and the strength of regional absorptive capacity and complementary assets in the host regions are crucial for FDI to serve as a driver of knowledge-based development (Fu, 2008). Moreover, local industrial configuration is closely related to economic and innovative activities. By comparing the computer and biotechnology industries in U.S. and UK, Swann and Prevezer (1996) suggested that incumbent firms are more likely to be attracted in sectors that is strong in their own sub-sector, rather than attracted by cross-sectoral effects and science base while Baptista and Swann (1999) found that the dynamics of clustering of computer industries in the US and the UK are similar, and new firms tend to grow faster if they located in a cluster that is strong in their own sub-sector. As in China, Li (2009) suggested that the constitution of R&D performers, regional industry-specific innovation environment, and government support are determinants of China's regional innovation capacity, and the gap in regional innovation capacity is huge among regions.

For the innovative activities in China, Hu and Jefferson (2009) tested several explanations (hypotheses) regarding the surge of patenting in China since 1995. The authors suggested that R&D intensity accounts partially for the innovative activities in China, the inward FDI, ownership reform and stronger legal system also contributed to this surge of patent applications in China. Although this work brought out some insightful conclusions, there are several shortcomings within this work. First, due the data limitations, the authors only focused on the period from 1995 to 2001 which missed the dramatic explosion of patenting from 2001. Second, the authors did not distinguish inventions from utility patents, which ignored the difference of innovativeness between these two types of patent. This ignorance may underestimate the role of FDI in affecting innovation capability with greater novelty. Finally, the analysis was only concerned with the patenting of LMEs, which cannot provide a convincing explanation of the determinants of regional innovation in China. More importantly, the effect of regional industrial structure was merely mentioned in this work, but the authors did not provide specific analysis and conclusion of the mechanism of how industrial structure would impact on regional patent applications.

Overall, the relatively short period of technology development in most developing countries leads to much confusion and unclear about the situation of RIS. For instance, little is known about the nuanced relationship between regional industrial structure and RIC (see Section 2.2), and there is no clear conclusion on the roles of inward FDI spillovers and coporate ownership in facilitating IC (see Section 2.3 and 2.4, respectively).

2.2 Regional industrial structure and innovation

Industrial agglomerations and clusters are suggested to exert externalities on regional economic and innovative activities (Bishop and Gripaios, 2009; Henderson, 1997; Paci and Usai, 1999). Nowadays, it is not surprising to find that industrial firms prefer to be clustered in a proximity district, and this is common in both developed and developing countries, for example the Silicon Valley in U.S. (Saxenian, 1994) and Zhongguancun Park in China (Tan, 2006). This phenomenon suggests that agglomeration economy is beneficial to improve regional productivity and may facilitate knowledge spillovers in locality (Breschi and Lissoni, 2001a; Marshall, 1890). For example, Multi facets of regional industrial structure, i.e., economic diversity and industrial specialization are important factors affecting the change of regional employment (Drucker, 2013), and both specialization and diversity exert positive effects on regional economic development (Bun and Makhloufi, 2007).

As innovation is a process in which knowledge from multiple disciplines is recombined or generated (Love et al., 2009), Jacobs (1969) contends that a city with multiple industrial sectors is more likely to benefit from cross-disciplinary knowledge bases and to be more innovative. Two broad types of industrial externalities are discussed in prior studies, which are Marshall-Arrow-Romer (MAR) externalities associated with specialization and Jacobs externalities associated with diversity. Given that there is no consensus about the effect of both industry specialization and diversity (MAR versus Jacobs externalities) on regional innovativeness, and much less empirical evidence from emerging market, it is reasonable to integrate this stream of literature into the research framework of this thesis and enhance the understanding of the determinants of local innovation.

2.2.1 Specialization and diversity: two dimensions of industrial structure

Besides the national innovation system (NIS) and regional innovation system (RIS), the proposed sector innovation system (SIS) approach is adopted by some prior studies as well. The SIS perspective highlights the path-dependent evolution of specific technologies as components of technological systems in specific sectors (Oinas and Malecki, 2002). Dynamic externalities are viewed as an engine for regional economic growth in the recent literature on endogenous growth, having implications for long-run industrial growth. A series of studies claims that knowledge spillovers not only produce externalities to regional innovation, but also tend to be spatially bounded (Audretsch and Feldman, 1996; Glaeser et al., 1992; Henderson, 1997).

Marshall (1890) firstly pointed out the benefits of specialized clusters within a certain geographical area which is crucial in boosting local economic growth. Specifically, Marshall (1890) observed that industrial sectors specialize geographically since spatial proximity facilitates intra-industry knowledge diffusion, reduces transport costs of both investment and output, and allows cluster members to benefit from local labor pool in a more efficient manner. Since then, a series of studies conducted in different contexts provided empirical evidence for this argument (Krugman, 1991). The seminal work of Glaeser et al. (1992) formalize the findings of Marshall (1890), Arrow (1962a) and

Romer (1986) and put forward the concept of Marshall-Arrow-Romer (MAR) externalities, claiming that agglomeration of manufacturers in an industry at regional level can facilitate knowledge spillovers between cluster members and improve the industry's innovative capability (Beaudry and Schiffauerova, 2009). The MAR model highlights that concentration of an industry in a regional proximity promotes knowledge spillovers between firms and facilitates innovation in that particular industry within that region (Beaudry and Schiffauerova, 2009). The evidence from ICT cluster in Zhongguancun (Beijing) also suggests that the presence of cluster members is beneficial to improve local firms' learning capacity (Zhou and Xin, 2003). More importantly, firms in an isolated cluster may not receive positive effect for innovation, more innovative firms in related sectors is helpful for spurring innovative performance (Beaudry and Breschi, 2003).

In contrast, Jacobs (1969) contends that essential fertilizers of innovation are more likely come from external environment and diversified industries than from within any particular industry or cluster. In other words, studies that support the positive role of industrial diversity highlight the role of new ideas and knowledge coming from different disciplines or fields in facilitating knowledge creation at the regional level (Desrochers and Leppälä, 2011b; Duranton and Puga, 2000; Feldman and Audretsch, 1999). Industry diversity is seen as the major engine for fruitful innovations since *'the greater the sheer number of and variety of division of labour, the greater the economy's inherent capacity for adding still more kinds of goods and services'* (Jacobs, 1969, p. 59), so the most important sources of knowledge spillovers are external to the industry in which the firm operates (Beaudry and Schiffauerova, 2009).

2.2.2 Industrial specialization and regional innovation

Previous researches suggest that knowledge spillovers are more likely to occur in a certain proximity because interactive relationship between individuals or organizations is an effective way for diffusing knowledge, particularly for tacit knowledge transfer (Howells, 2002; Lawson and Lorenz, 1999). Industrial clustering is helpful for knowledge diffusing since cluster members are able to benefit from knowledge spillovers from other members nearby with much less cost. Jaffe et al. (1993) adopted USPTO (United States Patent and Trademark Office) patent citation data to investigate the geographic attribute of knowledge spillovers and found that knowledge spillovers are more likely to occur within a certain spatial scope. Marshall's (1890) three favored factors for industrial concentration and Krugman's (1991) concern of knowledge spillovers have been discussed in Jaffe et al. (1993) by using patent citations. Specifically, empirical result of Jaffe et al. (1993) reveals that 1,980 citations, which have shorter average citation lags, are systematically more regionalized than other 1,975 citations, indicating that the industrial concentration as a specialized structure is helpful for regional knowledge transfer and spillovers. By modeling on Marshall's (1890) agglomeration economy theory, Krugman (1991) further unravels that spatial clustering is beneficial for manufacturers because of the shorter distance between large demand and lower transport cost than other industrial configurations. Focusing on shoe manufacturing and biotechnology industries in the U.S., Stuart and Sorenson (2003) delineate that regional concentration of skilled workers are able to induce entrepreneurs to establish their new plant in a proximity area. More importantly, as pointed out by Stuart and Sorenson (2003), the reason why industrial manufacturers have a propensity to locate in a proximity geographic scope is that transport costs may influence the productivity and profitability to a large degree, for those untraditional industries, however, transport costs and labor pool have no such effects on traditional industries. Entrepreneurs find it is hard to access useful information and resources if they locate outside the cluster, therefore to construct social links with less cost by clustering with other members is helpful for realizing new opportunities in the sector and to exploit mobilization of intellectual, financial and human capital at the regional level (Stuart and Sorenson, 2003). In addition, firms in a specialized district are more likely to become larger than those in a less specialized region (Li et al., 2012).

Considering the essential role of knowledge in innovative activities, how to conduct efficient knowledge diffusion and transfer is critical for innovation at both regional and firm level. Storper and Venables (2004) suggest that communication is an effective way in diffusing and exchanging knowledge, especially for diffusing tacit knowledge, and modern development of telecommunication changes people's way in connecting with others. The idea of a buzz through being here in the relationship between *face-to-face* (F2F) contact and urban economies is a new perspective in returns to learning and economic geography (Krugman, 1991). Criticizing the incomplete analysis of the three main forces that lie behind the persistence of urbanization and localization of organizations, Storper and Venables (2004) claim that the most fundamental aspect of proximity, e.g., face to face (*F2F*) contact, is an indispensable element in studying the mechanism of regional clustering: as networks of firms and industries clustered within regions interact more frequently with co-located university-based scientists than with those in other regions (Zucker et al., 2002). It is logical to understand that the current business environment in which information is rapidly changing and precious knowledge is always tacit and complex, and is conductive to buzz concept (Storper and Venables, 2004). As in China, Hong (2008) indicates that geographic distance is playing an increasingly important role in affecting knowledge flows, particularly between university and industry, since the trend in decentralization in China. Therefore, a specialized structure of regional industrial sectors provides a solid platform on which *F2F* communications are more likely to be conducted and in turn to stimulate knowledge sharing, diffusing, and spillovers, all of which are important for regional innovative activities.

Studies supporting industry specialization emphasize knowledge transfer within the same or proximate industries. Tacit or codified knowledge with lower transmission costs is more likely to flow between actors within the same sector (Saxenian, 1994). This knowledge exchange can be embedded within the mobility of skilled workers (Edler et al., 2011), collaborative R&D activities (Yeung et al., 2006) or even communications (Storper and Venables, 2004). Second, industrial localization prefers a less competitive or more monopolistic environment (Glaeser et al., 1992). An insular environment is believed to be better for the protection of intellectual property rights (IPR) and that powerful companies within a regional cluster can rearrange R&D resources more efficiently and pursue frontier technology (Frenken et al., 2004; Mukkala, 2004). This argument has been supported by various cases in both developed countries and emerging markets (Jaffe et al., 1993; Sun and Liu, 2010; Venables, 1996). For instance, by adopting annual surveys of manufacturing plants in China (1998-2005), Li et al. (2012) find that firms in a specialized district are more likely to become larger than those in a less specialized region. Thirdly, the role of MAR externalities may need a process of accumulation to be effective in local economic and innovative activities. Using a survey data of Spanish industrial sectors during the period of 1978 to 1992, de Lucio et al. (2002) suggest that industrial specialization negatively related to productivity, whereas this negative effect turns to be positive once it reaches a certain level.

From the perspective of micro economic manufacturing activities, Audretsch and Feldman (1996) claimed that manufacturers rely heavily on economic knowledge that spatially clustered in an industrial district to sustain their production process. As firms are keen to exploit R&D spillovers from regional universities and research institutes (Acs et al., 2002; Audretsch and Feldman, 1996; Feldman and Audretsch, 1999; Jaffe, 1989), the extent to which industrial activities cluster spatially depends on how easily firms can reap knowledge externalities from regional infrastructure and industrial structure. In fact, economic geography is suggested to escape from the perception that organizational practices are passively *'embedded'* in social structure (Grabher, 2002).

Additionally, regionalizing the learning economy plays an increasingly important role at global level, which indicates that regions have become the predominant contributors to the national economy (Chaminade and Vang, 2008; Vang and Asheim, 2006). Regionalisation refers to increased geographical concentration of economic activities in those functionally integrated regions within a nation (Vang and Asheim, 2006). Empirical studies indicate that regional innovativeness can be improved by regionalisation since the physical and relational proximity between manufacturers induce knowledge spillovers in a specialized or clustered structure (Chaminade and Vang, 2008; Vang and Asheim, 2006). Entrepreneurial activities may be affected by geographic factors as well. As Baltzopoulos and Broström (2013) noted, entrepreneurs are more likely to set up new firms in the location where they studied, and spin-offs established by academics are close to the universities in which they work.

2.2.3 Industrial diversity and regional innovation

The traditional definition of diversity refers to the degree to which a region with multiple industries, which highlights the externalities from various industrial sectors in a certain proximity (Beaudry and Schiffauerova, 2009; Glaeser et al., 1992). The essence of diversity measurement is to account for both the varieties and scale of urbanization economies. As Jacobs (1969) suggested, regional innovation relies heavily on the variety of regional economic organizations and cross-border knowledge spillovers from a diversified technology base is a catalyst for economic and innovative development.

Supporters of the Jacobs model emphasize the benefits of communication between different industries, especially complementary sectors. Emerging technology fields benefit from a more diverse economy since they promote greater skills exchange between sectors (Harrison et al., 1996). Further opportunities to imitate, share and recombine ideas and practices across industries are believed to be embedded within a more diverse economy of a region (Beaudry and Schiffauerova, 2009), and knowledge spillovers are more likely to occur between industries rather than within industries (Glaeser et al., 1992). For example, Desrochers and Leppälä (2011c) conducted a qualitative survey of Canadian inventors and suggested that a diversified regional economic milieu is found to be supportive for inter sectors knowledge spillovers, which is able to enhance creativity. Some infrastructures such as telecommunications, access to the internet and transportation capacity are taken into consideration for promoting regional diversity and are assumed to influence positively a region's economic and innovative structure (Fu, 2008; Gao, 2004). The effect of regional diversity is positively related to firm performance, whereas effect becomes negative once the level of regional diversity exceeds a certain threshold Qian et al. (2008). Some recent studies divide industrial diversity into two types - related variety and unrelated variety – and contend that impact of different type of industrial diversity is varied (Frenken et al., 2004). For instance, Boschma and Iammarino (2009) examined the impact of regional variety on regional economic growth in Italian provinces and find that related variety is a significant contributor to the economic growth. Buerger and Cantner (2011) employed a dataset of German patent applications during the period of 1995 to 2006 and found that diversity in the specialized supplier industries is found to be positive related to innovation output. Boschma et al. (2012) analyzed a dataset of NUTS 3 level regions in Spain during the period of 1995 to 2007 and find a higher level of related sectors is positively related to economic growth rates.

Meanwhile, it is common to find that small and medium enterprises (SMEs) are scattered in a diversified region where no giant companies or no monopolistic firms are engaged. As the motivation of R&D collaborations may vary according to the size of firms, in contrast to prior studies, Beaudry (2008) adopts a dataset of biotech enterprises in Canada to prove that, comparing with big firms, SMEs are more likely to cooperate with other firms and firms relying on developed product also keen in R&D collaborations. Additionally, industry configuration and variety correlate with regional economic development. For instance, evidence from Spanish provinces with wide range of related industries shows a higher rate of development than other provinces (Boschma et al., 2012).

Moreover, a technology base with multiple disciplines is found to be a crucial knowledge source for regional innovative activities. The variance of innovative activities across geographic boundary and regional innovation system is thus a reasonable perspective to investigate regional innovativeness. For example, Diez (2002) highlights the importance of spatial proximity among collaboration partners and confirms the concept of territorially based systems of innovation; Fritsch (2002) provides a knowledge production function (KPF) to measure the quality of RIS and finds that embeddedness in a well-functioning innovation system will result in a relatively high propensity to innovate. Firms are keen to take advantage of the coherence of regional knowledge diffusion infrastructure, and universities play a vital role in supporting such knowledge demands (Herstad and Brekke, 2008). Firms, especially those in high technology based industries, tend to set up nearby regional knowledge sources, such as universities and public research institutions. Existing literature explains this phenomenon as convenience for knowledge diffusion via R&D collaboration and skilled workers mobility (Díez-Vial and Fernández-Olmos, 2014). As an essential component of regional diversity, linkages between university and business organizations at regional level has been discussed in prior studies as well (Araujo et al., 2011; D'Este et al., 2013; Gilsing et al., 2011; Hong, 2008; Kim, 2013). An obvious phenomenon is that interactions between higher education and firms are more likely occur in regionality. For instance, using data from Brazil in 2008, Araujo et al. (2011) find that there is a great proportion of R&D collaborations (43.6%) conducted in the same city, 51.2% of the collaborations resided in the same region; and 75.3% in the same state. In fact, transferring science from the laboratory bench to the market is complex which involves various intermediaries (Cooke, 2002a, b). As shown in the work of Desrochers and Leppälä (2011b), economic diversities in the city scale provide a fertile milieu for the discovery and development of new technological combinations as well as knowledge transfer.

2.2.4 A debate: which type of industry structure is conducive for innovation?

Although a large body of literature focuses on the role of MAR and Jacobs externalities on the performance of the regional economy and innovativeness, there are no conclusive results as to which type is more beneficial and at which stages of industry life cycles, reasons for this uncertainty relate to differences in methodology and contexts of these researches (Beaudry and Schiffauerova, 2009).

As Beaudry and Schiffauerova (2009) noted, externality is an effect emanating from one activity that can influence other activities, but this process usually cannot reflect in market prices. The rationale behind externalities effect is that a firm usually cannot fully appropriate its R&D output, e.g., new technology, and other firms or organizations can benefit from knowledge spillovers. Griliches (1992) concluded this process as firms benefit from others' R&D process by *'working on similar things'*, cluster members are therefore more likely to increase their knowledge stock. Previous studies claim that industrial productivity has a close relationship with regional knowledge spillover and innovations, for instance local firm's productivity is found to be positively affected by knowledge spillovers by two basic mechanisms, transmitted via job changes and public R&D funding (Ehrl, 2011). Using the German establishment and employment level data, Ehrl (2011) finds that total factor productivity (TFP) is higher in more specialized and large countries. Henderson (1997) separated the industrial externalities by using panel data for five capital goods industries and found strong evidence of MAR externalities whose biggest effects are typically from several years ago, but die out after six years. Mukkala (2004) adopted a dataset of manufacturing subsectors in Finland during the period of 1995 to 1999 and found that regional specialization is found to be more effective to improve regional productivity than diversification.

In addition, from the perspective of the nature of knowledge, tacit knowledge usually plays an important role for innovation. Given that tacit knowledge is usually ill-documented and uncodified, it can only be acquired via social interactions, such as face-to-face communications between R&D staff (Gertler, 2003; Howells, 2002; Lawson and Lorenz, 1999). A specialized sector has proximity distance of (tacit) knowledge spillovers, which is helpful for innovative activities. However, Duranton and Puga (2000) insists that a diversified industrial structure is better for regional innovation than a specialized industrial district as a broad industrial composition takes over and amplifies benefits of regional industrial externalities, while Koo (2007) contends that industrial specialization and diversity are found to be essential for regional technology spillovers, but the magnitude of their importance declined with sector's knowledge intensity increases

On the one hand, specialization externalities highlight that knowledge spills over from intra-sector activities while diversity externalities argue that a variety of regional industries provides valuable knowledge for innovation. In contrast, some scholars find that industrial structure explains very little of the cross-sectional difference in country returns volatility (Heston and Rouwenhorst, 1994). For instance, Hornych and Schwartz (2009) find an inverted-U relationship between the degree of industry concentration and innovative performance based on the number of patent applications of 22 manufacturing industries in 22 Eastern German planning regions. And they claim that an extremely high level of industry concentration may hamper the regions' innovation output.

On the other hand, the classical argument made by Jacobs (1969) insists that knowledge cross disciplines is essential to stimulate novel ideas rather than from a knowledge spills over from the same industrial sectors. More recently, however, an emerging body of studies suggests that specialization externalities may produce negative effects on economic growth and regional innovative activities as well (Beaudry and Schiffauerova, 2009). Specifically, a highly specialized region is more vulnerable in the face of external shocks or crises due to its lower flexibility of industrial structure and its lower capacity to adjust to exogenous changes. This is especially essential when the core industry in the region is becoming obsolete. In a diversified industrial structure with much wider scope of industrial portfolio, however, it is more likely that some new sectors will spring out and search potential opportunities to grow up. In addition, given that technology innovation is usually a path dependent process, the thick knowledge stock of a specialized region are more likely to be *'locked-in'*, i.e., isolated in themselves and resist outside new knowledge to pump into the regional innovation system (Beaudry and Schiffauerova, 2009). This is a practical concern for innovative activities nowadays as more and more innovative products are based on multiple knowledge bases (van Beers and Zand, 2013). In other words, a specialized region has propensity to exploit existing knowledge and technology, and therefore experiences increasingly fewer external links than a diversified region. Moreover, as Ó Huallacháin and Lee (2011) noted, it is common to find that specialization and diversity are not competing characteristics of urban technological structure, especially at city level, and the specialization of diverse technologies is beneficial for regional innovation.

Moreover, from the perspective of firms' life cycle, a higher level of agglomeration of mature industrial sectors in regional districts hinders regional absorptive capacity to innovate, rejuvenate and restructure (Beaudry and Schiffauerova, 2009). As noted by Combes (2000), a specialized structure may lead to asymmetric effects on information diffusion: while regional economic development can be enhanced by Marshall economics during an expansion phase, it would also reduce regional employment due to inflexibilities and rigidities. From the perspective of product lifecycles, a specialized region is expected to induce more process innovations and incremental innovations and therefore improve regional productivity; a diversified region, on the other hand, is expected to stimulate more product innovation and radical R&D by fertilizing through regional multiple knowledge bases and therefore establish new market and extra employment opportunities (Frenken et al., 2007). Meanwhile, Porter (2003) also pointed out that to rely too much on a few specialized clusters for regional economic development is a dangerous strategy, since it *'exposes a region to business cycles and shocks'*. Considering the size of regions, Porter (2003) finds that Economic Areas which are smaller, are becoming diversified while US states are becoming more specialized, which is in contrast to the findings of Beaudry and Schiffauerova (2009).

Additionally, existing empirical evidence about industrial externalities varies at different levels of research. Based on a review of literature, Beaudry and Schiffauerova (2009) finds that a positive influence of a diversified industry structure is more likely to be found at the regional level, whereas the benefits of industry specialization are more pronounced at firm level studies. That is, specialization externalities are easily to be inflated in firm level studies while diversity externalities are more likely to be inflated in regional level studies. Indeed, regional specialization and diversity are not naturally exclusive strategies for regional industrial structure. Specialization reflects the extent to which a certain sector agglomerates or clusters in an industrial district whereas diversity is a characteristic of the whole regional industrial structure. For example, Paci and Usai (1999) examined a cross-sectional dataset of 85 industries and 784 Italian Regional Labor Systems and contended that both specialization and diversity externalities have significant effect on regional innovation and productive activities. The heterogeneous feature of technology level of the sector in which firms engage is closely related to firms' geographic location. For instance, firms in traditional sectors with low R&D intensity and strong extensive labor forces dependency are expected to be benefit from a specialized industry structure, whereas diversity industrial structure is believed to exert positive effect on those high technology and R&D intensive firms because the cross-fertilization of knowledge spillovers from multiple technologies (Frenken et al., 2007). This cross-fertilization of knowledge spillovers is very important for high technology breakthroughs, which are more likely to happen in a diversified region.

Actually, a possible explanation for the controversial effect of specialization and diversity on industrial innovation depends on what kind of industry is being studied. For instance, using German patent applications within the period of 1995 to 2006, Buerger and Cantner (2011) find that while diversity is associated with high innovative output in the specialized supplier industries, the same does not hold for science-based industries. While Greunz (2004) tests with a sample of 153 European regions and 16 manufacturing sectors and finds that both kinds of externalities significantly influence innovation, although the influence of Jacobs externalities is more essential in the setting of *'high density'* regions as well as for high tech sectors. Moreover, from the perspective of industry life cycle, with sectors become mature in a longitudinal trend, the MAR externalities are found to be steadily increased whereas Jacobs externalities are less positive or even become negative in some point (Neffke et al., 2010).

In summary, studies that support the MAR model highlight the possibility that knowledge transfer can only occur within the same or similar industries (Chaminade and Vang, 2008; Duranton and Puga, 2000; Feldman and Audretsch, 1999; Fritsch and Slavtchev, 2010). Tacit or codified knowledge with less or no transmission costs is frequently flowing between actors within the same sector (Gertler, 2003; Saxenian, 1996). The ways of this knowledge exchange can be embedded within mobility of skilled workers (Edler et al., 2011), collaborative R&D activities (Yeung et al., 2006) or even daily communications (Storper and Venables, 2004). However, based on a telephone survey of 265 software firms in the Netherlands, Weterings and Boschma (2009) finds that although spatial proximity between organizations is able to facilitate face-to-face interactions, the benefits from *F2F* interactions are not strengthened in this process. Secondly, industrial localization prefers a less competitive or much more monopoly environment (Glaeser et al., 1992). This opinion sharply contrast with Porter's idea because specialization scholars believe that an insular environment is good for innovation protection and some powerful companies within a regional cluster are able to rearrange R&D resources more efficiently and pursue frontier technology with less bargaining costs (Frenken et al., 2004; Mukkala, 2004). This argument is verified by plenty of cases in both developed countries and emerging markets (Jaffe et al., 1993; Sun and Liu, 2010; Venables, 1996). Supporters of the Jacobs model focus mainly on the interactive effect of communication between different industries, especially those complementary sectors (Beaudry and Schiffauerova, 2009). Emerging technology fields benefit from a more diverse economy since it offers necessary skills exchange (Harrison et al., 1996), and the influence of Jacobs externalities is more pronounced in 'high density' region and high technology sectors (Greunz, 2004) In addition, more opportunities to imitate, share and recombine ideas and practices across industries are believed to be embedded within a diverse economy of a region (Beaudry and Schiffauerova, 2009). And for some infrastructures like telecommunications, access to the internet and capacity for transportation are taken into the consideration of regional diversity and assumed to be positive for a region's economic and innovative production by prior studies (Fu, 2008; Gao, 2004).

Regional industrial specialization is believed to positively affect one region's economic and innovative output (Chaminade and Vang, 2008; Fritsch and Slavtchev, 2010), but regional R&D activities cannot be fully understood without considering contributions of both regional universities and research institutions (Guan and Chen, 2012; Hong, 2008). The MAR model mainly focuses on the outcomes of localization but not the antecedent factors of regional knowledge specialty on which regional clusters were built. As for developing countries, like China, knowledge specialties of regional universities and research institutes are a very important factor that determines what specialization of regional industries would be.

In addition, the MAR model does not include the incentive structure of industrial sectors but claims the protection effects of specialization. Incentive and motivation of R&D activities are positively related to innovation output (Becker and Dietz, 2004; Blind et al., 2006). Firms in a competitive market are more likely to achieve comparative advantage by creating new products or services and R&D staff are inclined to fulfill their potential under competitive atmosphere (Porter, 2000). Porter (2003) also agrees with the Marshallian specialization hypothesis in identifying intra-industry spillovers as the main source of knowledge externality, and I think competition within localization also works under this context. For a diverse economy, it is reasonable to take the regional knowledge configuration into the research framework as well. Not every industry can benefit from the Jacobs model, because some of industries, like traditional industries, are more likely to benefit from localization while those emerging technologies, like biochemistry and culture industries, are more willing to incorporate from complementary and diverse knowledge sources (Beaudry and Schiffauerova, 2009). This is a critical point that needs to be taken into consideration in explaining the mixed evidence of the specialization versus diversity debate.

Last but not least, extant studies mainly focus on the direct effect of industrial specialization and diversity without consideration of the moderating roles of industrial structure in affecting the association between knowledge source and innovation. In fact, both specialization and diversity closely interplay with other knowledge source in affecting regional knowledge recombination and recreation activities. For instance, FDI and the level of industrial agglomeration in China are found to be closely related, and those export focused sectors are more likely to concentrated in regions that are easy to overseas market (Ge, 2009). I therefore aim to bridge the gap in the existing literature by examining the real and comprehensive effect of industrial specialization and diversity on both regional and firm innovations in this thesis.

2.3 FDI spillovers and innovation

Foreign direct investment (FDI) is embedded with capital and new knowledge, both of which are essential for host countries' economic development and technological upgrading (Buckley et al, 2002; Cantwell & Iammarino, 2000; Dunning, 1988). Prior studies have investigated the mechanism whereby host countries can benefit from the inward FDI (Ben Hamida, 2013; Buckley et al, 2007a; Du et al, 2008; Ferragina & Mazzotta, 2013; Gaffney et al, 2013; Ito et al, 2012; Liu & Zou, 2008; Tian, 2006; Yao & Wei, 2007). However, the research is inconclusive regarding the question of whether inward FDI brings beneficial effects to host countries (Buckley et al, 2002; Cantwell & Iammarino, 2001; Cantwell & Piscitello, 2002; Dunning, 1994; Dunning & Lundan, 1998; Giroud et al, 2012; Ito et al, 2012; Zhou & Li, 2008). After three decades of development, the literature on the role of FDI can be classified into three general groups, namely the motivation and location choice of FDI (e.g., Blanc-Brude et al, 2014; Cantwell, 2009; Dunning, 2009; Iammarino & McCann, 2013), the economic impact of FDI (e.g., Buckley et al, 2002; Girma & Gong, 2008) and the spillover effects of FDI (e.g., Ben Hamida, 2013; Buckley et al, 2007a). In my thesis, I mainly focus on FDI spillovers and their potential effect on innovative activities.

2.3.1 FDI spillovers

FDI spillovers occur when 'the entry or presence of multinational companies affiliates leads to productivity or efficiency benefits in the host country's local firms and the MNCs are not able to internalize the full value of these benefits' (Blomstrom & Kokko, 1998:p.249). A recent meta-analysis focusing on the effect of FDI on economic growth in Central and Eastern Europe and the former Soviet Union demonstrated a growth-enhancing effect of FDI (Iwasaki & Tokunaga, 2014). As prior studies have suggested, the sources/channels of FDI spillovers can be classified into three types (Buckley et al, 2002, 2007c; Cheung & Lin, 2004). The first channel is local firms' learning via reverse engineering, as shown by Japanese firms in the 1960s and 1970s; the second is through labour market turnover, whereby skilled workers from the FDI subsidiary migrate to local firms, carrying with them valuable (tacit) knowledge; and the third is through demonstration effects whereby new products and technologies developed in other markets are observed in the host economies and local firms copy them in their own R&D efforts. FDI spillovers occurring from the above sources can be either horizontal spillovers from competitor firms in the same industrial sectors or vertical spillovers from FDI subsidiary firms linked to local suppliers in their value chains (Liao & Yu, 2013; Liu et al, 2009). For instance, Tang and Koveos (2008) examined the R&D spillovers of FDI from G7 countries to other developing and developed countries and found effective knowledge spillovers through FDI, although they were smaller than those through trade and information technology. Using an industry–province data set, Ito et al (2012) found that there are substantial intra-industry spillovers promoting invention patent applications but inter-industry spillovers have little effect. They also found that the positive effect of FDI spillovers on TFP (total factor productivity) is mainly from production activities, whereas the effect on invention patent applications occurs mainly through R&D activities. By comparing FDI spillovers and their effects from various channels, Tian (2006) found that tangible assets, domestically consumed products, 'traditional' products and unskilled workers employed by foreign-invested enterprises are important channels for positive FDI spillovers.

In addition, the motivation for overseas investment matters for the effect of FDI spillovers as evidence from sectors in 16 OECD countries demonstrates that asset-exploiting FDI and market-seeking FDI are particularly effective in relation to export intensity (Franco, 2013). In addition, through all these various channels, the importance of geographical clustering or regional proximity comes to the fore, with a greater FDI impact on local firms in their immediate geographical vicinity. Employing a panel of more than 10,000 indigenous and foreign-invested firms during 1998 to 2001, Wei and Liu (2006) found positive inter-industry productivity spillovers from R&D and exports and positive intra- and inter-industry productivity spillovers from the foreign presence to indigenous Chinese firms within regions. Similarly, Liu (2002) examined 29 manufacturing sectors in Shenzhen and found that FDI spillovers have a significant positive effect on manufacturing industries' growth rate, domestic sectors being the main beneficiaries.

How and to what extent host enterprises can gain knowledge spillovers from inward FDI are among the central questions in prior international business (IB) studies (Meyer & Sinani, 2009). Emerging countries and less-developed areas have tried very hard to attract FDI due to their lack of capital and backward technology (Ito et al, 2012; Sasidharan & Kathuria, 2011). As prior studies have suggested, domestic enterprises can reap advanced knowledge and new opportunities embodied in FDI in four possible ways. First, FDI brings capital and new technology to enlarge and upgrade indigenous markets (Buckley et al, 2007c). Second, new products and services put forward by foreign-invested enterprises (FIEs) provide the possibility for domestic firms to improve their technology level through learning and imitation (De La Potterie & Lichtenberg, 2001; Serapio & Dalton, 1999). Third, labour transfer from FIEs to domestic-owned enterprises is an effective method of tacit knowledge transfer (Breschi & Lissoni, 2001a) as employees in FIEs are more likely to receive training opportunities and can more easily access advanced knowledge or new information. Finally, local firms can learn from FIEs by vertical linkage, that is, they can become suppliers or customers of FIEs or compete with FIEs in regional and global markets (Fritsch & Franke, 2004; Liu et al, 2009).

In fact, whether local firms can gain positive spillovers from FDI depends not only on the amount of FDI, but also on the types of FDI (Buckley et al, 2002, 2007c) as well as the absorptive capacity of the indigenous firms (Cohen & Levinthal, 1990b; Fu, 2008). Leahy and Neary (2007) and Vang and Asheim (2006) contended that the local science base and domestic firms' knowledge stock play a critical role in exploiting knowledge spillovers from regional inward FDI. Considering the overall technology gap between emerging markets, such as China, and developed countries (Guo et al, 2013), local innovators' absorptive capacity is believed to be an essential determinant of the ability to gain knowledge spillovers from FDI. Moreover, the extent to which FDI spillovers can improve regional innovativeness depends on the level of regional openness. For instance, foreign-invested enterprises (FIEs) might survive in an open environment that is similar to or easily accepts FIEs' original context and managerial manner (Fu, 2012).

The origin of overseas investment is also suggested as a critical factor for the effect of FDI spillovers. Buckley et al (2007c) examined the annual industrial data of Chinese local-owned enterprises (LOEs) in 2001 and found that the FDI spillover effect is greater in technology-intensive industries than in labour-intensive industries; the spillovers of Hong Kong, Macau and Taiwan (HMT) investment impact positively on local-owned enterprises (LOEs) in labour-intensive industries, whereas the spillovers from Western investments positively affect LOEs in technology-intensive industries. Meanwhile, Buckley et al (2007a) adopted the data from the *Third Industrial Census* of China and suggested that foreign investors' nationality significantly affects the productivity of indigenous firms; they found a curvilinear relationship between HMT investment and the productivity of local firms, but not for other Western investors, and this relationship is especially pronounced in low-technology host industries. Even the mode of foreign investment is critical for the role of FDI spillovers. Using a sample of 41,641 firms throughout 31 provinces in China, Wang et al (2012) contended that the pace and irregularity of foreign entry negatively moderate the relationship between foreign presence and host firms' productivity, and this moderating role is affected by technical knowledge and R&D intensity in the domestic sectors.

2.3.2 Relationship between FDI spillover and innovation

A practical issue of developing countries, such as China, is the lack of capital and knowledge for promoting economic and innovative capabilities. With the increasing trend of economic globalization, various feasible platforms and channels are available for investors from developed countries to search potential markets in emerging countries (Meyer & Sinani, 2009). It is not surprising that inward FDI has become one of the most important sources of advanced knowledge for innovative activities in host countries (Tian, 2006), which is also a main driver facilitating regional innovativeness in host regions, especially in developing countries (Buckley et al, 2002; Cantwell & Zhang, 2013; Cheung & Lin, 2004; Wei & Liu, 2006; Yao & Wei, 2007).

During the last two decades, the nuanced role of FDI spillovers in innovation and technological upgrading has attracted a great deal of academic interest (e.g., Dantas et al, 2007). Research concentrating on developed countries has found that, compared with the US, Japan and eleven European countries, developing countries that invest in R&D-intensive countries are more likely to gain a productivity increase than attract investments from nations with advanced technologies (De La Potterie & Lichtenberg, 2001). OECD countries that receive FDI absorb FDI-related knowledge spillovers; however, the outward FDI of these countries, especially non-G7 countries, seems to be negatively related to sectors' production (Bitzer & Kerekes, 2008). In addition, the empirical evidence from 1799 Spanish manufacturing firms during the period from 1990 to 2002 suggested that the ex post innovation of local firms is negatively related to FDI inflows (García et al, 2013). Similarly, Barbosa and Eiriz (2009) examined a data set from the Portuguese manufacturing industry during the period from 1994 to 1999 and found that both horizontal FDI spillovers and vertical FDI spillovers exert an insignificant effect on local firms' productivity.

Studies that focused on the developing countries suggested that, for instance, the increasing inward FDI in China is seen as an essential driving force behind the surge of patent applications during the last decade (Hu & Jefferson, 2009; Li, 2012; Zhang & Rogers, 2009), while Fu (2008), using a panel of 30 Chinese regions during 1998–2004, found that whether innovators in host countries can gain benefits from overseas investment depends not only on the amount of FDI, but also on the absorptive capacity and complementary assets. This is in line with the argument of Meyer and Sinani (2009) that the development level of the regional economy in the host countries is a decisive factor affecting the role of FDI. Examining manufacturing firms in 8 regions of Vietnam during the period from 2000 to 2005, Anwar and Nguyen (2013) suggested that the real effect of FDI spillovers on manufacturers' total factor productivity (TFP) varies according to the region in which they are located and this variation may be due to the regional knowledge base and absorptive capacity. Focusing on more than 90,000 firms in 10 transition countries, Damijan et al (2013) found that idiosyncratic firm features, like absorptive capacity, size, productivity and technology levels, affect the results of FDI spillovers. Considering the mixed results regarding FDI spillovers within some recent literature, Marin and Sasidharan (2010) distinguished MNEs in India as creative activity-oriented versus exploiting activity-oriented and suggested that creative activity-oriented MNEs exert a positive effect while exploiting activity-oriented MNEs lead to a negative effect. From the perspective of vertical and horizontal FDI spillovers, Anwar and Nguyen (2014) indicated that different regions may gain varied results from FDI spillovers in Vietnam. Examining panel data from Romanian manufacturing firms during the period from 1996 to 2005, Merlevede et al (2014) contended that the effect of foreign entry on local counterparts varies according to the duration as a negative effect was found in the short term, while with a majority of foreign-owned firms' presence, a positive and lasting effect was found. Moreover, a recent study focusing on the comparison of developed countries and transition countries in terms of gaining technological spillovers from trade, FDI and patenting found that the effect of foreign patenting is larger in developed nations while FDI is an important source of know-how for transition economies (Krammer, 2014a).

Overall, the ability of technological investments of any kind to have an impact on raising performance – productivity, transferring technology, increasing capabilities – depends not only on the character of the investment but also on the receptivity, innovation capabilities and knowledge structure of innovators in the recipient area (Leahy & Neary, 2007; Sasidharan & Kathuria, 2011; Wang & Zhou, 2013). A meta-analysis of 1,205 estimates suggested that the features of both foreign investors and the domestic economy affect the horizontal spillover effect of FDI; in particular, the horizontal linkages with developed technology countries or joint ventures with domestic firms can bring significant benefits (Iršová & Havránek, 2013). More recently, FDI spillovers have been thought of as a spur to entrepreneurial activities in host countries. For instance, Kim and Li (2014) empirically analysed a panel of 104 firms during the period from 2000 to 2009 and suggested that FDI encourages business creation and this effect is strongest in countries with low general human capital, weak political stability and poor institutional support. This finding is similar to those of other researchers, such as Herrera-Echeverri et al (2014).

As prior studies have noted, innovative activities can gain benefits from inward FDI spillovers via various channels, for example reverse engineering, skilled labour turnover, demonstration effects and supplier–customer relationships. For instance, using Chinese provincial data from 1995 to 2000, Cheung and Lin (2004) found positive effects of the regional foreign presence on the number of patent applications in China, and the spillover effect was the strongest for minor innovation, such as external design patents. Glass and Saggi (1998) contended that the technology gap between locally owned firms and MNEs can be minimized via successful imitation of low quality levels of technology or products from FDI. From the institutional perspective, the foreign presence can enhance the regional intellectual property rights (IPR) environment, thereby improving the realization of local firms' intangible resource investments (Jiang et al, 2011). Similarly, Dang (2013) found that a better institutional environment is more likely to attract foreign investment, while FDI can lead to an improvement of institutional quality, especially for northern regions in Vietnam. A recent study compared the direct and indirect (moderating) roles of the local institutional environment in developed and developing countries and demonstrated that a good institutional context leads to a positive effect on productivity, while this relationship is negatively moderated by IPR and economic freedom in transition economies and positively affected by the ease of doing business in both developed and developing countries (Krammer, 2014b).

Because my thesis is mainly based on the evidence from the Chinese context, more ink is used to illustrate the prior studies related to FDI in China in this section. Since China entered the World Trade Organization (WTO) in 2001, an increasing volume of inward FDI has taken place in China (as shown in Figure 1.6 in Chapter 1). FDI usually brings advanced technologies to the host market and the expansion of FDI into different industries and regions brings great opportunities for domestic innovators to imitate and learn from foreign knowledge spillovers and hence inspires R&D activities (Meyer & Sinani, 2009). For example, Liu and Wang (2003) employed a national industrial census of China and found that R&D investment, firm size and foreign presence are the most essential factors driving TFP in Chinese industries. Moreover, compared with indigenous firms, foreign-invested enterprises (FIEs) [5] in China are more knowledgeable about using legal weapons to protect their intellectual property rights (Luo, 2003; Yang, 2003). Domestic firms can improve their cognition of intellectual property by collaborating or competing with foreign encounters (Hu & Jefferson, 2009). This demonstration effect of FDI serves as a textbook for indigenous firms to engage in R&D activities and increases the propensity for patent applications of local firms. To investigate the effect of FDI spillovers on innovation performance, Liu and Buck (2007) examined a panel of sub-sector-level data from 1997 to 2002 and suggested that Chinese indigenous firms can promote innovation through learning-by-exporting; both

[5] The criterion for assessing a foreign-invested enterprise (FIEs) is in accordance with the official criteria jointly published by the National Bureau of Statistics of the PRC. and the State Administration for Industry & Commerce of the PRC. Specific information is available in Table A1 in the Appendices.

the source of FDI spillover and the self-effort made by domestic firms jointly determine the effect of FDI spillovers. Focusing on the Chinese state-owned enterprises (SOEs), Girma et al (2009) argued that foreign capital participation is positively related to firms' innovation performance while FDI presence at the sector level has a negative effect on innovation, although SOEs benefit from FDI spillovers in exports, human capital investment and R&D. Meanwhile, using the annual report of industrial enterprise statistics, Liu et al (2009) found that FDI generates positive vertical linkage effects in Chinese manufacturing at both the national and the regional levels, and limited positive horizontal spillovers at the regional level and SOEs can benefit from vertical linkages with MNEs but non-SOEs are unable to do so. From the organizational ecology perspective, the empirical evidence of Zhou and Li (2008) suggests that a faster pace of innovation, a higher level of FDI legitimization and a region with more agglomerated innovative activities have a positive effect on product innovation. Mixed findings regarding the role of FDI spillovers in China still exist. For instance, Huang and Sharif (2009) examined the role of Hong Kong, Macau and Taiwan-funded companies in Guangdong and found that they are less active in facilitating domestic firms to conduct R&D activities. However, focusing on the high-technology sectors in China, Liu and Zou (2008) found that greenfield R&D activities exert a positive effect on domestic firms' innovation performance and both inter-sector and intra-sector spillovers exist.

As the aforementioned review of the literature suggests, whether a foreign presence has positive or negative effects on economic and innovative performance depends on both exogenous and endogenous factors, rather than solely on the amount of FDI itself. For instance, Fu (2008) argued that to appropriate the advantages of FDI fully, the roles of absorptive capacity and complementary assets need to be taken into consideration. This argument is particularly pronounced in China due to the uneven distribution of the industrial structure and regional absorptive capacity among Chinese regions (Du et al, 2008; Fu, 2008; Ge, 2009). China is marked by the unequal distribution of both inward FDI and innovation capabilities between regions, with marked variation between coastal regions, central regions and western regions[6] (Prevezer et al, 2013; Wei et al, 1999). This fact suggests that Chinese regions are likely to be characterized by independent innovation systems (Edquist, 2004), while the role of a foreign presence may be different among different regions. For example, Huang et al (2012) studied the spillover effects of FDI by Chinese regions and found that there are minimum threshold levels of innovation capability in the region that are necessary for spillovers from FDI to take effect on the productivity of local firms. Examining innovation capabilities by Chinese regions, Fu (2008) found that a regional foreign presence is influential upon the overall regional innovation capabilities, and the strength of the positive effect is attributed to the greater absorptive capacity and complementary assets in terms of R&D staff, skilled labour, universities and research institutes. This chimes with the study by Bajo-Rubio et al (2010), which finds that for FDI (in Spain) to result in spillovers by region, those regions need a minimum threshold level of development and absorptive capacity, again in the form of social and human capital, that is, an educated workforce and organizational structures. They found significant productivity effects for all the Spanish regions, both above and below the average GDP per employee, and argued that Spain, being a medium-sized industrialized economy, is in a better position in regard to its regions than China or Russia, where FDI's impacts on their regions have been more

[6] According to the classification proposed by the National Bureau of Statistics of PR China, Chinese provinces' municipalities can be categorized into three groups: eastern (coastal) regions (including Beijing, Tianjin, Liaoning, Hebei, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong and Hainan), central regions (including Jilin, Heilongjiang, Shanxi, Anhui, Jiangxi, Henan, Hubei and Hunan) and western regions (include Neimenggu, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shannxi, Gansu, Qinghai, Ningxia and Xinjiang).

mixed (positive and significant in China (Yao & Wei, 2007) and not significant and negative in Russia (Ledyaeva & Linden, 2008)).

In summary, the research is inconclusive regarding whether inward FDI is definitely conducive to innovative activities for regions and firms in host countries. For instance, Aitken and Harrison (1999) examined a panel of more than 4,000 Venezuelan plants between 1976 and 1989 and suggested that the foreign presence of small joint ventures' ownership is positively related to plant productivity (the *own-plant* effect), whereas the FDI spillover effect on indigenous plants is negative. Evidence from different contexts (e.g., developing countries versus developed countries) seems to illustrate an inconsistent outcome, which entails the examination of the effect of inward FDI spillover on regional and firms' innovation capability, particularly the contingent factors affecting the role of FDI spillovers. In fact, FDI is found to be a positive source of knowledge spillovers on technological upgrading, and this effect is conditioned on the host country's social capability and income. This moderating effect of social capability is more pronounced in poor countries (Kemeny, 2010). Based on a large data set of Chinese large and medium enterprises (LMEs), Hu et al (2005) suggested that firms' in-house R&D effort is complementary to technology transfer, of a domestic or a foreign origin, whereas FDI does not enhance the market-mediated foreign technology transfer. Similarly, examining panel data from Chinese high-technology firms, Liu and Buck (2007) suggested that Chinese indigenous firms are more likely to benefit from R&D spillovers from FDI when they have sufficient absorptive capacity. Furthermore, a recent study on regional spillovers in the Swiss manufacturing industry showed that only local firms with sufficient absorptive capacity benefit from spillovers that stem from technology transfer (Ben Hamida, 2013), and this result is in line with a prior study on service/construction sectors (Ben Hamida & Gugler, 2009). In my thesis, I focus on the role of inward FDI by integrating the effects of industrial externalities (the literature of which has been reviewed in section 2.2) and corporate ownership (state-owned corporate versus non-state-owned corporate).

2.4 Corporate ownership and innovation

Firms are seen as the main player in innovative activities. Rather than homogeneously conducting innovations, firms have varied motivations, patterns, ways and objectives for their innovative efforts. The idiosyncratic features of firms are highly concerned as influential factors in explaining firms' innovations. For example, Shefer and Frenkel (2005) conducted personal interviews involving 209 industrial firms in Israel and highlighted the close relationship between R&D expenditure and firms' features, for example the size, ownership, industrial brand, organizational structure and location of the firm. An early study conducted by Liu and White (1997) found that the synergy of both R&D investment and absorptive capacity (R&D personnel) is the main driver of firm innovation in developing countries. Similarly, Liu and Wang (2003) analysed survey data with a national scope and suggested that R&D investment, firm size and foreign presence are the most essential factors driving the total factor productivity (TFP) in Chinese industries. Employing a large-scale data set including 23,577 firms in China, Park et al (2005) contended that institutional changes affect firm performance by shaping managerial incentives, affecting transaction and agency costs and making selective resource allocations across and within industries. More recently, the enrolment of sufficient R&D staff, collaboration with universities and research institutions and collaboration with local community firms have been found to be positively related to technology licensing and technological capacities (Wang & Zhou, 2013), and the relationship between R&D investments and CEO compensation is moderated by family ownership (Tsao et al, 2014).

2.4.1 Ownership as an influential factor for firms' innovation

Different owners of firms have varied goals and impose varied constraints on firm governance (Xia & Walker, 2014). The ownership of a firm partially determines how the firm allocates resources and establishes links with customers and suppliers, thus impacting on the firm's performance (Cuervo & Villalonga, 2000; Mascarenhas, 1989). Corporate ownership is taken into account in my thesis because ownership is an influential factor on a firm's innovation strategies and innovation performance (Chen et al, 2014; Demsetz & Villalonga, 2001; Jiang et al, 2013; Yang et al, 2011). The essential role of ownership in innovation is found in both developed countries and emerging markets. For instance, examining 2,049 Welsh listed firms plus 700 firms in 3 other regions of Britain, Mainwaring et al (2007) found that the innovation activities in Ireland are relatively weak, while firms owned by outside investors of the region make a limited contribution to the patent stock. An early study focusing on the innovativeness of manufacturers in Scotland suggested that non-UK ownership (i.e., foreign ownership) is positively related to the likelihood of innovation (Love et al, 1996). Regarding emerging markets like China, Sun and Tong (2003) examined 634 listed Chinese SOEs during the period from 1994 to 1998 and argued that state ownership is negative for firm performance, whereas legal-person ownership has positive impacts on firm performance after share issuing privatization (SIP). A recent empirical study examined 548 Chinese PLCs in 8 industries and found that foreign ownership and firm affiliation within a business group have a significant impact on patent applications, while the influence of state ownership is positive but lagged (Choi et al, 2011). Moreover, a recent survey-based study of 303 Chinese firms suggested that the benefits of firms in gaining competitiveness from different innovation sources are largely dependent on their ownership and foreign ownership was found to be more effective than state ownership and private ownership.

In fact, the separation of management right from ownership right has spurred extensive discussions of the role of the ownership structure in a firm's value, profit, costs and risks of agency problems (Baysinger et al, 1991; Cho, 1998; Demsetz & Villalonga, 2001; Kim et al, 2008; Thomsen & Pedersen, 2000). Some prior studies have used the broad definition of ownership and focused on the relationships between different types of ownership, for instance state-owned enterprises (SOEs), non-state-owned enterprises (NSOEs), private-owned enterprises (POEs) or foreign-invested enterprises (FIEs), and firms' financial or innovation performance. This strand of literature has usually adopted the official definition/classification of corporate ownership. For example, Girma et al (2009) investigated the determinants of SOEs in China and found that a foreign presence is positively related to SOEs' innovation in China, while inward FDI at the sector level exerts a negative effect on SOEs' innovative activity on average. In contrast to SOEs, other domestic enterprises in China are more likely to gain knowledge spillovers from local overseas Chinese affiliates from Hong Kong, Macau and Taiwan (HMT) (Buckley et al, 2007c). Sun and Hong (2011) employed a panel data set with more than 70,000 Chinese firms during the period 2001 to 2005 and found that foreign ownership improves firm performance. Li (2011) analysed the innovative activities of hi-tech SOEs in China and contended that hi-tech SOEs absorb knowledge sourced from the domestic market more easily than knowledge purchased from abroad. Dachs and Peters (2014) examined the relationship between employment growth and innovation by integrating the perspective of foreign ownership and domestic ownership.

Another stream of literature has focused on specific features of corporate ownership and their effects on firms' operation and management. For instance, from the perspective of corporate governance differences, Xiao et al (2013) developed a theoretical framework for understanding latecomer firms' technology strategy and successfully applied it in three specific Chinese firms. Moreover, the variations in corporate governance are one of these essential features and Tylecote and Conesa (1999) and Tylecote and Ramirez (2006) proposed a theoretical framework to define appropriate variations in corporate governance. The good commercial performance of minority state-owned enterprises in China is one typical case of appropriate variations in corporate governance as the state stake offers good access to finance and resources and the private stake avoids the potential risk of bureaucratic meddling (Cai & Tylecote, 2008). Ownership concentration is another typical feature that has often been discussed in prior studies. For instance, concentrated ownership and shareholder monitoring are found to be effective mitigators for the high agency and contracting costs in the innovation process (Francis & Smith, 1995). A comparison between US and Japanese firms suggested that ownership concentration is an effective factor for firms' innovation (Lee, 2005). Employing a data set of 1,044 US listed firms and 270 Japanese listed firms in 1995, Lee (2005) suggested that ownership concentration and investors' identity of large ownership positions affect corporate innovation. Using a sample of 351 Chinese firms, Li et al (2010) found that the relationship between ownership concentration and product innovation is inverse U-shaped and the learning orientation mediates this association. However, Choi et al (2012) examined the relationship between corporate ownership and innovation in 301 firms from 8 industries in Korea and argued that ownership concentration does not have a significant effect on innovation performance, whereas institutional and foreign ownership do have a positive effect. Recently, Shin and Shin (2013) used a data set of 128 US firms from the Compact Disclosure Database and suggested that institutional investors, especially the pension fund ownership, are more likely to be attracted by firms enhancing technological relatedness.

Some studies have also examined the role of family ownership in innovation. For instance, Lodh et al (2014) studied family PLCs in India and found that family ownership is positively correlated with firms' innovation productivity, and Matzler et al (2014) used a data set of German publicly traded firms and pointed out that family involvement in management and governance has a positive effect on innovation outputs but a negative impact on R&D inputs. Moreover, Sciascia et al (2014) examined the R&D intensity of SMEs in Italy and contended that whether family ownership exerts a negative effect on R&D investment largely depends on the degree of overlap of the family's total wealth and the single firm equity.

Though the differences in corporate governance and the distinction between minority state-owned enterprises (MISOEs) and majority state-owned enterprises (MASOEs) are very important and meaningful to understand how firms' technological capability is developed (Cai & Tylecote, 2005, 2008; Liu & Tylecote, 2009), I can only examine the role of domestic firms' ownership in a broad manner by distinguishing Chinese indigenous firms into SOEs and non-SOEs according to the criterion of whether the largest shareholder (with at least 10% shares) is the state (Ning et al, 2014). This is mainly because the focus of this thesis is the effect of regional-level features, that is, inward FDI and industrial externalities, on domestic firms' innovation, and there are constraints regarding the data sets. This shortcoming is highlighted in the limitations of this thesis and the role of distinguishing MISOEs and MASOEs in innovation is also acknowledged as a meaningful direction for future studies.

2.4.2 Chinese state-owned enterprises and innovation

Numerous SOEs have been established in China since 1978 and these SOEs are usually large or medium enterprises (LMEs) due to the principle of economic reform (*zhuadafangxiao policy*, i.e., 'grasp the big and let go of the small'); only those profitable companies with competitiveness were corporatized and many small SOEs owned by the local government were privatized (Bai et al, 2004). In the early stage of Chinese economic reforms, former SOEs were privatized by moving property rights from state sectors to non-state sectors with various forms of ownership (Child, 1994; Child & Lu, 1996). Chinese SOEs (CSOEs) are believed to be hierarchical organizations with a heavy burden and low efficacy (Cai & Tylecote, 2005; Raiser, 1997). During the process of economic transition from a command-based to a market-driven economy, the CSOEs as the main style of industrial enterprises in the command economy have been restructured and upgraded over the last three decades (Cai & Tylecote, 2005; Raiser, 1997).

Previous research has studied the transition process of CSOEs and its effect on economic and innovative activities. This strand of literature conveys mixed answers to the question of whether CSOEs have positive effects on economic or innovative activities. For instance, the majority of early studies contended that Chinese SOEs are harmful to the development of the local economy because nearly one-third of SOEs lost money during the reform period (Raiser, 1997) and the concentration of state assets in CSOEs has a negative effect on their performance (Jefferson et al, 2003). It has also been well documented that SOEs were unprofitable and drained government budgets (e.g., Putterman & Dong, 2000). An explanation for this phenomenon is that agents in CSOEs have a greater propensity to pursue their own interests via on-the-job purchasing and hiding profit or embezzling state assets rather than furthering the state's interests during the process of economic reform (Lin et al, 1998; Sun & Tong, 2003).

However, some recent studies have put forward new arguments regarding the relationships between state ownership and corporate value. For example, Bai et al (2004) and Tian and Estrin (2008) claimed that the association between state ownership concentration and corporate value is non-linear; specifically, corporate value will decline with increasing state ownership up to a certain point, but after this threshold, the value will rise with an increase in state ownership (U-shape). Moreover, CSOEs are the major beneficiary of social resources as they are more likely to gain S&T projects and have much better access to financial sources (bank loans) than private and SME sectors (Fu & Mu, 2014). In general, state-owned or state-held industrial enterprises (SOEs) are the main players in the Chinese market (Li, 2009). An obvious advantage of CSOEs is their close relationship (*guan xi*) with the central or regional government, which can be understood as *social capital* (Elfring & De Man, 1998). This advantage provides SOEs with special access to market and financial resources; for instance, CSOEs are more capable of exploring overseas markets and gaining comparative advantages in other developing countries (Ramasamy et al, 2012a). In addition, examining 1,244 Chinese firms in Beijing, Guan et al (2009) suggested that firms receiving government support through the high-tech firm accreditation system generally perform better. Nowadays, the majority of Chinese SOEs are agglomerated in key sectors, for example oil and gas or telecommunications. Therefore, SOEs are more likely to gain benefits from their quasi-monopoly market power or status

(Jefferson et al, 2003).

Whether CSOEs are innovative actors and which factors determine CSOEs' innovativeness are not clear yet. Some studies have argued that CSOEs are less innovative because of their policy-directed social objectives and low level of efficiency (Lin et al, 1998; Raiser, 1997). Considering the characteristics of the sectors in which CSOEs operate, CSOEs face less competition in domestic markets than other types of enterprises (Jefferson et al, 2003). This is another reason why CSOEs are believed to be reluctant to conduct R&D activities (Gao, 2004; Raiser, 1997). Nevertheless, numerous studies have pointed out that CSOEs are facing increasing challenges from FIEs and private SMEs, and they have a strong incentive to invest in R&D (Li, 2011). The majority of CSOEs have substantial R&D resources, for instance sufficient scientists and engineers, as well as R&D expenditure. Moreover, China is endeavouring to shift from the *World Manufacturing Factory* to the *Global Innovation Centre* (Williams et al, 2011), CSOEs are playing an essential role in implementing this strategy. For instance, CSOEs have undertaken series of S&T projects solely or in collaboration with universities and research institutions (Hong, 2008) and actively participated in various S&T outsourcing activities in the 1990s (Motohashi and Yun, 2007).

More recently, scholars have found that CSOEs are becoming innovative, particularly CSOEs based in highly technological sectors (for example, Li, 2011). Considering the potential effect of government support, Guan et al (2009) examined 1,244 firms in Beijing and found that manufacturers that obtain support from the Government via the high-tech firm accreditation system achieve better innovation performance. CSOEs are more likely to gain access to the essential infrastructure that will boost government-initiated innovations (Chang et al, 2006b). However, based on an extensive survey of 766 Chinese firms, Wu (2011) found that firms' political ties (state ownership) have an inverted U-shaped relationship with product innovation. Li (2011) examined the role of external technology sources and SOEs' absorptive capacity in their innovation capability in terms of patenting and contended that CSOEs in high-technology sectors are more likely to gain benefits from purchasing domestic technologies than from importing foreign technology; more importantly, SOEs' in-house R&D was found to be critical when SOEs are trying to absorb technology from overseas sources. However, these findings reflect only the SOEs in the high-technology sectors and not SOEs in other industries and the panel of 1995–2004 cannot capture the latest changes and developments of CSOEs.

In addition, as the main participant in the Chinese economy, CSOEs are seen as the main receiver of FDI spillovers. For example, by using a comprehensive panel of 20,000 CSOEs during 1999 to 2005, Girma et al (2009) found that foreign entry can exert positive effects on SOEs' production innovations, but it has a detrimental impact on SOEs' innovative activities on average. Moreover, they noticed that inward FDI is a facilitator for CSOEs to increase their investments in R&D and human capital. These results indicate that even if FDI exerts negative effects on those SOEs with insufficient absorptive capacity, SOEs have ambitions to be more capable in innovation through substantive R&D investments. However, limited regional linkages and low levels of absorptive capacity were found to be the main obstacles to CSOEs achieving positive spillovers from FDI, although this conclusion was made regarding the status of CSOEs a decade ago (Girma and Gong, 2008). Therefore, whether and how domestic CSOEs can gain opportunities from a foreign presence remain open questions.

As prior studies have pointed out, one of the Chinese approaches to economic reform is remodelling many large formerly state-owned firms to implement modern corporate governance structures (Anglo-Saxon corporate governance structures), which include public listing on the stock market (Lau et al, 2000; Tian & Estrin, 2008). The majority of PLCs in China are state-funded or holding corporations, which are crucial for the development and stability of the Chinese economy (Tian & Estrin, 2008). Recently, a number of studies have begun to investigate the role of different forms of ownership of domestic companies in their innovativeness. Employing a data set of all Chinese public listed companies (PLCs) between 1999 and 2001, Bai et al (2004) found that issuing shares to foreign investors and a high concentration of non-controlling shareholding have positive effects on market valuation. Focused on 142 Chinese PLCs in 2005 and 2007, Dong and Gou (2010) suggested that with the increase in shares held by managers, R&D investment has witnessed a U-shaped development curve. Choi et al (2012) employed a data set of 548 Chinese public listed companies (PLCs) with various ownership structures and found a positive and lagged effect of state and institutional ownership on firms' innovation performance in terms of patent registration, whilst foreign ownership plays an important role in facilitating innovation performance. I therefore examine the roles of regional inward FDI and industrial structure in domestic PLCs' innovation in Chapter 6.

In summary, what is missing from this stream of literature concerns whether domestic firms are able to gain benefit from knowledge spillovers from a foreign presence and whether different types of indigenous firms, that is, SOEs and non-SOEs, have different mechanisms to grasp opportunities embodied in foreign knowledge spillovers. More importantly, though domestic firms are the main actors in the regional industrial structure, I find that relatively few attempts have been made to investigate the role of industrial specialization and diversity in indigenous firms' innovation process, although the effect of contextual factors has been highlighted in recent studies (Zahra et al, 2014).

2.5 Concluding remarks

The above review of extant literature regarding innovation system, industrial structure, FDI spillovers and corporate ownership suggests that the core research question of this thesis, namely 'd*o regional foreign presence and industrial structure (IS) affect innovation capability (IC) and, if so, how?*', is inconclusive and worthy to investigate the answer for it. The census of the above streams of literature delineates that a comprehensive investigation of the driving forces for regional and domestic firms' innovation capabilities is lacking. Relevant studies in the developing countries, particularly in the Chinese context, show that inward FDI is a critical channel and source for advanced knowledge sourcing of host innovators. Numerous studies focus on whether FDI can bring positive spillover effects on host regions' innovation output (macro perspective) and on domestic firms' innovation capability (micro perspective). The regional innovation system (RIS) is a useful lens to investigate the answer for the core research question because regional heterogeneity is an essential factor for the unbalanced economic structure in nations with huge spatial scope. This is especially applicable in the Chinese context because the gap between developed regions and less developed regions in terms of both economic and innovative capabilities is significant.

Numerous factors, e.g., regional R&D intensity, regional absorptive capacity, regional science base in terms of first-tier universities and research institutions, collaboration between innovators inside and outside the region, technology licensing and R&D outsourcing are found to be essential factors for innovation while the effect of foreign spilloverson the innovativeness of host regions and domestic firms is not clear yet. Meanwhile, industrial externalities, i.e., MAR (specialization) and Jocabs (diversity) externalities, is an important source of knowledge for innovation as well. However, as Beaudry and Schiffauerova (2009) point out, the effects of industrial specialization and diversity are varied according to the specific methodology and context adopted by prior studies. Relevant studies in the Chinese setting are limited and usually used old datasets to examine the impact of the degree of industry specialization and diversity on the innovativeness of domestic regions and firms with the latest data.

Though prior studies suggest that the effect of FDI not only depends on its amount, but also relies on other factors, such as absorptive capacity, institutional quality, openness, source of FDI, corporate ownership, etc, I find no prior research considered the contingency role of regional industrial structure - specialization and diversity – in affecting association between foreign presence and regional innovation capability. In following chapters, I posit that the effect of foreign presence on regional innovativeness and domestic firms' innovation capability is actually moderated by the degree of both industrial specialization and diversity.

In summary, by reviewing relevant literature about regional and firm innovation, FDI spillovers, and industrial structure in terms of specialization and diversity, I realize that each of these themes is an attracting topic in existing literature, but much less attention has been placed on the relationships between them. First of all, regional innovation system (RIS) is a feasible perspective for me to investigate whether FDI spillovers is a real driver for regional innovativeness. In the Chinese context little is known about determinants of and how they affect regional innovation, especially for the latest period since China entered the WTO. I expect that both FDI and regional industrial structure play essential roles in affecting innovative activities at regional level.

Secondly, although scholars highlight the benefits of foreign presence in the host countries, less evidence has unraveled the contingent factors that will impact on the final effect of FDI spillovers. I therefore aim to investigate whether FDI brings benefits for innovations at regional and firm level and how this process is affected by regional industrial structure, i.e., industrial specialization and diversity.

Finally, plenty of prior studies analyzed the ownership structure of firms and their economic and innovative performance, but much fewer efforts have been made on whether and how domestic firms in host countries can gain benefits from regional foreign presence. More importantly, from the perspective of corporate ownership, indigenous SOEs and non-SOEs are different in terms of organizational structure, profitability, absorptive capacity, etc, albeit majority of prior studies focused on the issue of SOEs' innovations. Thus, it is crucial to explore how these two types of domestic firms can gain benefits from FDI spillovers.

Overall, the review of prior studies provides me with a reasonable foundation for the research that is carried out in this thesis.

Chapter 3 Research design and methodology

3.1 Introduction

In the preceding chapter, I reviewed the literature focussing on innovation systems, IS, knowledge spillovers of FDI, and corporate ownership. In this chapter, the research design and methodology selection for this thesis are presented. Identifying suitable methods for conducting this study was a challenging job because there are five specific research questions that cover both regional and firm level innovative activities. As Figure 1.12 in Chapter 1 illustrates, the five specific research questions are assigned to three chapters – 4, 5, and 6 – and each of these chapters is designed to answer corresponding specific research questions. In order to select appropriate methodology for each chapter, I designed the research strategy for specific chapters; the process of selecting appropriate research methods is elaborated on in Section 3.2. Moreover, because it was demanding work to search, collect, clean, and tidy up data from various sources for the present study, the process and procedure of data collection as well as selection of appropriate data analysis methods for chapters 4, 5, and 6 is detailed in the sections 3.3, 3.4, and 3.5, respectively. Section 3.6 revisits and concludes the whole chapter.

3.2 Research strategy and method selection

As the review of prior studies in Chapter 2 indicates, the major research methodologies adopted by prior studies were found to include case studies and surveys, as well as descriptive analysis, comparative analysis, evolutionary analysis, and explanatory analysis. For instance, the object of descriptive research is to "*portray an accurate profile of persons, events or situations*" (Robson, 1993: 4). This may be an extension of, or a forerunner to, a piece of exploratory research. It is necessary to have a clear picture of the phenomena on which one wishes to collect data prior to searching for specific data sources. This method is very helpful in the present research as it is adopted to investigate the status of the RISs, IS and inward FDI in the Chinese context as well as preliminary insights into the relationships between IS, foreign presence and local innovativeness.

In addition, studies which establish causal relationships between variables may be termed explanatory studies (Robson, 1993). The emphasis here is on studying a situation or a problem in order to explain the relationships between variables. Since the research objective of this thesis is to examine the effects of foreign presence and IS on regional innovativeness and companies' IC, the method of explanatory studies is employed using two panel datasets at regional and firm levels. Each of these methods has advantages and shortcomings. The point here is to select an appropriate method for specific research questions as shown in Chapter 1. In doing so, it is necessary to think about the features of each specific research questions and then choose corresponding research methods.

Table 3.1 below elaborates the features of each research question as well as the requirements for answering these questions. The last column of Table 3.1 presents the selected methods for each specific research question. Figure 3.1 below further illustrates the comprehensive research framework of this study, encompassing both specific research methods and data source for each chapter.

Table 3.1 Research method selection for each research question

Chapter	Research question	Feature & requirement	Selected method
Chapter 4	*RQ1*: *Why are foreign direct investment and industrial structure two critical factors in a regional innovation system?*	A explorative question; need to derive insights from the deep analysis of literature and data	Evolutionary analysis; Theoretical sampling; Comparative analysis;
Chapter 5	*RQ2*: *Do foreign presence and industrial structure (i.e., specialization and diversity) exert direct and interactive effects on* ***regional*** *innovation capability?*	An explanatory question; need to make arguments and estimate specific effect	Theoretical analysis; Panel regression; Regional level data;
Chapter 6	*RQ3*: *Do foreign presence and industrial structure (i.e., specialization and diversity) exert direct and interactive effects on innovation capability of* ***domestic firms****?*	An explanatory question; need to make arguments and estimate specific effect	Theoretical analysis; Panel regression; Firm level data

3.3 Evolutionary and comparative studies in Chapter 4

3.3.1 Methods adopted in Chapter 4

In order to answer RQ1 in Chapter 4, it is necessary to explore the reasons why FDI and IS are important for regional innovation. To do so, the evolutionary process of the Chinese RISs, inward FDI, and IS during the period of implementation of the "*Reform and Opening Up*" policy (1978–2010) is analysed. Particularly, I am interested in the potential relationships between inward FDI and IS and the development of the Chinese RISs. The method of evolutionary analysis enables us to examine the features of different phases of the development path of RISs, FDI and IS using various documents, data, and archives. The results of evolutionary analysis provide preliminary evidence to link both foreign presence and IS with each RIS.

In the second half of Chapter 4, I investigate the roles of FDI and IS in a RIS by comparing five Chinese regions – Beijing, Shanghai, Guangdong, Hubei, and Hunan – chosen using the method of theoretical sampling. The method of theoretical sampling can be simply understood as "*cases … selected because they are particularly suitable for illuminating and extending relationships and logic among constructs*" (Eisenhardt and Graebner, 2007: 27). Theoretical sampling with multiple cases is particularly helpful for researchers in conducting a broader exploration of research questions and theoretical elaboration (Eisenhardt and Graebner, 2007), which typically provides a stronger base for theory building (Yin, 1994). The comparative study of the five regions helps to deeply and comprehensively dig out the circumstance of foreign presence, IS, and regional innovative activities in these regions.

Figure 3.1 Geographic positions of the five regions

Specifically in the present study, as shown in Figure 3.2, Beijing and Shanghai are the political and financial centres of China, respectively, and Guangdong is the frontier and experimental district of the "*Reform and Opening Up*" policy implemented from 1978. The reasons why Hunan and Hubei are focussed on, in comparison with Beijing, Shanghai and Guangdong, are as follows. Firstly, prior studies mainly divide Chinese regions into two categories – favoured regions and less favoured regions[7] (Gao et al., 2011) – and the majority of the literature focuses on the innovative or economic activities in coastal regions of China, such as the interactive patterns between MNEs and local technology actors in China's leading information and communications technology (ICT) cluster in Zhongguancun in Beijing (Zhou and Xin, 2003); the role of state-led efforts in promoting technology innovation in Shanghai (Wu, 2007); and the ICT industrial cluster in China's leading SEZ – Shenzhen – in Guangdong (Wang et al., 2010). Others focus on some clustering districts of China, for example the redistribution of Taiwanese personal computer investment from the Pearl River Delta to the Yangtze River Delta (Yang, 2009). In this thesis attention is also paid to central regions since 2006 when the Chinese government launched the "*Strategy of Central Rise*", stating that central regions will be developed as a new engine for national economic development. As shown in Figure 3.2, Hubei province and Hunan province are core members of this national strategy since both play critical roles in linking coastal regions with inland regions, providing great opportunities for improving regional innovativeness. Table 3.2 below shows that the economic strength in terms of regional GDP of Hubei and Hunan is similar to Beijing and Shanghai.

[7] Favoured regions include coastal provinces and most municipalities, such as Beijing, Shanghai, Shandong, Jiangsu, and Guangdong; these regions are generally richer and have better business environments than less favoured regions. Less favoured regions include central and western regions, such as Sichuan, Neimenggu, Ningxia, Shaanxi, and Guizhou, etc. Most of them are poor and mountainous.

Table 3.2 An overview of the five regions (2010)

Region	Position	Population (million people)	Area (km^2)	GDP (billion RMB)
Beijing	Coastal	1.96	16410.54	1411.4
Shanghai	Coastal	2.30	6340.5	1716.6
Guangdong	Coastal	10.43	179800	4601.3
Hubei	Central	5.72	185900	1596.8
Hunan	Central	6.56	211800	1603.8

Source: Compiled by the author using data collected from NBS.

In addition, the rising costs of human capital and land rent have led traditional industries that originally settled in coastal provinces to transfer to central and inner areas during the last decade. Against this background, both Hubei and Hunan have attempted to absorb shifting industries and to reconstruct their industrial configuration to be more innovative and have higher value. Therefore, Hubei and Hunan are two central regions that are endowed with much potential for economic and innovative development in the coming decades. By comparing these two groups of regions, I provide some new insights for understanding RISs in the context of the biggest emerging country in the world. Further, the "*Reform and Opening Up*" policy and the "*Strategy of Central Rise*" policy are two national strategies for development. I intend to explore the differences in these target regions from the perspective of IS and regional innovation, so as to draw some implications for improving the RISs of those regions catching up in China.

It is worth noting that there may be some weaknesses of the comparative analysis of only five Chinese regions, although they were chosen using the method of theoretical sampling. Besides Beijing, Shanghai, and Guangdong, there are some other powerful innovators in China, such as Jiangsu, Zhejiang, etc. The objective of Chapter 4 is to use the big-three regions as a mirror to reflect the main features of the IS of developed regions in China. However, this might leave some idiosyncratic features of regional industrial configuration and of RISs beyond the discussion of the comparative analysis in Chapter 4. In addition, the expectations and arguments derived from Chapter 4 are mainly based on existing literature and descriptive data analysis. As such, it is difficult to indicate precisely the roles of FDI and IS on IC. In Chapter 5 and Chapter 6, both regional and firm level datasets are employed to conduct empirical analyses of the specific effects of regional foreign presence and IS on regional innovativeness and local firms' IC.

3.3.2 Data source and collection for Chapter 4

In order to answer the first specific research question, Chapter 4 is designed to examine the development paths of RISs, FDI, and IS in China during the last three decades. Yet, there is little literature or data that directly describes the evolutionary path of all these three aspects. In order to collect appropriate data and information for the evolutionary analysis, I identified three data sources from reviews of prior studies that may provide some relevant information about the development paths of RISs, FDI, and IS in China.

Academic publications

Considering the research objective and context of this thesis, academic publications were chosen as a possible source for collecting information on RISs, FDI, and IS. I collected academic articles focussing on RISs, FDI, or IS in the Chinese context from leading peer-reviewed journals, e.g. *Research Policy*, *R&D Management*, *Technovation*, *Technology Forecasting and Social Change*, etc., and thesiss written by scholars who have expertise in Chinese innovation systems, for instance "*China's Rise in the World ICT Industry: Industrial Strategies and the Catch-up Development Model*" written by Ning (2009a). In addition, given that some insightful articles cannot be published in

English because of the language constraint, I also incorporate lots of academic papers and thesiss written in Chinese, for example "*Chinese Regional Innovation System*" written by professor Xin Gu.

It is common to find that academic papers or thesiss usually focus on very specific questions, and thus the pattern or relationships between FDI, IS, and RISs in China cannot be derived directly. In these cases, I can only identify the database or data sources used by these researchers and then search for those data sources and check whether they are appropriate for research in this thesis. Both the information directly collected from academic publications and information from potential data sources that were used in these academic papers or thesiss enrich my knowledge of the evolutionary process of Chinese RISs, FDI, and IS.

Government policies

As extant literature points out, policy orientation may have an influence on the development of innovation systems. This argument might be particularly effective in the Chinese context as the government has played a critical role in organising and guiding S&T activities during the past few decades (Fu and Mu, 2014; Gu and Lundvall, 2006; Huang et al., 2004; Motohashi and Yun, 2007; Sharif, 2006). For instance, the "*Reform and Opening Up*" policy and Deng Xiaoping's southern tour in 1992 inspired the increasing trend of overseas investment in China; foreign ventures in particular have become some of the main players in China's innovation system since China joined the WTO in 2001 (Hu and Mathews, 2008). I wish to learn more about how each Chinese RIS is established from the perspective of policy makers through reading relevant policy documents.

Given that the administrative organisation in China is a relatively large system, policy documents were mainly collected from the website of the Ministry of Science and Technology,[8] which is an overarching agency overseeing S&T affairs from proposing policies, programmes, and plans to budgeting and allocation of R&D resources for some national S&T programmes (Cao et al., 2013); the Ministry of Commerce,[9] which is an executive agency and responsible for formulating policy on foreign trade, export and import regulations, FDI, consumer protection, and market competition as well as negotiating bilateral and multilateral trade agreements; and the National Development and Reform Commission,[10] which has broad administrative and planning control over the Chinese economy. Suggested by prior studies, such as Xue (1997) and Liu et al. (2011), I mainly focus on those most influential and strategic policies – programmes, regulations, decisions – that are relevant to S&T, R&D, FDI, and IS, and analyse the potential influence of the these policies on the evolutionary process of RISs, FDI, and IS. For instance, I thoroughly analysed the "*Outline of the National Medium and Long-term Education Reform and Development Plan (2010–2020)*".[11]

Given that regional government is closely related to the development of RISs, besides national policy proposed by the central government, it was necessary to collect information relevant to the orientation of regional policy makers. The "*Local Government Work Report*" (LGWR) is usually delivered by the chief officer, i.e. provincial governor, at the beginning of each year, providing specific information about

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[8] Information available at: http://www.mostgov.cn
[9] Information available at: http://mofcom.gov.cn
[10] Information available at: http://www.sdpc.gov.cn
[11] For the details of this policy document, please refer to the website of the Central People's Government of the People's Republic of China, available at: http://www.gov.cn/jrzg/2010-07/29/content_1667143.htm

the regional government's orientation and key points for administrative work for the whole year. I collected information on the orientation of regional policies relevant to RISs using the method of template analysis. According to King (1998), template analysis can be understood as the process of organising and analysing textual data according to themes, and it enables researchers to gain insights into the meaning of observed behaviour.

For the comparative analysis of five regions, ten copies of the LGWR for each regional government were collected from online sources, e.g. newspapers, websites of regional governments, etc. Then, based on the method of template analysis, these 50 copies of LGWR were reviewed to evaluate whether some aspects, e.g. importance of foreign investment, or RISs, were highlighted in the report. Specifically, I carefully read through each LGWR and found out whether it included keywords related to six specific aspects: inter-regional collaboration (*kua di qu he zuo*), international collaboration (*kua guo he zuo*), importance of foreign investment (*xi yin wai zi*), industrial transfer (*chan ye jie gou tiao zheng*), high technology industry development (*fa zhan gao ke ji chan ye*), R&D cooperation (*chan xue yan he zuo*). All these aspects were identified based on the review work conducted in Chapter 2. This procedure is similar to that used by Hong (2008), where the author identified industry–university R&D collaborations from patent application records registered by the State Intellectual Property Office (SIPO).

China Statistical Database and China Statistical Yearthesis

Though I can extract useful information from academic publications and government policy documents, I cannot gain concrete data from them as they are mainly based on aggregate level studies or descriptions. Finding reliable data sources from which data related to innovation systems, foreign presence, and IS can be collected is a challenging job. Prior studies basically reported rough sources of the data they used for specific research, but most did not report how they accessed those data sources.

My solution to this problematic issue was twofold. The first method involved finding a possible data source used in academic papers and then contacting the corresponding authors of specific papers via email and seeking their advice for the data source. I received some responses using this method; most advice offered a rough direction of how to access the data source or stated that their usage of the data was under a non-disclosure agreement. The second method involved identifying the corresponding data source reported in the literature by translating and matching with the data source published in Chinese journals, followed by discussion with scholars focussing on innovation in some Chinese universities, for example Hunan University, to explore how I could access them. Through these two methods, it was found that the China Statistical Database (CSD) and "*China Statistical Yearthesis*", both of which are compiled by the National Statistics Bureau (NBS) of China, and some related bureaus and commissions, are the main data sources adopted in the previous studies.

NBS is a national department which releases various types of public data every year, every quarter, and every month. In the present study I mainly used the annual data because the data release in each quarter and month does not include useful information for this research, for example, data of regional R&D expenditure by regions in each quarter or month is unavailable. The "*China Statistical Yearthesis*" is compiled by NBS and other administrative departments (e.g. the Ministry of Science and Technology), which is a comprehensive dataset including major sectors of the national economy, e.g.

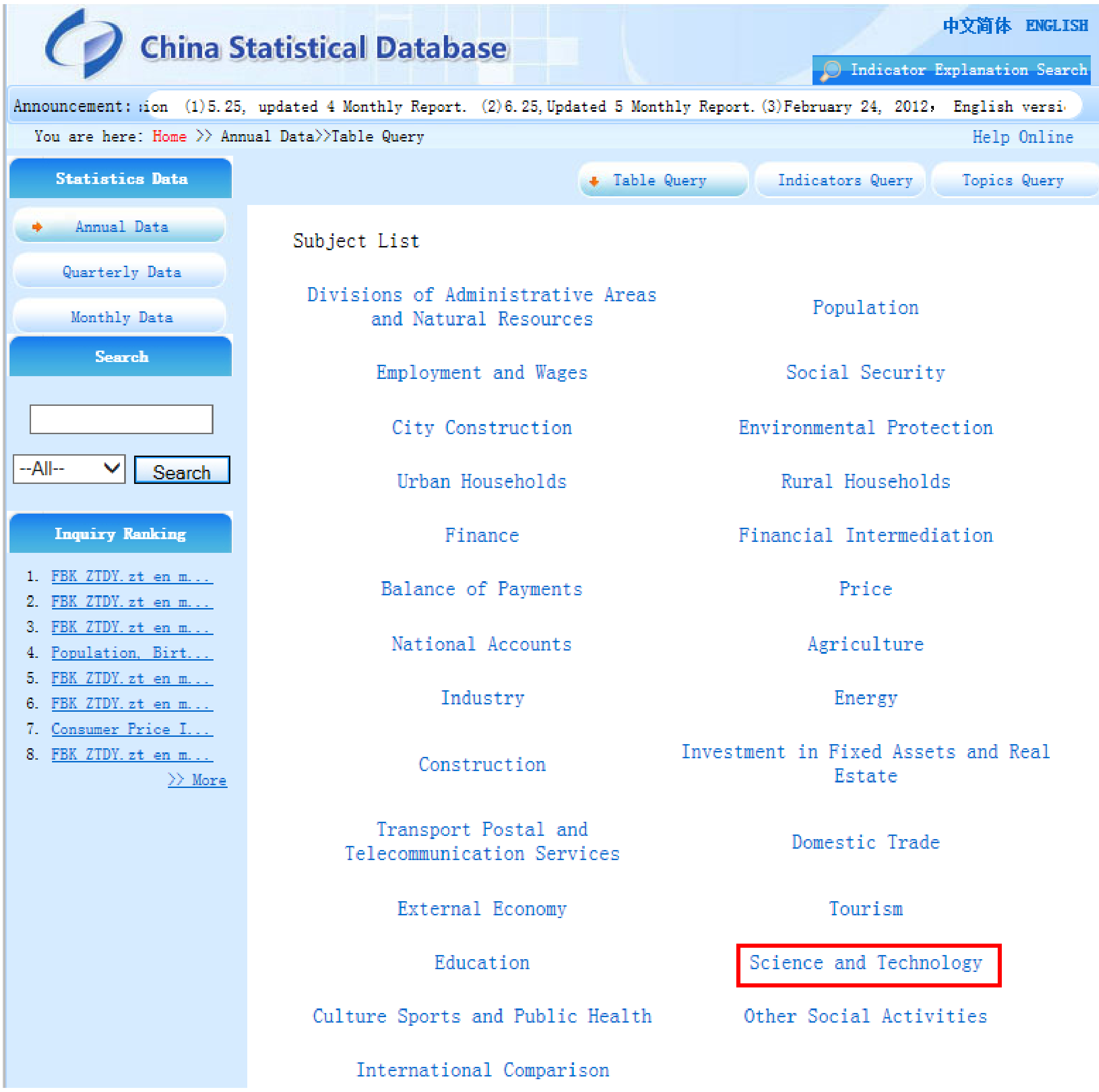
population, trade, employment and wages, investment in fixed assets, energy, natural resources and environment, industry, education and S&T, etc. As the CSD and yearthesiss report macro level (national and regional level) data, regional features (e.g. employment, population, technology market transaction value, GDP growth rate, etc.), regional R&D input in terms of R&D expenditure and human capital, and regional IC in terms of patent applications, could be obtained from these two data sources.

Specific data related to the development of the Chinese innovation system, FDI, and IS at both national and regional levels were collected. Since NBS is an administrative institution, useful data can be searched for using the search platform within the website of NBS. The procedure of collecting data from the CSD is presented as follows.

Source: The screenshot is compiled by the author through internet (http://219.235.129.58/welcome.do#)

Figure 3.2 Searching platform of the China Statistical Database

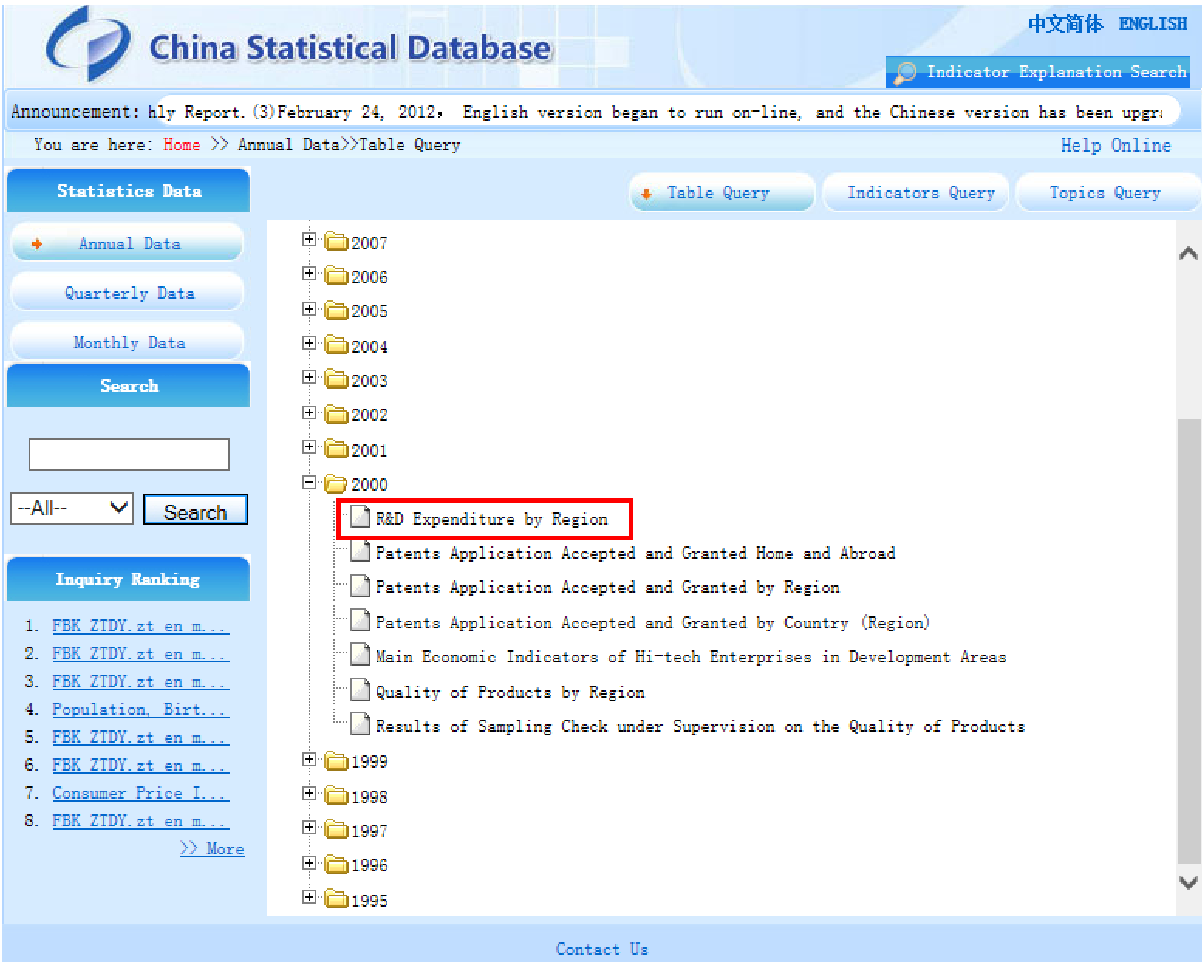
Figure 3.3 shows the search platform of NBS. Specific categories of statistics can be collected either using keywords in the search engine of the platform or by clicking on the '*Annual Data*', '*Quarterly Data*', and '*Monthly Data*' buttons and then identifying appropriate data for usage. As it was unclear whether the variable name was consistent with specific statistical category names, '*Annual Data*' was mainly used to search for statistics related to the present research.



Source: The screenshot is compiled by the author through internet.

Figure 3.3 Searching page of Annual Data in the China Statistical Database

As Figure 3.4 above illustrates, the '*Annual Data*' category includes 27 subclasses of statistics, from which interesting data can be extracted. For instance, as RISs are a key theme of the present study, it was necessary to collect as much related data from the '*Annual Data*' as possible and thus the '*Science and Technology*' subclass was chosen (which is highlighted in a red box in Figure 3.4).



Source: The screenshot is compiled by the author through internet.

Figure 3.4 Searching page of "Science and Technology" subclass in the China Statistical Database

As shown in Figure 3.5 above, the statistics within the '*Science and Technology*' subclass are arranged in the folder of specific year and specific statistics available in each specific year. For example, as shown in Figure 3.5, one can extract R&D

expenditure by region for the year 2000.

2000Year Inquiry

View the information of table describes

R&D Expenditure by Region

100 Million Yuan

item	Expenditure on R&D(100 Million Yuan)
National Total	895.7
Beijing	155.7
Tianjin	24.7
Hebei	26.3
Shanxi	9.9
Inner Mongolia	3.3
Liaoning	41.7
Jilin	13.4
Heilongjiang	14.9
Shanghai	73.8
Jiangsu	73.1
Zhejiang	33.4
Anhui	20
Fujian	21.2
Jiangxi	8.2
Shandong	52
Henan	24.8
Hubei	34.8

Source: The screenshot is compiled by the author through internet.

Figure 3.5 Data sheet of "R&D Expenditure by Region" in 2000 in the China Statistic Database

Figure 3.6 above shows the specific format and content of the statistics of R&D expenditure by region in 2000. I collected regional level data for other variables using the same procedure, and tidied up them into a Microsoft Excel file which includes year, region name (regional ID) and specific variables. Though the CSD can provide data for most regional level variables, there are still some variables that cannot be directly collected from CSD, for instance technology market transaction value, GDP growth rate, etc. In addition, as a procedure to ensure the reliability of the data source, I cross-checked the regional level data collected from the CSD and the "*China Statistical Yearthesis*".

Specifically, the regional level dataset for the subject related to this research was identified, for instance '*Education and S&T*', and then downloaded as a relevant data sheet, for example "*Patents Application Accepted and Granted by Region*". As shown in Figure 3.7 below, once the specific data sheets were downloaded from the NBS website, it was necessary to extract the five regions, which are highlighted by red boxes on the left side of Figure 3.7, and compile them as a part of a regional dataset. Based on this procedure, interesting data was collected from various statistics yearthesiss, e.g. "*China Statistics Yearthesis*", "*China Statistical Yearthesis on Science and Technology*", "*China Statistical Yearthesis of Industry and Economy*", and compiled them into the regional dataset (as an Excel file) for further analysis.

20-59 Patents Application Accepted and Granted by Region (2010)

Region	Number of Patents Application Accepted	Inventions	Utility Models	Designs	Number of Patents Application Granted	Inventions	Utility Models	Designs
National Total	**1109428**	**293066**	**407238**	**409124**	**740620**	**79767**	**342256**	**318597**
Beijing	57296	33466	18637	5193	33511	11209	16579	5723
Tianjin	25973	7347	11064	7562	11006	1930	6718	2358
Hebei	12295	3270	7089	1936	10061	954	6838	2269
Shanxi	7927	3046	3533	1348	4752	739	3096	917
Inner Mongolia	2912	932	1406	574	2096	262	1276	558
Liaoning	34216	9884	14994	9338	17093	2357	12067	2669
Jilin	6445	2789	2993	663	4343	785	2806	752
Heilongjiang	10269	4070	4815	1384	6780	1512	4391	877
Shanghai	71196	26165	23188	21843	48215	6867	21821	19527
Jiangsu	235873	50298	51436	134139	138382	7210	41161	90011
Zhejiang	120742	18027	50231	52484	114643	6410	47617	60616
Anhui	47128	6396	17367	23365	16012	1111	8839	6062
Fujian	21994	5117	10846	6031	18063	1224	9664	7175
Jiangxi	6307	1968	2947	1392	4349	411	2588	1350
Shandong	80856	17259	43441	20156	51490	4106	36391	10993
Henan	25149	6408	13856	4885	16539	1498	11048	3993
Hubei	31311	7411	12791	11109	17362	2025	10431	4906
Hunan	22381	6438	9601	6342	13873	1920	7861	4092
Guangdong	152907	40866	47706	64335	119343	13691	43900	61752
Guangxi	5117	1574	2512	1031	3647	426	2167	1054

Source: The screenshot is compiled by the author through internet.

Figure 3.6 Data sheet of patent application accepted and granted by region (2010)

3.4 Empirical Studies in Chapter 5

In order to answer specific research question 2, 3, and 4 shown in Chapter 1, I need to elaborate and testify the associations between foreign presence, IS and regional IC. To achieve this objective, I mainly use the theoretical analysis to derive hypothesis for each specific research question. And then, I need to choose appropriate dataset and propose the strategy to collect and compile the data, as well as identify justifiable data analysis method. Panel regression estimating results are used for testing specific hypotheses and make explanations.

3.4.1 Data adopted in Chapter 5

In order to answer the specific research question 2, I need to establish a regional database which includes data of regional innovation output, FDI, IS, and other regional features that relevant to regional innovative activities. China is a big country with 31 administrative regions at regional level, following prior studies (Cheung and Lin, 2004; Fu, 2008; Li et al., 2011; Li, 2009, 2012), I set up this research on the provincial level in the Chinese context (refer to Chapter 1 for the reasons).

A followed up question is where can I collect data for all the 31 Chinese regions? Based on the review of related studies (as shown in Chapter 2), I find that most studies that focused on regional innovation questions in the Chinese context usually collected data from various types of statistical yearthesis, for example, Fu (2008) extracted data of regional FDI inflow, R&D intensity, regional technology transaction value and patent applications number from the China Statistical Yearthesis to investigate whether regional complementary infrastructure affected the impact of FDI on regional innovation capability; Cheung and Lin (2004) also draw data of FDI inflow and other regional features from the China Statistic Yearthesis to prove that FDI spillovers lead positive influence on regional innovativeness in terms of total patent applications and specific type of patents (i.e., invention, utility model, and external design). Similar with the dataset constructed for Chapter 4 (as presented in section 3.3.2), I identified the data sources for the regional level study as CSD and various types of China Statistical Yearthesis, and I adopt the same procedure of collecting regional level data from these two data sources.

Specifically, Tibet was excluded from the sample due to limited statistical information about it, which is also a common way adopted by prior studies (Cheung and Lin, 2004; Fu, 2008; Li et al., 2011; Li, 2009, 2012). The panel consists of 30 regions with 330 observations over the period of 2000 to 2010. The data are collected from various issues of *The China Statistical Yearthesis on Science and Technology*, *The China Industry Economy Statistical Yearthesis*, and *The Database of China Main S&T Index (DCMSTI)*. The statistical yearthesiss are official publications of statistics which were compiled by National Bureau of Statistics of China (NBSC) and State Intellectual Property Office (SIPO). The *DCMSTI* is compiled by the Ministry of Science and Technology (MOST). Different from the previous research that rely mostly on the China Statistical Yearthesis, the *DCMSTI and MOST* data provide both more detailed regional economic and S&T indicators such as R&D expenditure, S&T personnel, and regional GDP growth (Fu, 2008; Huang et al., 2012). In order to analyse the regional panel dataset, I followed prior studies, e.g., Fu (2008) and Cheung and Lin (2004), to adopt panel regression with fixed effect using regional patent applications in one year, two years, and three years lag as dependent variables.

3.4.2 Econometric configuration in Chapter 5

Econometric configurations in a large body of innovation studies are based upon the knowledge production function (KPF). After decades of practice and improvement, the KPF has become an important tool in analyzing knowledge creation and technology innovation. Drawing on endogenous development theory, which is also known as the "*new growth theory*" that emphases technology progress as the driving force of economic growth and development (Aghion and Howitt, 1992; Lucas, 1988), prior studies adopted the framework of the knowledge production function (KPF) approach in which both the input and output within the innovation process are integrated to analyze the RIC (Jones, 1995; Romer, 1990). For example, Griliches (1979) firstly analyzed the process of innovation and pointed out that the output of innovation is a function of R&D inputs, which can be understood as R&D capital. Based upon a threshold model and the dataset of 29 Chinese provinces during the period 1985-2008, Huang et al. (2012) found that FDI brings to produce positive spillover effect in the region only when regional innovation reaches a minimum threshold of innovativeness. From the perspective of spatial interdependency, Caragliu and Del Bo (2011) examined determinants of knoweldge spillovers of 103 Italian provinces and found that higher level of regional absorptive capacity, measured by regional R&D investment and social capital, will reduce interregional knowledge spillovers.

Referring to the form of Cobb-Douglas production function, Griliches (1979) puts forward the KPF as following.

$$R\&D_{output} = a \cdot f(R\&D_{input})^{\alpha} \tag{1}$$

Following studies, such as Jaffe (1989), argue that new economic knowledge is the most essential output of R&D activities, and R&D expenditure and R&D human resources are two main R&D inputs. The KFP then expressed as following.

$$Q_t = AK_i^{\alpha} L_i^{\beta} \mu_i \qquad (2)$$

where Q is R&D output, K is R&D expenditure and L is R&D human resource respectively, α and β is the elasticity of K and L respectively, A is a constant, μ is the stochastic disturbance term.

Besides the factor inputs, knowledge spillovers from other sources are essential for economic knowledge production as well. As I discussed in the prior sections, knowledge spillovers from regional industrial configuration, i.e., specialization and diversity, and from inward FDI (foreign presence), are important sources of knowledge for regional innovativeness. In addition, regional characteristics, especially those related to regional innovative activities, such as GDP growth, economic scale, government S&T supports, technology market, are essential for regional innovations. I take these factors into the following model.

$$Y_t = \psi(R\&D, FDI, INS, RS), \qquad (3)$$

where *R&D* is the R&D input, FDI is regional foreign presence, INS is the knowledge spillover of industrial structure, RS is a vector of regional features. Model (3) combines the Grilliches model and the Jaffe model for knowledge production and also considers the effect of knowledge spillovers from inward FDI and regional industrial structure and regional features. I then put regional human capital (L) into model (3) and assume it complies with the style of C-D production function as following.

$$Y_t = \psi(R\&D, L, FDI, INS, RS) = aR\&D^{\alpha} L^{\beta} FDI^{\theta} INS^{\gamma} RS^{\lambda} \mu, \qquad (4)$$

where μ is the stochastic disturbance term, θ, γ and λ is the elasticity of FDI, industrial structure and regional features against innovation output, respectively. I use natural logarithm to process the model (4) and get:

$$\ln y_{it} = C + \alpha \ln rdi_{it} + \beta \ln hrc_{it} + \theta \ln fdi_{it} + \gamma \ln ins_{it} + \lambda \ln rs_{it} + \mu_{it} \qquad (5)$$

A very important point here concerns the causal relations between independent variables, for example inward FDI, and the dependent variable, that is, innovation capability in terms of patent applications. Specifically, on the one hand, it is possible that overseas investors are more willing to invest in those regions with a great knowledge base (Cantwell, 2009), a high degree of openness to external technologies (Dunning, 2009) and significant innovation capabilities (Cantwell & Iammarino, 2000); on the other hand, regional innovative capabilities are forged by a foreign presence and local industrial externalities as the SIS and TSI strongly overlap with the RSI (Iammarino, 2005). Therefore, the difficulty in grasping the causal relations is huge. To overcome this critical problem, I reviewed the prior studies and econometric books and found that there are two main ways of dealing with the endogeneity problems. The first method is to adopt the two-stage least squares (2SLS) estimator. The drawback of using this method is that an appropriate instrumental variable (IV) is indispensable. As Wooldridge (2002) noted, an IV should have no correlation with the unobservable factors (residual) of the dependent variable (namely instrument exogeneity) but should have a correlation with the endogenous explanatory variable (namely instrument relevance). Since the statistical regulations in China are not perfect yet, and regional-level data are usually limited and aggregated, the difficulty in finding a proper IV for inward FDI spillovers and industrial externalities within the regional-level dataset is considerable and I cannot use the 2SLS estimator method to overcome the potential endogeneity problem. Alternatively, prior studies have suggested that a lagged structure of dependent variables is a feasible method to reduce the risk of two-way causalities within an econometric configuration (Fu, 2008; Usai, 2011).

> A potential problem of using a lagged structure is that different independent variables may exert their effect on the innovation capability in varying time lengths. For example, the assumption of a one-year lag from R&D to patent applications seems reasonable, while a lag of two or three years seems more reasonable for other explanatory variables, such as industrial externalities. The logic behind this is that FDI spillovers and externalities of specialization and diversity may work through R&D and must take some time to have an impact on regional innovative activities. However, as in my research, various lagged lengths of independent variables may lead to a dramatic decrease in observations and make the regression equation unstable, which may reduce the explanatory power of the estimation results. Therefore, it is a particularly hard decision to use the current specification (lagged settings) as an alternative method to investigate the role of these independent variables in patenting. Perhaps this is a promising avenue for future research to account for the possible effect of independent variables with varied time lengths on innovative activities. Given that the length of innovative activities is varied, I use not only a one-year lag but also a two-year lag and a three-year lag for all the independent variables in the estimations,

which can serve as a robustness test for the results (Schilling & Phelps, 2007).

Specifically, the econometric analysis of the spillover effect of inward FDI on regional innovation capability begins from the region's knowledge production functions (KPF) (Fu, 2008; Griliches, 1992) as follows:

$$\begin{aligned} ln(Pat_{it}) = \alpha + \beta_1 \ln(rdi_{i,t-1}) + \beta_2 \ln(hrc_{i,t-1}) + \beta_3 \ln(gdpg_{i,t-1}) + \beta_4 \ln(scale_{i,t-1}) \\ + \beta_5 \ln(govst_{i,t-1}) + \beta_6 \ln(stecm_{i,t-1}) + \beta_7 \ln(fdi_{i,t-1}) + \beta_8 \ln(spe_{i,t-1}) \\ + \beta_9 \ln(div_{i,t-1}) + \varepsilon_{it} \end{aligned} \qquad (6)$$

where Pat_{it} is the innovation output measured by the number of patent applications per 10,000 inhabitants, $rdi_{i,t-1}$ is R&D intensity, $hrc_{i,t-1}$ is human capital, $gdpg_{i,t-1}$ is the regional economic growth rate, $scale_{i,t-1}$ is region scale in terms of regional employment, $govst_{i,t-1}$ is regional government's S&T support, $stecm_{i,t-1}$ proxies regional technology market, $fdi_{i,t-1}$ is foreign presence, $spe_{i,t-1}$ is industrial specialization, $div_{i,t-1}$ is industrial diversity, ε_{it} is the random disturbance. *i* and *t* denote region and time, respectively. All variables are as defined in the following sections (shown in Table 3.3).

To test the hypotheses that the degree of regional industrial specialization and diversity shapes the spillover effects of inward FDI on regional IC, I extend equation (6) and include the interaction terms of FDI and specialization, and FDI and diversity respectively as follows:

$$\ln(Pat_{it}) = \alpha + \beta_1 \ln(rdi_{i,t-1}) + \beta_2 \ln(hr_{i,t-1}) + \beta_3 \ln(gdpg_{i,t-1}) + \beta_4 \ln(scale_{i,t-1})$$
$$+\beta_5 \ln(govst_{i,t-1}) + \beta_6 \ln(stecm_{i,t-1}) + \beta_7 \ln(fdi_{i,t-1}) + \beta_8 \ln(spe_{i,t-1})$$
$$+\beta_9 \ln(div_{i,t-1}) + \beta_{10} \ln(fdi_{i,t-1}) \times \ln(spe_{i,t-1}) + \beta_{11} \ln(fdi_{i,t-1}) \times \ln(div_{i,t-1}) + \varepsilon_{it} \quad (7)$$

all variables are in natural logarithms. The other independent variables are as defined in equation 6 and lagged for one year.

3.4.3 Variable measurements in Chapter 5

3.4.3.1 Dependent variable

The extant literature suggests that regional innovation capability is often measured by regional patent applications as an intermediate innovative output (Fu, 2008; Liu & White, 1997; Usai, 2011; Wang & Zhou, 2013). The number of patents is thought to be an appropriate indicator as it reflects the process and product innovation. However, its limitations have been pointed out by some scholars. As Jaffe et al (1993) argued: 'Not all inventions are patentable, not all inventions are patented, and even if they are, they differ greatly in their quality, innovative output and economic impact, making simple patent count quality a noisy measure of innovativeness.' However, patents may indicate a more accurate level of technological capability than new product sales, especially in China, where new products are often loosely defined and potentially over-recorded by firms to gain subsidies from regional authorities (Li, 2011; Wang & Zhou, 2013). In fact, the measurement of innovation capability has been discussed in prior studies and patents are favoured by the majority of relevant researchers as an indicator of innovative capacity and knowledge transfer across various innovative actors, such as enterprises, universities, sectors and even countries (Acs et al, 2002; Choi et al, 2011; Griliches, 1998; Hong & Su, 2013; Jaffe et al, 1993; Wang et al, 2013). Although patents as a proxy for innovation output suffer from some weaknesses (Jaffe et al, 1993), there are many advantages of using this indicator. As Malerba et al (1997) pointed out, patents are an effective indicator of technological development and they are available in a longitudinal series.

Patents are also the best available source for evaluating technological innovation as the standard and stable assessment procedure of patents guarantees their quality; usually, the data source for the patent is publicly available and the patent document usually provides potential technological and organizational details (Griliches, 1990). In addition, since the measurement of economically useful new knowledge is essential to understand regional innovation performance, patent counts and other innovation count data are usually adopted for this aim (Acs et al, 2002). In China, the surge of patenting since the mid-1990s signals a dramatic increase in innovation. Specifically, the patent figures published by the WIPO (World Intellectual Property Organization) show that patent applications by resident per million population in China increased nearly 13 times in the period from 1995 to 2007 (Li, 2012). This dramatic increase in innovative activities in terms of patenting helped China to surpass Korea in Asia and to become the third nation in the rank of global patenting (behind the United States and Japan).

The innovation systems among Chinese regions have also become relatively independent due to the significant differences in economic and technological development and autonomous regional policy since the open-door reform (Li, 2009). Patent application counts may well represent the innovation capability of individual regions, given the same patent application standard and procedure applied across regions (Huang et al, 2012; Li, 2011; Usai, 2011). Thus, it is suitable to use patents as the indicator for measuring innovation capability in the Chinese context. In this study, I follow Fu (2008), Huang et al (2012) and Paci and Usai (1999) in using the number of patent applications per 10,000 inhabitants as the dependent variable to reduce the heterogeneity of territorial units.

3.4.3.2 Explanatory variables

FDI intensity (fdi): To test the relationship between FDI and regional innovation capability, I employ the proportion of total industrial product value contributed by FIEs in a region to measure the presence of FDI *(fdi)*, following Buckley et al. (2002) and Tian (2006).

Industrial specialization (spe): Based on the work of Glaeser et al. (1992) and Gao (2004), I construct the regional industrial specialization variable to measure Marshall externalities that reflect the extent to which a region's IS is specialized relative to economic activities in the country as a whole. It is defined as follows:

$$S_i = \sum_{j=1}^{n} \lambda_{ij} \left[\left(\frac{E_{ij}}{\sum_{j=1}^{n} E_{ij}} \right) / \left(\frac{\sum_{i=1}^{m} E_{ij}}{\sum_{j=1}^{n} \sum_{i=1}^{m} E_{ij}} \right) \right] \tag{8}$$

where E_{ij} is output in industry j in region i, *n* and *m* are the numbers of industry and region respectively, λ_{ij} is an assigned weight to each industry *j's* relative prominence in the total industrial employment in region i. A higher value of S_i indicates a greater degree of specialization in region i.

Industrial diversity (div): to identify the impact of increased regional diversity of industries (Jacobs externalities), I construct this diversity variable following the work of (Gao, 2004; Henderson, 1997). Let $\varphi_{ij} = (y_{ij} / y_{i.})$ be industry j 's share of the total industrial output in region i. y is the industrial output. I then subtract D_i from 1 to allow a higher value of it to reflect higher diversity. It is defined as follows:

$$D_i = 1 - \sum_{j=1}^{n} \varphi_{ij}^2 \text{, } i\text{=1, 2, 3,…, n} \tag{9}$$

where D_i is the diversity index. The higher the value of D_i, the more diversified the regional industrial structure is in region i.

3.4.3.3 Control variables

I control for a number of factors that might affect the regional innovative activity. In the regional KPF, regional R&D input such as R&D investment and employees often play important roles in determining innovation performance (Griliches, 1992; Jaffe et al., 1993; Usai, 2011; Wang, 2010). Regions with a higher level of R&D expenditure are more likely to innovate as R&D investment (capital) creates new products and production process. I control for regional R&D intensity *(rdi),* which is the ratio of regional R&D expenditure over GDP. The availability of human capital *(hrc)* particularly the skilled labour force, is also important in enhancing regional innovation capability as they represent the regional capability to absorb and recognize external knowledge (Fu, 2008; Mankiw et al., 1992; Wang, 2010). I thus control for *hrc,* which is calculated as the ratio of residents with tertiary degrees divided by regional total inhabitants.

Moreover, the regional characteristics can influence regional innovation. Regional scale can have an effect on innovative output as increasing returns to scale yield externalities (Feldman and Audretsch, 1999). To account for such impact, I use the natural logarithm of the number of total employees (*lemp*) in a region as a proxy for the economic size of the regions. I also expect that R&D activities thrive in regions with a high rate of economic and industrial growth (Rodríguez-Pose and Crescenzi, 2008). These regions attract more foreign and domestic investment for innovation and grow faster (Fu et al., 2011). I use regional GDP growth rate *(gdpg)* as a proxy to control for the effect of regional economic growth potential across regions and sectors (Cheung and Lin, 2004).

Additionally, Huang et al. (2012) and Li (2009) point out that technology policies and innovation plans have a strong regional character in China due to the autonomy of economic and social policy that regional authorities gradually gained since the open-door reform. Regional governments usually launch S&T policies in accordance with specific key features of regional innovation pattern, so innovators, e.g., local firms and universities, in different regions in fact receive varied policy support or subsidies for their R&D activities. I use *govst* as a proxy, which is the share of government spending on science and technology (S&T) activities to its total expenditure to account for such an effect.

Finally, the regional technology market in which such technology transfer, consultation, technical services and training and various research and production cooperation happen represents the strength of technology linkages and commercialization as well as the level of technology development in a region (Fu, 2008). I thus use total transaction value in a region's technological market against regional GDP to control for the impact of technological markets (*stecm*). The definition, operationalization and data source for each variable are summarized in Table 3.3 below.

Table 3.3 Definition and description of variables for the regional level study

Variable name	Acronym	Operationalization	Source
Regional patent applications	$lpatent_{i,t}$	Natural logarithm of region *i*'s patent applications/10,000 inhabitants in year *t*	China Statistical Yearthesis
Inward FDI intensity	$lfdi_{i,t-1}$	Natural logarithm of region *i*'s FIEs' industrial output value/total industrial output value in year *t-1*	China Statistical Yearthesis
Specialization	$lspe_{i,t-1}$	Natural logarithm of Formula (8) in year *t-1*	China Industry Economy Statistical Yearthesis
Diversity	$ldiv_{i,t-1}$	Natural logarithm of Formula (9) in year *t-1*	China Industry Economy Statistical Yearthesis
R&D intensity	$lrdi_{i,t-1}$	Natural logarithm of region *i*'s R&D expenditure/GDP in year *t-1*	China Statistical Yearthesis on Science and Technology
Human capital	$lhrc_{i,t-1}$	Natural logarithm of the proportion of regional residents with a tertiary degree in year *t-1*	China Statistical Yearthesis on Science and Technology
GDP growth rate	$lgdpg_{i,t-1}$	Natural logarithm of region *i*'s GDP growth rate in year *t-1*	Database of China Main S&T Index
Employment	$lemp_{i,t-1}$	Natural logarithm of region *i*'s total employment in year *t-1*	Database of China Main S&T Index
Government S&T support	$lgovst_{i,t-1}$	Natural logarithm of region *i*'s Government S&T spending/Government's total spending year *t-1*	Database of China Main S&T Index
Technology market	$lstecm_{i,t-1}$	Natural logarithm of region *i*'s transaction value of technology market/regional GDP in year *t-1*	Database of China Main S&T Index

3.5 Empirical studies in Chapter 6

To answer RQ3, it is necessary to go one step further to explore whether and how the roles of regional foreign presence and IS affect local indigenous firms' IC, and whether these associations are varied according to different ownerships (state-owned firms versus non-state-owned firms). Specifically, I elaborated the effect of foreign presence and IS on regional domestic firms' innovativeness using theoretical analysis and then estimated specific effects using appropriate datasets and data analysis methods.

3.5.1 Data adopted in Chapter 6

The first problem I needed to overcome was how to collect a reliable dataset for the firm level inquiry. Through comparison of the advantages of survey questionnaires and secondary datasets, the latter were found to be more appropriate for the research objective. This is because the method of survey questionnaires is usually used for collecting cross-sectional data, while it is common to find that innovative activities usually need some time to produce innovative output, and thus a panel dataset is therefore more suitable for the research objective. Another question I needed to solve was identifying reliable and available sources for secondary data collection. A lot of prior studies focus on Chinese public listed companies (PLCs), e.g. Tian and Estrin (2008) argue that information announced in the annual reports of listed companies is a reliable data source since the reliability of the information is supervised by the China Securities Regulatory Commission (CSRC). Thus I collected the data regarding PLCs' features, e.g. size, return on assets, Tobin's Q, etc., from the China Stock Market Accounting Research (CSMAR) database.

According to the format of the Center for Research in Security Prices and Compustat, the CSMAR database is compiled by the GTA (Guo Tai An) Information Technology Company[12] and The University of Hong Kong. The sample drawn from the CSMAR database incorporated all listed companies on both the Shenzhen and Shanghai Stock Exchanges between 2000 and 2010. The CSMAR database has been widely adopted in

[12] For detailed introduction of GTA Information Technology Company, please refer its website available at: http://www.gtafe.com/14-7-160.html.

economic and managerial related studies. For example Bai et al. (2004) investigated the relationship between Chinese companies' ownership structures and market value using the CSMAR dataset and Kato and Long (2006) examined the role of top managers' turnover in affecting firms' performance based on the CSMAR database. The validity and reliability of the CSMAR dataset is appropriate for the present research. Since the CSMAR database is a commercial database, access to it was obtained through the account of Hunan University.

However, there is a troublesome problem: the CSMAR dataset does not include any R&D output-related data. In order to deal with this issue, suggested by prior studies such as Hong (2008) and Wang et al., (2013), I manually collected the number of patents of each PLC through the search platform on the website of China's SIPO. The SIPO (vice ministry level) is directly affiliated with the State Council, and one of its main responsibilities is organising and coordinating intellectual property rights (IPRs) protection work nationwide and improving the construction of IPR protection systems. Though it is possible for Chinese inventors to apply for patents in other countries, for instance with the United States Patents and Trademark Office (USPTO), or the European Patent Office in the European Union countries, for a broader protection of their IPRs, Prevezer et al. (2013) compared the number of Chinese inventors patenting with SIPO and USPTO during the last decade and found that Chinese inventors have a propensity to patent their R&D outputs in the SIPO system rather than with the USPTO.

Table 3.4 Number of grants for patents of USPTO and SIPO (1996-2005)

Region	1996-2005		1996-2005(USPTO)		
	USPTO	SIPO	Regional	Nonregional	Overseas
China	1052	1022231	1052	NA	1746
Beijing	278	62100	250	10	353

Shanghai	106	65510	100	17	258
Guangdong	150	191875	130	15	294
Hubei	21	22245	21	5	21
Hunan	10	24153	10	3	14

Notes: Nonregional means the number of assignees that located in other regions in the mainland China.
Source: Compiled by author from website of USPTO and SIPO

Specifically, as Table 3.4 shows, the discrepancy between the number of Chinese patents granted by the USPTO and SIPO is huge during the period of 1996 to 2005. This reflects the tendency for most Chinese inventors to register their R&D outcomes in the patent office (SIPO) rather than with the USPTO where it is significantly more expensive to register a patent. Those patents registered with the USPTO are more likely to be done by larger, internationalised companies and for commercially more significant patents. Moreover, the three columns on the right display the number of assignees of patents that were invented or co-invented by regional inventors. At the national level, a total of 2,798 patents were invented or co-invented by inventors who resided in mainland China from 1996 to 2005, and over half of those patents (62.4%) were granted to overseas assignees. Within those overseas patents, the number of assignees from the US and Taiwan is 712 and 689 respectively, whilst the main assignees from mainland China are China Petroleum and Chemical Co., Ltd (Beijing, 108), Tsinghua University (Beijing, 20), and Huawei Technologies Co., Ltd (Guangdong, 16). This indicates that international corporations and top universities in China are more likely to patent with the USPTO than other organisations.

Indeed, from the *de jure* perspective, any invention or utility model patent in China should possess innovativeness, novelty, and practical applicability which means that the patent needs to incorporate prominent substantive features and represent notable progress compared with existing technologies (Xiang et al., 2013). Therefore the SIPO is a reliable data source of patents, which has been frequently adopted by prior studies, e.g. (Hong and Su, 2013; Kroll, 2011; Li, 2012; Wang and Zhou, 2013).

Source: The screenshot is compiled by the author on the website of SIPO.

Figure 3.7 Searching platform of patent record at the web page of SIPO

Figure 3.8 above shows the search platform on the SIPO website. In the search platform, I used applicant name and application date, which are highlighted in the red boxes in Figure 3.8, as keywords to collect the number of patent applications of each PLC in each individual year of the sample period (2000–2010). A potential problem of searching PLCs' patent applications in each year is using PLCs' names as the keywords. This problematic issue has been discussed in prior studies using patent records to establish collaborative networks among inventors, and industry–university joint R&D collaborations (Hong, 2008). I used the name of each PLC in the stock exchange as the keyword for searching patent applications to reduce the potential bias of choosing appropriate keywords.

Once the firm level dataset was compiled, it was necessary to integrate it with the regional level dataset. In order to match these two different datasets, I used the regional code (region ID) and year of each PLC as clues to link with regional features. After this procedure I finally obtained an integrated dataset which included both firm level and regional level data. Additionally, I dropped PLCs operate in service sectors because most of them never apply for patents at all and there are little R&D activities in these firms. I also deleted those PLCs with foreign ownership since our research objective is to examine the role of foreign presence in affecting local indigenous firms' innovativeness. After omitting those observations with missing values, the final sample covers the period from 2000 to 2010 with an unbalanced panel of 9,596 firm-year association for 1,610 firms with a record of 124,200 successfully granted patents.

3.5.2 Econometric configuration in Chapter 6

As the dependent variable in this study is a patent count variable and takes only nonnegative integer value, the linear regression is inappropriate. This is mainly because the distribution of residuals of the dependent variable will be heteroscedastic nonnormal. Poisson regression is recommended to model count data (Hausman et al., 1984). The

Poisson distribution, however, requires that the mean and variance of the sample data are equal, which is a strong assumption that usually cannot be achieved as patent data often display overdispersion, where the variance exceeds the mean (Hausman et al., 1984). As the descriptive statistics shown in Table 6.1 in Chapter 6, the standard variation (S.E.=123.50) of firms' patent number is much greater than the mean (Mean=12.47), indicating that the patent data has overdispersion.

Though the coefficients will be estimated consistently in the presence of overdispersion, their standard errors will generally be underestimated which produces spurious high levels of significance (Cameron and Trivedi, 1986). Other empirical studies suggest an alternative method, i.e., negative binomial regression, to deal with the overdispersion problem of patent data (Almeida et al., 2002; Chang et al., 2006a; Choi et al., 2011; Schilling and Phelps, 2007). As Hausman et al. (1984) suggested, the negative binomial model is a generation of the Poisson model which allows overdispersion by incorporating an individual, unobserved effect into the conditional mean. In other words, I relax the variance restrictions of the underlying Poisson model. Blundell et al. (1995) suggested the conditional probability density function in the Poisson model for firm$_{i,t}$ is:

$$Pr(Y_{it} = y_{it}|X_{it}) = \frac{e^{-\lambda_{it}}\lambda_{it}^{y_{it}}}{y_{it}!} \tag{10}$$

In line with prior studies (Almeida et al., 2002; Chang et al., 2006a; Choi et al., 2011), individual, unobserved effect was introduced into a conditional mean as follows:

$$\mathrm{E}[Y_{it}] = \lambda_{it} = \exp(\mu_t + \beta x_{it} + \gamma z_i + \alpha_i + \varepsilon_{it}) \tag{11}$$

where $\exp(\varepsilon_{it}) \sim \Gamma[1, \alpha]$, which means the error term is assumed to have a gamma distribution. The subscripts i and t mean that the parameter λ is allowed to vary across individuals (i=1, 2, …, n) and year (t=1, 2, …, m). The parameter α is estimated directly from the data and captures overdispersion.

I therefore adopt the dynamic count data model of patent data on firms' innovation capability, and I applied the negative binomial panel models with fixed effects to examine both the direct and interactive effects of foreign presence ($fdi_{i,t-1}$), specialization ($spe_{i,t-1}$) and diversity ($div_{i,t-1}$) on Chinese firms' innovation capability. The log-linear function of all covariates of this study can be shown as the following.

$$\begin{aligned}\log\lambda_{it} = \alpha_i &+ \beta_1 frd_{i,t-1} + \beta_2 age_{i,t-1} + \beta_3 size_{i,t-1} + \beta_4 leverage_{i,t-1} \\ &+ \beta_5 ROA_{i,t-1} + \beta_6 Tobin's\ Q_{i,t-1} + \beta_7 hrc_{i,t-1} + \beta_8 gdpg_{i,t-1} \\ &+ \beta_9 emp_{i,t-1} + \beta_{10} fdi_{i,t-1} + \beta_{11} spe_{i,t-1} + \beta_{12} div_{i,t-1} \\ &+ \beta_{13}(fdi_{i,t-1} \times spe_{i,t-1}) + \beta_{14}(fdi_{i,t-1} \times div_{i,t-1}) \end{aligned} \tag{12}$$

As knowledge spillovers from foreign presence take time to be absorbed and to have an effect on a firm's innovation capability, I use a one year lag for all independent variables in the regression estimations (as shown in formula (5) above). The underlying assumption is that patents are a result of a lengthy innovative process, R&D inputs and firm and regional features need some time to impact on innovative activities. As the discussion of the endogeneity problem within the econometric models in Section 3.4.2, another advantage of lagging all independent variables by a year is that this procedure can remove possible endogeneity in the model (Fu, 2008; Usai, 2011). Given that the lengthy of innovative activities is varied, I also use two years lag and three years lag for all independent variables in the estimations, which can be served as robustness test for the results (Choi et al., 2011; Schilling and Phelps, 2007).

3.5.3 Variable measurements in Chapter 6

3.5.3.1 Dependent variable

Knowledge created by innovative activities is treated as innovation output. Innovation capability is a proxy that illustrates to what extent an innovator creates new knowledge. Patents are preferred in a large number of empirical studies as an indicator for innovation capability. The advantages of adopting patents as the dependent variable in this research are threefold. First of all, as prior studies suggested, the procedure and criteria of assessing a patent is reasonable and reliable (Griliches, 1990). For instance, SIPO is the only authority in China for evaluating patent applications and issuing patent grants. Though some studies point out that the legal system of intellectual property right (IPR) in China is far behind that in developed countries, like U.S. and European countries, the patent system of China experienced a huge development since China entered WTO (Li, 2012). More recently, the number of Chinese patent grants has been drastically increased from 105,345 in 2000 to 814,825 in 2010[13], implying that the awareness of IPR of Chinese innovators has been improved significantly. Secondly, patent number has become a core index of competitiveness evaluation system at both regional and firm level in China (Kroll, 2011). Chinese firms have realized the importance of patenting as it is a label of innovativeness, and seek to obtain patent registrations. Thirdly, the empirical estimates I conducted can be easily compared with prior studies if I use patent number as dependent variable, which can link the findings with existing literature in a comparative manner. Specifically, as in this study, I cannot

[13] The details of the huge surge of Chinese patenting can be referred at the website of SIPO (http://www.sipo.gov.cn/).

directly collect information about Chinese PLCs' patent registration. Following prior studies, I manually collect this data from the search platform of SIPO, and use the patent number of each PLCs as the dependent variable.

3.5.3.2 Explanatory variable

FDI intensity (fdi): To test the relationship between FDI and domestic firms' innovation capability, I employ the proportion of total industrial product value contributed by foreign invested enterprises (FIEs) in a region to measure the regional presence of FDI *(fdi)*, following Buckley et al. (2002) and Tian (2006).

Industrial specialization (spe): Based on the work of Glaeser et al. (1992) and Gao (2004), I construct the regional industrial specialization variable to measure Marshall externalities that reflect the extent to which a region's industrial structure is specialized relative to economic activities in the country as a whole. It is defined as follows:

$$S_i = \sum_{j=1}^{n} \lambda_{ij} \left[\left(\frac{E_{ij}}{\sum_{j=1}^{n} E_{ij}} \right) / \left(\frac{\sum_{i=1}^{m} E_{ij}}{\sum_{j=1}^{n} \sum_{i=1}^{m} E_{ij}} \right) \right] \tag{8}$$

where E_{ij} is output in industry j in region i, *n* and *m* are the numbers of industry and region respectively, λ_{ij} is an assigned weight to each industry *j's* relative prominence in the total industrial employment in region i. A higher value of S_i indicates a greater degree of specialization in region i.

Industrial diversity (div): to identify the impact of increased regional diversity of industries (Jacobs externalities), I construct this diversity variable following the work of (Gao, 2004; Henderson, 1997). Let $\varphi_{ij} = (y_{ij}/y_{i.})$ be industry j's share of the total industrial output in region i. y is the industrial output. I then subtract D_i from 1 to allow a higher value of it to reflect higher diversity. It is defined as follows:

$$D_i = 1 - \sum_{j=1}^{n} \varphi_{ij}^2 \text{ , } i\text{=1, 2, 3,…, n} \tag{9}$$

where D_i is the diversity index. The higher the value of D_i, the more diversified the regional industrial structure is in region i.

3.5.3.3 Control variable

Both firm level and regional level characteristics are taken into account when I try to examine the specific effect of explanatory variables, which is also in line with the argument that both firm and regional level features cannot be neglected in innovation researches (Wang and Lin, 2013; Zahra et al., 2014). I controlled possible effect of following firm features.

Firm R&D intensity (*frd*): R&D investment is found as one of the main drivers for firm R&D output, a large number of prior studies suggest that high R&D intensity will produce fruitful innovation output (Laursen and Salter, 2006). Unlike the international account reporting system, annual report of PLCs in China does not include R&D investment records. To overcome this deficiency, I followed the suggestion of Dong and Gou (2010) that "*Cash Paid for the Business Related Activities*" reported in firms' financial statement is equivalent to R&D investment in China. It includes the development and design cost, technology development cost and research cost. I therefore used the ratio of a firm's R&D investment against its sales as a proxy for the firm's R&D intensity.

Firm age (*age*): numerous empirical studies suggest that innovation is closely related to a firm age (Thornhill, 2006). Both firms' R&D investment and innovation highlight are varied in different phase of a firm's life cycle. I therefore used the number of years since the firm's establishment as a proxy for the firm's age.

Firm size (*size*): prior studies suggest that bigger firms have more resources to conduct R&D activities, large firms usually have ambitions to improve technology innovation capacity (Cohen and Klepper, 1996). I use the natural log of a firm's total assets at the end of fiscal year as a proxy of the firm's size.

Firm leverage (*leverage*): it is expected by prior studies that a high debt to equity ratio will impact on the R&D investment decisions as higher leveraging increases the likelihood of bankruptcy (Choi et al., 2012). I thus used the percentage of a firm's percentage of total debt over total equity as a proxy of the firm's leverage rate.

Firm return on asset (*ROA*): a firm with higher profitability is more likely to invest R&D resources in innovative activities (Choi et al., 2012), I thus used a firm's return on assets as a proxy of the firm's profitability.

Firm performance (*Tobin's Q*): it is reasonable to expect that a firm with better performance will invest more in innovation and set up long term R&D plan to establish or reinforce its competitiveness. I therefore follow prior studies and used a firm's market value of assets over thesis value of assets (Tobin's Q) as a proxy of the firm's performance (Talke et al., 2011).

Besides firm level features, regional characteristics that closely relate to innovative activities should be taken into account. Following prior studies as well as the empirical results regarding the determinants of regional innovation capability (see Chapter 5 for details), I control for possible effects of following regional features.

Regional human capital (*hrc*): the availability of human capital particularly the skilled labour force, is essential in enhancing regional innovation capability as they represent the regional capability to absorb and recognize external knowledge (Fu, 2008; Mankiw et al., 1992; Wang, 2010). I thus control for *regional human capital,* which is calculated as the ratio of residents with tertiary degrees divided by regional total inhabitants. Moreover, regional scale is closely related to innovative output as increasing returns to scale yield externalities (Feldman and Audretsch, 1999). To account for such impact, I use the natural logarithm of the number of total employees (*emp*) in a region as a proxy for the economic size of the region. I also expect that R&D activities thrive in regions with a high rate of economic and industrial growth (Rodríguez-Pose and Crescenzi, 2008) since regions with higher pace of development may attract more foreign and domestic investment for innovation and grow faster (Fu et al., 2011). I thus use regional GDP growth rate *(gdpg)* as a proxy to control for the effect of regional economic growth potential across regions and sectors (Cheung and Lin, 2004).

In summary, the definition, operationalization and data source of each variable are presented in Table 3.5 below.

Table 3.5 Definition and description of variables for firm level study

Variable name	Acronym	Operationalization	Data source
Firm patent	$patent_{i,t}$	Firm *i*'s patent count in year *t*	SIPO website
Firm R&D intensity	$frd_{i,t-1}$	Firm *i*'s R&D spending/sales in year *t-1*	CSMAR database
Firm age	$age_{i,t-1}$	Year *t* minus firm *i*'s establishment year	CSMAR database
Firm size	$size_{i,t-1}$	Nature log of firm *i*'s total assets at the end of fiscal year *t-1*	CSMAR database
Firm leverage	$leverage_{i,t-1}$	Firm *i*'s percentage of total debt over total equity in year *t-1*	CSMAR database
ROA	$ROA_{i,t-1}$	Firm *i*'s return on assets in year *t-1*	CSMAR database
Tobin's *Q*	$Tobin'sQ_{i,t-1}$	Firm *i*'s market value of assets over thesis value of assets in year *t-1*	CSMAR database
FDI intensity	$fdi_{i,t-1}$	Firm *i*'s regional FIEs' product value/total product value in year *t-1*	China Statistical Yearthesis
Specialization	$spe_{i,t-1}$	Firm *i*'s regional industrial specialization in year *t-1*, calculated using formula (1)	China Industry Economy Statistical Yearthesis
Diversity	$div_{i,t-1}$	Firm *i*'s regional industrial diversity in year *t-1*, calculated using formula (2)	China Industry Economy Statistical Yearthesis
Human capital	$hrc_{i,t-1}$	Firm *i*'s regional proportion of residents with a tertiary degree in year *t-1*	China Statistical Yearthesis on Science and Technology
GDP growth rate	$gdpg_{i,t-1}$	Firm *i*'s regional GDP growth rate in year *t-1*	Database of China Main S&T Index
Employment	$emp_{i,t-1}$	Nature log of firm *i*'s regional total employment in year *t-1*	Database of China Main S&T Index

3.6 Concluding remarks

In this chapter, I mainly focussed on the selection of appropriate methods for specific research questions. Firstly, an overview was made of the methodologies relevant to innovation studies. Then, according to the requirement of answering each specific research question and the advantages of existing methodology, the most suitable research method for each research question was selected. Moreover, I illustrated the process and procedures of searching and collecting data from various sources according to the specific research question. I hope that this chapter not only presents the research question but also demonstrates the logic of how this research was conducted using different research methods combining various data sources. As shown in Figure 3.1 in a preceding section, methodological concerns and data sources were integrated, with each corresponding specific research question, into the conceptual framework of this thesis. More importantly, by doing so, I aim to link the preceding chapter's literature review with the following three chapters in which the focus is answering specific research questions using the identified methods and datasets.

Chapter 4 Developmental path of RISs, IS and FDI in China

4.1 Introduction

In Chapter 1, I identified five research gaps in previous literature and made clear the core research question of this thesis. I elaborated the selection process of methods for this research, and documented the procedures and processes of collecting data for each specific research question within this thesis in Chapter 3. According to the research framework shown in Figure 3.1, in this chapter I will answer the first specific research question (RQ1), i.e. "*Why are FDI and IS two critical factors in a* ***regional*** *innovation system?*", through systematic analysis of the research background of this thesis at both national level and regional level. The focus is mainly on the developmental path/trajectory of the innovation system, IS and FDI, as well as key points of relevant policies in the Chinese context.

Although the literature repeatedly emphasises the importance and idiosyncratic features of China, a comprehensive examination of the development process and policy orientations of the innovation system, IS, and FDI are scarce. In this thesis, a systematic investigation of these aspects provides a solid basis and a understanding for the theoretical and empirical analyses in the following chapters (i.e. Chapter 5 and Chapter 6). Specifically, I investigate the developmental path of Chinese RISs, IS and FDI in the section 4.2, and conduct a comparative analysis of five regions, i.e. Beijing, Shanghai, Guangdong, Hubei, and Hunan, in respect to IS, FDI and regional IC in the section 4.3 of this chapter.

Table 4.1 Main features of Chinese RIS, IS and inward FDI in four phases during the last three decades (1978-2010)

	Phase I: 1978-1984	Phase II: 1985-1992	Phase III: 1993-2000	Phase IV: 2001-2010
Regional innovation system	• Government dominates S&T framework; • Military technologies oriented; • Research institutes are the main innovators;	• A series reform transform government from an organizer of S&T activities into a coordinator of R&D activities; • Many R&D programs are launched by both central and local government; • Plenty of National High-Tech Industrial Development Zones and science parks are established;	• Further reform enhances the role of firms as main innovator of RIS; • Research institutes are reformed as much more open to market competition; • Universities begin to play an increasingly important role in contributing regional innovativeness;	• R&D investment in terms of R&D expenditure and human capital experience a huge surge; • Patent applications register in SIPO increased dramatically; • Independent innovation capabilities and collaboration with external knowledge sources are highlighted in various policies;
Industrial structure	• Government is the organizer of national economies; • The primary industry is the key of economic development; • Share of manufacturing (secondary) industry in national GDP experiences a decrease; • The "*rural construction*" policy drives the configuration of	• Both manufacturing industry and services industry increase dramatically while the primary industry experiences a huge decrease; • Human capital mobilized from the agriculture industry to the manufacturing industry;	• Regional governments have more autonomy to decide the priority of the development of industrial structure; • Coastal regions have much better business environment than inland regions; • Inland regions have rich natural resources and	• Transition of regional industrial sectors from labor intensive to technology intensive; • Development of high technology industries are strongly encouraged by most regions;

	regional industrial structure in most Chinese regions;	• Eastern regions are the priority of economic development;	industrial structure in these regions become more energy based or labor intensive sectors;	• Though manufacturing industrial sectors are productive in most regions, the general R&D capabilities of regional industrial sectors are much lower than overseas encounters;
Foreign direct investment	• Foreign investment is encouraged by Chinese government since the implementation of the "Opening the door" policy; • A series of regions are set as special zones with highly opened environment for foreign investment; • Overseas' investment is not very big and most of FDI focuses on coastal regions;	• Basic legal system regarding to foreign investment is established; • A series of National Economy and Technology Development Zones have been established, in which FIEs can enjoy favorable policies and conveniences; • Most of coastal regions focus on attracting FDI, and the volume of foreign investment is increased;	• Deng Xiaoping's Southern Tour in 1992 summarized the experience of attracting FDI and inspired a increasing trend of foreign investment in China; • A series of inland cities, e.g., 17 province capitals, open to foreign investment; • Spectrum of opened industries is enlarged as foreign investments are approved in more sectors;	• China joined WTO in the end of 2001, meaning that industrial sectors are gradually opened to overseas' investment; • Both the volume and the quality of FDI (in terms of embedded knowledge for example) has been improved; • More inland regions are open to foreign investment, and general environment is much better;

Source: Compiled by the author.

4.2 Evolutionary analyses of RISs, IS and FDI in China

Table 4.1 above illustrates the main features of RISs, IS and FDI in each time phase, which provides some preliminary evidence and understanding of the relationships between RISs, IS and FDI in China.

4.2.1 Developmental path of Chinese innovation system

The literature contends that the innovation system in China is relatively weaker than that of developed countries due to the relatively short time span for technology accumulation, economic development, and technical strength (Fu and Mu, 2014; Gu et al., 2009; Huang et al., 2004; Huang et al., 2013; Motohashi and Yun, 2007; Sun and Liu, 2010). In this section, I investigate the developmental path of the Chinese innovation system from a perspective of strategic evolution which focuses on the change process of the Chinese innovation system using historical data. I thereby divided the evolution process of the Chinese innovation system into four phases as each of these phases has some idiosyncratic features.

Phase I: generation of Chinese innovation system (1978–1984)

In the early stage of the generation of S&T framework in China, various research institutes, e.g. the Chinese Academy of Sciences (CAS), were established with support of the central government. Most innovative activities were organised for the demands of national defence, i.e. in the development of military technologies (Xue, 1997). For instance, the orientation of high technology development in this phase was focused on high-energy physics, chemical physics, air space, and oceans, all of which were used for improving military strength. The successful development of the atomic bomb, missiles, and satellites (*liang dan yi xing*) is a remarkable signal of the improvement of

China's S&T capability in this phase, which not only enhanced the global prestige of China but also served as the solid basis for the development of novel technologies in following phases.

As the Chinese system was less developed, policy makers were able to directly intervene in the coordination, operation, and orientation of S&T organisations and activities: for instance most Chinese research institutes were subordinated to the government. Administrative organisations relevant to innovative activities would provide specific services for the R&D process. Moreover, innovation incentives within the Chinese system were motivated by central and regional governments' perceptions of the demands of social development, national economy, and national security. S&T development plans in this phase were mainly formulated by the central government, which was also the main investor of R&D expenditure. R&D resources, both expenditure and human resources, were strictly allocated by policy makers according to various plans or proposals.

In general, the Chinese innovation system in this phase is referred to as a government dominated innovation system (Xue, 1997). The advantages of this arrangement were threefold. Firstly, the central government was able to allocate a vast volume of R&D resources for significant technology innovation projects that were usually directly related to the urgent demands of social development and national security. Secondly, limited R&D expenditure and human capital could be efficiently allocated by the government according to the S&T development plan, and this mechanism avoided risks and waste caused by repetitive R&D investment in different regions. Finally, R&D outcomes could be efficiently applied as the government was the main organiser of innovative activities, which was helpful to enhance the technology transfer between different regions. The predominant role of government in S&T development activities in this phase was primarily due to the Chinese Communist Party (CCP) trying to establish socialism through socialist industrialisation (Xue, 1997). Specifically, the Chinese constitution highlights that the task of the CCP is to strategically develop the national economy and complete industrialisation as soon as possible, as well as significantly improve the level of modern industry, modern agriculture, modern transportation, and modern national defence (*si ge xian dai hua*). The administrative power of government was the basis for the implementation of the Chinese system in this period, which was manifested in three aspects: i.e. the government was the solely authority to propose S&T projects; the government had strong power to facilitate innovative activities; and the government was the main R&D investor.

Why was such an S&T framework adopted in this phase? Firstly, the overall S&T capability of China was very weak in this period (Liu and White, 2001). In order to fulfil the demands of social development, limited R&D resources should be exploited and allocated efficiently. In other words, integration of limited resources for urgent research projects is more reasonable than distributing these resources to other innovative activities. According to this principle, the "*National S&T Development Research Strategy (1956–1967)*" was proposed, which identified six categories with 57 significant R&D projects. The objective of this strategy was to try to introduce advanced technologies into the departments of science, national defence, production, and education, to catch up with the Soviet Union and other developed countries. Secondly, the unstable status of national security in this phase required the government to focus on the promotion of military related technologies. In order to reinforce the political regime of China, the central government had to play the predominant role in planning and organising S&T activities to ensure that those military-related R&D projects could be achieved in a short term. Meanwhile, the focus on R&D activities in the defence sector advanced the proportion of R&D investment in heavy industry, which fundamentally influenced the regional technological structure as well as the geographic position of R&D sectors in China (Huang et al., 2004). For instance, the Chinese central government implemented the policy of rural construction (*san xian jian she*) from 1964 to 1980, which stipulated that the south-western area and north-western area were primary areas for national investments and investments mainly focussed on the development of several key sectors, e.g. machinery, steel, energy. For instance, since the 1980s, Hunan has grown to become an essential centre for steel, machinery, and electronics production. In particular, it is a main recipient of the manufacturing sectors' transfers from coastal provinces, such as Guangdong and Zhejiang, and the province is noted for its stibnite mines and is one of the major centres of antimony extraction in China.

Although the administrative power-based S&T framework produced many significant R&D outcomes, disadvantages of this framework cannot be neglected. First of all, the focus of innovative activities was on the needs of government rather than on market demands. The direct outcome of this S&T framework was that most R&D resources were allocated to military technologies; the technological level of the production of daily used goods was relatively low. In other words, although the demands of daily consumption products were becoming diversified, R&D activities in these sectors were relatively weaker than in heavy industries. The innovative output in this phase lacked market value. Secondly, the channels of technology transfer from research institutes to industrial sectors were limited and inefficient. Collaboration between different sectors was scarce, and governments at different levels acted as the agent to generalise the R&D outcomes into industrial enterprises. Communication and coordination between sectors was based on administrative relations, which was detrimental for companies wanting to utilise R&D outcomes developed by research institutes. The overall circumstances of S&T development were not parallel with practical demands of production in business sectors and R&D activities did not facilitate companies' IC. Finally, business sectors had few incentives to conduct innovative activities. Companies, as a type of administrative organisation in the planned economic system, did not have autonomy to organise technological R&D activities and were unable to determine their products, prices, and profits as well as technology-related issues. Companies neither reaped the benefits from technology upgrades nor suffered the losses of the R&D failures. Moreover, due to the property rights of companies belonging to the state, state-owned organisations could take advantage of the R&D outcomes without charges. Inventors' property rights could not be realised in such circumstances.

Phase II: reform of the Chinese innovation system (1985–1992)

Reform and adjustment of S&T frameworks was the main feature of the Chinese system in this phase. A lot of policies and regulations were launched by both the central and regional governments in this phase. The predominant role of government had been transformed into a guide for coordinating innovators within a RIS (Huang et al., 2004; Xue, 1997). Although the S&T development mechanism in this period was based on planning, i.e. the "*National S&T Development Plan*", competition rules were introduced. This mechanism was developed in line with the essence of the "*Reform and Opening Up*" policy. The increasing autonomy of companies in the Chinese economy and the emerging role of the '*invisible hand*' (market regulation) was the background of this reform. The implementation of the "*National S&T Development Plan*" provided support for innovative activities, and research institutes played an important role in contributing innovation output to economic development (Huang et al., 2004). Although the S&T expenditure was arranged by the "*National S&T Development Plan*", central and regional governments still managed R&D resource deployment. In this phase, the Chinese government launched a series of S&T development programmes, for instance the "*National High-Tech R&D Programme*" (so-called '*863*' programme), "*Torch Programme*", "*Spark Programme*", "*Significant Outcome Generation Programme*", "*National Natural Science Foundation*", "*Climb Programme*", etc. (Huang et al., 2004). Meanwhile, in order to catch up with the global wave of high technology, China set up lots of science parks in coastal regions. Since the first high technology park – Shenzhen Science Industry District – was established in July 1985, a total of 114 Chinese National High-Tech Industrial Development Zones[14] have been established. Recent studies, for instance Huang et al. (2013) focus on the national independent innovation demonstration zone of East Lake in Hubei province, highlight that science parks facilitate regional technology development through various supportive policies for technology transfer. These science parks provide "*a source of knowledge spillovers, a mechanism for the technology transfer, and a catalyst for regional innovativeness*" (Link and Scott, 2007).

Moreover, government began to offer business sectors and enterprises more autonomous rights for their operations and innovation. Such efforts did not activate

[14] For details of the Chinese National High-Tech Industrial Development Zones, please refer to the website of the Ministry of Science & Technology of China, available at: http://www.most.gov.cn/gxjscykfq

companies' R&D incentives as the reform of corporate governance structures was at an early stage and opportunistic behaviours among managers frequently occurred. Specifically, although the state owned the enterprises, the state could not operate the enterprises by itself and thus needed to "*delegate their control to the enterprises' managers*" (Lin et al., 1998, p. 422). As the state could not directly oversee managerial behaviour, this left room for the managers to pursue a lot of shirking and on-the-job consumption.

In addition, a series of S&T regulations and policies were launched in 1987 and 1988 which emphasised two fundamental principles for the Chinese system. The first encouraged research institutes and universities to directly participate in economic activities via various channels, e.g. joint R&D efforts, start-up establishment, R&D outcomes commercialisation, etc., and to reshape their function as a scientific organisation open to domestic and foreign markets. The second idea was to support the promotion of S&T development organisations with various ownership models, e.g. collective-owned, private-owned, etc. This idea aimed to amplify the contributions of various R&D organisations for the NIS. Overall, the reform of the Chinese system not only released the potential of regional R&D capabilities but also increased the uneven distribution of economic strength.

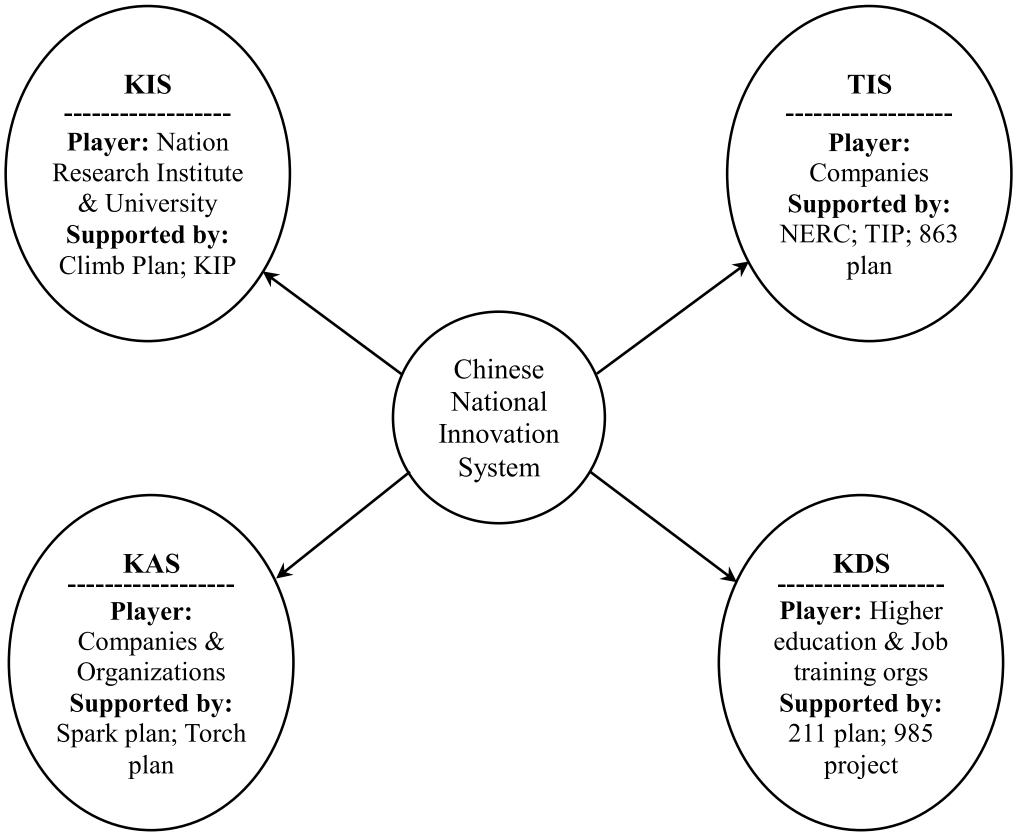
Phase III: development of the Chinese innovation system (1993–2000)

The main feature of the Chinese innovation system in this phase was that industrial enterprises began to play the main role as innovators. The remarkable reforms in corporate governance structures enabled Chinese companies to implement modern corporate structures, i.e. the separation between ownership and management, which motivated industrial enterprises to conduct R&D activities. The S&T management system at national level also changed as the S&T development plan was jointly determined by scientific and economic sectors, e.g. the National Engineering Research Centre, the National Engineering Technology Research Centre, and the Productivity Facilitation Centre (PFC), rather than solely determined by government. Such reform facilitated the commercialisation process of S&T products. In addition, the government implemented a series of strategies that focussed on the fundamental role of S&T in promoting national competitiveness and highlighted the importance of sustainable development strategy. Market demands became a primary driving force for S&T progress and an indispensable part of the innovation system, which meant that the objective of various innovative activities was to meet the increasing market demands.

According to the definition developed by the CAS in the report "*Construction of National Innovation System to Greet Knowledge Economic Era*", the Chinese NIS is a network system that contains organisations related to knowledge innovation and technology innovation; the RIS has a similar structure to the Chinese NIS. Business sectors, e.g. large enterprises and high technology enterprises (HTEs); research institutes, e.g. national, regional, and non-profit research organisations; and universities became the main components of the Chinese innovation system with the support from government and knowledge intensive business services (KIBS).

Specifically, according to the aforementioned report, the innovation system included four components. The knowledge innovation system (KIS) is a network system that contains organisations related to activities of knowledge generation, diffusion, and transfer. The core components of the KIS are national research institutes and first-tier universities. As the primary job of the KIS is to generate and transfer knowledge in the Chinese NIS, government, especially those science-related administrations, still play a dominant role in this subsystem. Similarly, the technology innovation system (TIS) is composed of organisations that are closely related to technological R&D activities. The core component of the TIS is industrial companies. The interactive effect between the KIS and TIS creates significant R&D outcomes and economic outputs for national economic and technological development.

In addition, the knowledge diffusion system (KDS) includes the higher education system and vocational training system. The primary function of KDS is to cultivate essential and valuable human resources with novel knowledge, high skills, and innovation capabilities. Knowledge and information diffusion infrastructure also play essential roles in the KDS. The primary function of the knowledge application system (KAS) is to generalise and commercialise the R&D outcomes developed in R&D activities with companies and other organisations as main components. Market mechanisms play the fundamental role in dominating the KAS while government proposes relevant laws, policies and regulations to provide a reliable institutional environment and encourages the development of high technology sectors and knowledge intensive service sectors. The framework of the Chinese NIS is illustrated in Figure 4.1 below.



Note: KIP is the Knowledge Innovation Project; NERC is the National Engineering Research Centre; TIP is the Technology Innovation Project.
Source: Compiled by the author based on the report of "*Construction of National Innovation System to Greet Knowledge Economic Era.*"

Figure 4.1 Framework of Chinese innovation system

Phase IV: development of the Chinese innovation system (2001–2010)

Given that the empirical analyses in Chapter 5 and Chapter 6 mainly focus on the period of 2000 to 2010, I particularly explored the key points of Chinese S&T policies after China entered the WTO in 2001 (a detailed summary of relevant policies or historical events is presented in Appendix 1). For example, I analysed the "*Eleventh National Five-year Plan (2006–2010)*" and "*Medium- to Long-Term Plan for the Development of Science and Technology (2006–2020)*" in which the Chinese government declared its objective to transform China into an '*innovative society*' by 2020 and become a leading innovator in global S&T by 2050.

First of all, the role of government in building an institutional environment for technology innovation was highlighted in various policies and regulations. As companies became the main player in R&D activities, government started to change its function from allocating R&D resources to providing a reasonable institutional context for innovators to conduct innovative activities. In addition, technology innovation projects became critical for both economic and social development. A third party, including representatives of companies, research institutes, universities, the National People's Congress (NPC), and government, it was suggested, should play a scrutinising role in the process of evaluating project applicants, i.e. companies, universities, and research institutes. This is helpful to make the granting process of S&T projects a transparent and fair matter. The highlight of this strand of policies is that the government became obligated to provide an institutional environment that is conducive to innovation. This requires the government to reduce those unnecessary regulations and institutional obstacles in the process of technology innovation.

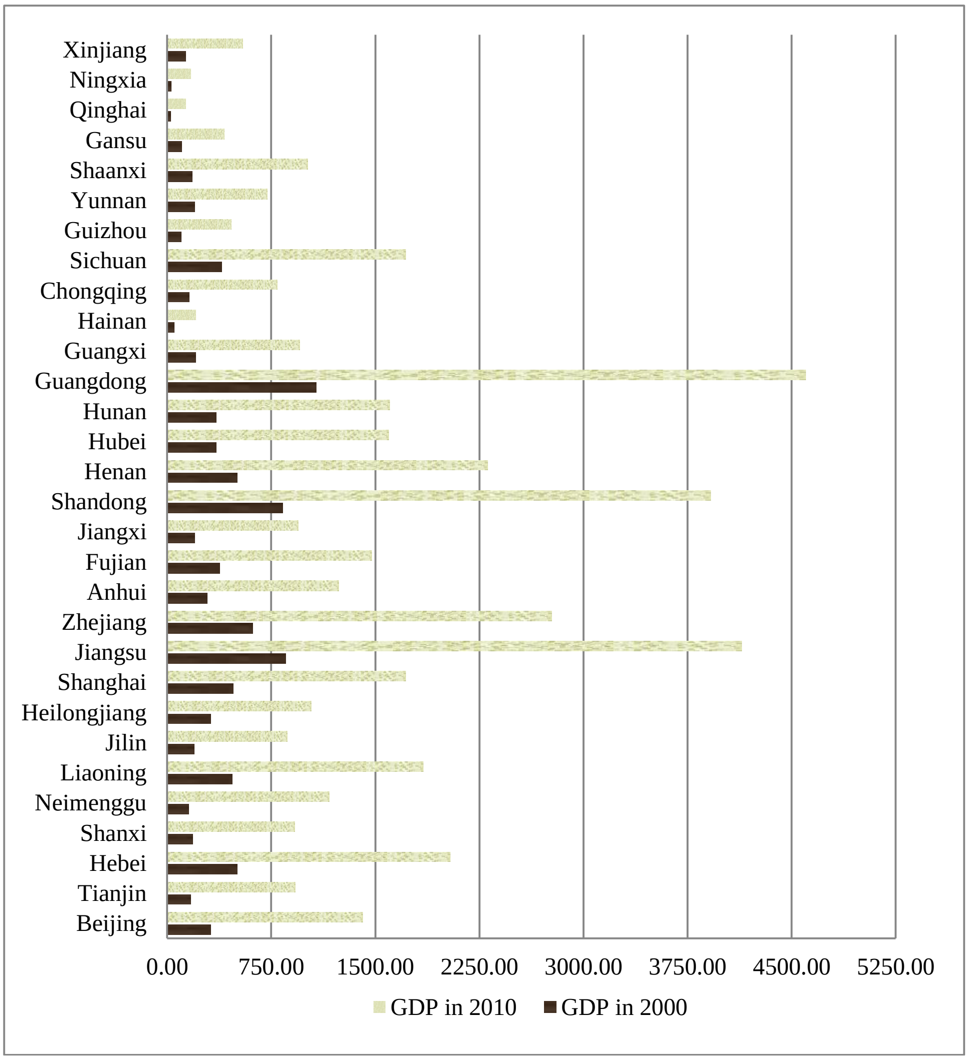
In addition, the government is aiming to establish a positive culture that can stimulate potential innovative passions for the whole society, especially to encourage innovations in business sectors, research institutes, and universities. Considering the resource constraints of the majority of innovators, the government will launch S&T development projects in which the collaborations between participants, e.g. companies, national institutes, and universities, can be promoted.

Table 4.2 Number of employees and average wage by province: 2000 and 2010

Province	Employee number[a] (2000) (1)	Employee number (2010) (2)	Change in Employee number (2)-(1) (3)	Average wage[b] (2000) (4)	Average wage (2010) (5)	Change in Average wage (4)-(5) (6)
Beijing	6221	13180	6959	16.35	65.68	49.33
Tianjin	4067	5210	1143	12.48	52.96	40.48
Hebei	34412	37900	3488	7.78	32.31	24.53
Shanxi	14191	16650	2459	6.92	33.54	26.63
Neimenggu	10166	11850	1684	6.97	35.51	28.53
Liaoning	18126	22380	4254	8.81	35.06	26.25
Jilin	10789	12490	1701	7.92	29.40	21.48
Heilongjiang	16350	17430	1080	7.84	29.60	21.77
Shanghai	6731	9250	2519	18.53	71.87	53.34
Jiangsu	35588	47320	11732	10.30	40.51	30.21
Zhejiang	27005	39890	12885	13.08	41.51	28.43
Anhui	33729	38470	4741	6.99	34.34	27.35
Fujian	16602	21810	5208	10.58	32.65	22.06
Jiangxi	19353	23060	3707	7.01	29.09	22.08
Shandong	46618	56550	9932	8.77	33.73	24.96
Henan	55717	60420	4703	6.93	30.30	23.37
Hubei	25078	31170	6092	7.57	32.59	25.02
Hunan	34621	40080	5459	8.13	30.48	22.36
Guangdong	38610	57770	19160	13.82	40.36	26.54
Guangxi	25304	29450	4146	7.65	31.84	24.19
Hainan	3337	4460	1123	7.41	31.03	23.62
Chongqing	16365	19120	2755	8.02	35.33	27.31
Sichuan	44358	49980	5622	8.32	33.11	24.79
Guizhou	20459	24020	3561	7.47	31.46	23.99
Yunnan	22954	28140	5186	9.23	30.18	20.95
Shaanxi	18128	19520	1392	7.80	34.30	26.50
Gansu	11821	14320	2499	8.56	29.59	21.03
Qinghai	2386	2940	554	10.05	37.18	27.13
Ningxia	2744	3260	516	8.59	39.14	30.55
Xinjiang	6725	8530	1805	8.72	32.36	23.64

Note: [a] the unit of employee number is 1,000 people; [b] the unit of average wage is 1,000 *yuan*.
Source: Author's calculations based on *China Statistical Yearthesis* (2001, 2011).

The reform of the RISs, however, led to economic discrepancy among Chinese regions. Table 4.2 above shows that Jiangsu, Zhejiang, and Guangdong witnessed a huge increase in labour force during the period of 2000 to 2010, indicating that the regional markets of these regions were much more prosperous than other regions. Besides these three coastal regions, most developed regions and central regions experienced a larger increase of employee numbers than less developed regions, such as Qinghai and Ningxia. The three columns on the right side of Table 4.2 illustrate the average wages in each region. Compared with less developed regions, e.g. Guizhou and Shanxi, etc., the developed regions, e.g. Beijing and Tianjin, had much higher levels of average wages and increases.



Note: unit of regional GDP is one billion *yuan*.
Source: Compiled by the author use the data collected from NBS.

Figure 4.2 Regional GDP of 30 regions in China (2000 and 2010)

Figure 4.2 above presents the GDP of each Chinese province and municipality in 2000 and 2010. The gap between different regions in terms of GDP, it can be noted, is much smaller in 2000 than that in 2010, indicating that the economic discrepancy of Chinese regions became much larger during the decade. Guangdong, Shandong, and Jiangsu were the top three regions with the highest level of GDP while Qinghai, Ningxia, and Gansu were the poorest regions. This fact indicates that the economic capability of developed regions is much stronger than those western regions.

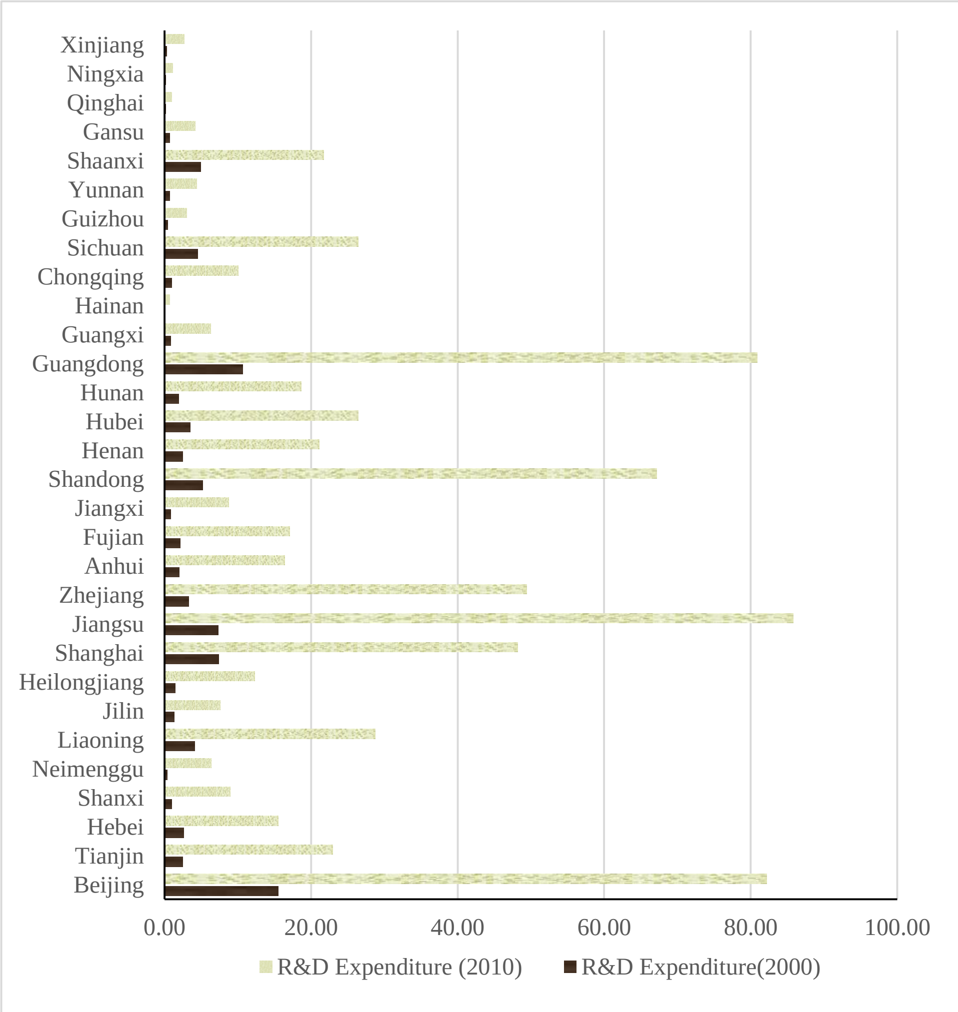
Table 4.3 Fixed assets investment and number of university teachers by province: 2000 and 2010

Province	Fixed assets investment[a] (2000) (1)	Fixed assets investment (2010) (2)	Change in Fixed assets investment (2)-(1) (3)	University teachers (2000) (4)	University teachers (2010) (5)	Change in University teachers (4)-(5) (6)
Beijing	151.33	540.30	388.96	105.15	133.87	28.72
Tianjin	70.50	627.81	557.31	25.95	45.19	19.24
Hebei	191.25	1508.34	1317.08	46.33	94.55	48.22
Shanxi	66.36	606.32	539.96	24.95	56.91	31.96
Neimenggu	50.36	892.65	842.28	19.23	36.44	17.21
Liaoning	142.12	1604.30	1462.18	61.71	93.18	31.48
Jilin	70.17	787.04	716.87	41.81	59.54	17.72
Heilongjiang	96.36	681.26	584.90	43.12	75.74	32.62
Shanghai	200.46	510.89	310.43	60.80	74.16	13.36
Jiangsu	282.32	2318.43	2036.11	78.85	158.65	79.80
Zhejiang	283.49	1237.60	954.11	35.08	79.79	44.70
Anhui	89.34	1154.29	1064.96	31.86	71.26	39.40
Fujian	117.29	819.91	702.62	21.83	58.66	36.83
Jiangxi	63.18	877.23	814.04	25.57	70.75	45.18
Shandong	278.87	2328.05	2049.18	54.91	139.10	84.19
Henan	154.41	1658.59	1504.18	44.38	110.43	66.05
Hubei	148.66	1026.27	877.62	72.27	123.49	51.23
Hunan	117.43	966.36	848.93	46.64	94.87	48.23
Guangdong	348.44	1562.37	1213.93	46.83	121.36	74.54
Guangxi	65.56	705.76	640.19	19.30	50.70	31.40
Hainan	21.33	131.70	110.37	3.85	12.36	8.51
Chongqing	69.70	668.89	599.19	24.97	48.36	23.39
Sichuan	161.75	1311.67	1149.92	46.09	100.50	54.41

Guizhou	53.60	310.49	256.89	14.88	29.72	14.84
Yunnan	73.85	552.87	479.03	19.85	39.68	19.83
Shaanxi	77.34	796.37	719.02	52.22	98.54	46.32
Gansu	46.04	315.83	269.80	16.56	32.87	16.31
Qinghai	19.64	101.69	82.05	4.23	6.68	2.45
Ningxia	19.11	144.42	125.31	4.00	9.17	5.18
Xinjiang	70.60	342.32	271.72	17.89	26.77	8.88

Note: [a] the unit of fixed assets investment is one billion RMB; [b] the unit of number of university teachers is 1,000 people.
Source: Author's calculations based on *China Statistical Yearthesis* (2001, 2011).

As Table 4.3 shows, fixed asset investment in developed regions, such as Zhejiang, Shandong, Guangdong, etc., is much higher than the investment in less developed regions, and volume of the increase in developed regions in terms of GDP per capital is also much larger than that in less developed regions. This fact implies that regional infrastructure of coastal regions was much better than inland regions, which may have boosted the development of the RISs. Table 4.3 also illustrates the top five regions, i.e. Beijing, Jiangsu, Shandong, Hubei, and Guangdong, and the bottom five regions, i.e. Qinghai, Ningxia, Hainan, Guizhou, and Guangxi, in terms of the number of university teachers, indicating that most higher education resources were assigned to developed regions rather than less developed regions The overall distribution of the number of university teachers implies that the discrepancies of regional human capital grew in this period.

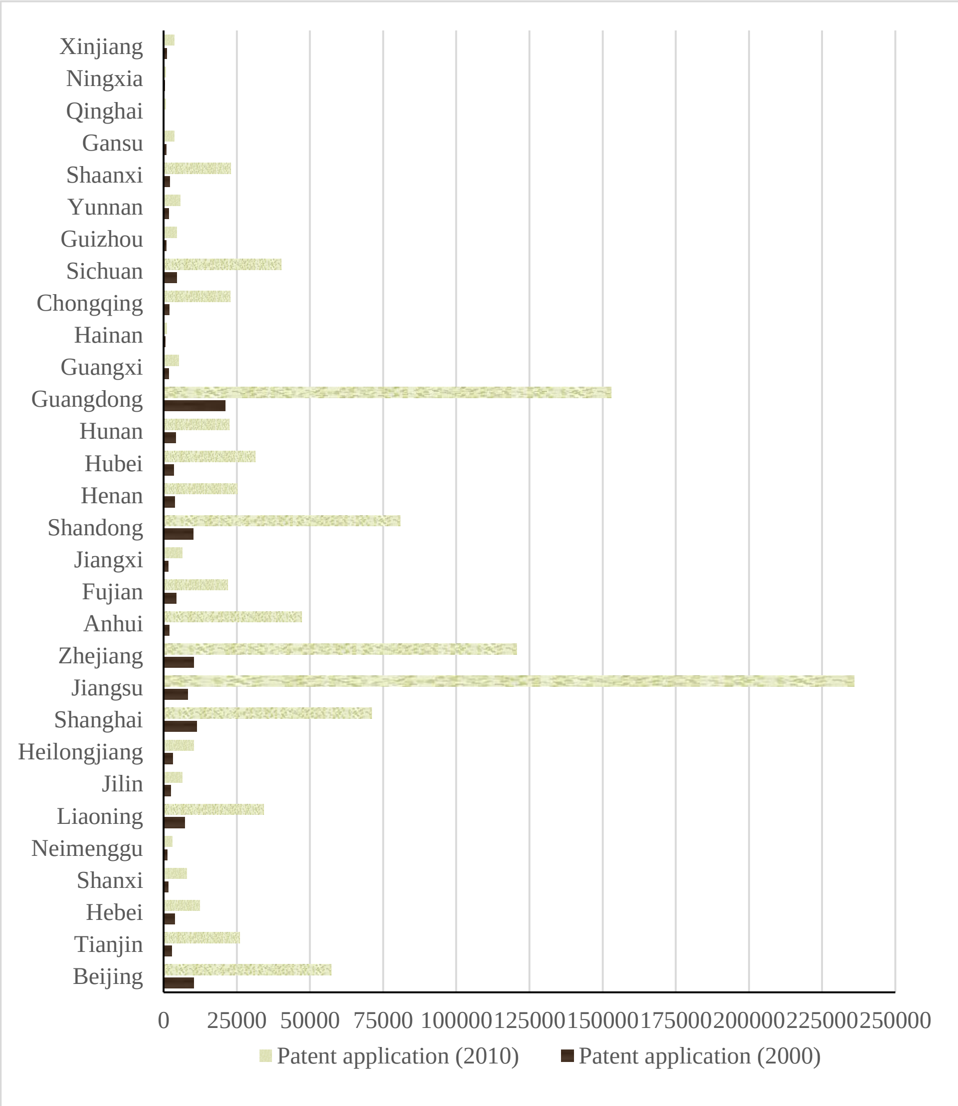


Note: unit of regional GDP is one billion *yuan*.
Source: Compiled by the author use the data collected from NBS.

Figure 4.3 R&D expenditure of 30 regions in China (2000 and 2010)

Figure 4.3 above shows the R&D investment of each of the Chinese provinces and municipalities in 2000 and 2010. Obviously, most regions invested very limited R&D expenditure in the year 2000; only Beijing and Guangdong invested over 10 billion RMB in innovative activities. This circumstance changed dramatically as six regions invested more than 40 billion RMB and 12 regions invested more than 20 billion RMB in R&D activities in the year 2010, indicating that the RISs in China experienced a huge boost during 2000 to 2010. However, most western regions, e.g. Xinjiang, Ningxia, Qianghai, Gansu, etc., still had little R&D expenditure (less than 5 billion RMB).

Secondly, policy makers have objectives to improve the protection level of IPR. Although patent registration procedures and assessment criteria were refined through learning from the experience of constructing IPR systems in developed countries, e.g. in the US and European countries, the effort of improving patent protection in China is important. Companies are reluctant to commercialise their in-house R&D outputs through patenting or licensing is due to the fact that IPR protection in China is relatively weaker than in other developed markets (Liang and Xue, 2010). For instance, the wide scope of piracy has become a serious problem that hinders the further development of the software sector in China (Wang et al., 2005). However, since China joined WTO at the end of 2001, IPR protection protocols have become severer and more detailed. The primary objectives are to reinforce the recognition of IPR among innovators, e.g. companies, research institutes, and universities. Additionally, government organises and supports those core inventors of advanced technologies to develop international technology standards and international trade rules. Scientific departments and industrial associations are required to propose specific regulations and policies that relate to the development of standardisation and support the utilisation of new national or international standards. Joint efforts between various innovators for developing and implementing key standards is strongly encouraged by policy makers, for instance for the surge of technological breakthroughs and standardisation activities in Chinese ICT sectors (Gao, 2014).



Note: unit of regional patent application is one piece.
Source: Compiled by the author use the data collected from NBS.

Figure 4.4 Number of patent applications of 30 regions in China (2000 and 2010)

As Figure 4.4 above shows, the number of patent applications of 30 regions increased dramatically during the last decade. Most Chinese regions in 2000 had very limited patent applications as none of them had more than 25,000 patent applications. However, in 2010, the total patent applications of three regions, i.e. Jiangsu, Guangdong, and Zhejiang, exceeded 100,000 and the number of patent applications in Jiangsu roared to over 225,000 which is much greater than in the other 29 regions. Comparing Figure 4.4 with Figure 4.3, it can be seen that regional R&D expenditure may not be the sole determinant of regional IC as some regions, for example Beijing and Jiangsu, had similar levels of R&D investment, yet the R&D output of these regions is significantly different.

Thirdly, the university–industry linkages have become keywords in a series of S&T policies. As China has made great efforts to establish first-tier universities since the late 1990s, the R&D capabilities of key universities, especially those supported by the '*211*' project and/or '*985*' project, have been improved dramatically during the last decade (Hong, 2008; Hong and Su, 2013). It is beneficial for companies to exploit research outcomes developed by universities, which is suggested as a useful complementary source of knowledge for the in-house R&D conducted by companies (Díez-Vial and Fernández-Olmos, 2014; Hong, 2008; Hong and Su, 2013). Meanwhile, as mentioned in a preceding section, as Chinese universities and research institutes are encouraged to participate in market activities, university–industry collaborations are prosperous in various forms, such as joint-R&D projects, joint ventures, and start-ups. Government is therefore required to play the role of catalyst in promoting such collaborations. For instance, joint ventures that set up by universities can enjoy tax subsidies. Additionally, domestic firms are encouraged to explore overseas advanced knowledge through various channels, for example, acquisition of foreign counterparts, setting up joint-venture companies overseas, and establishing R&D centres in foreign countries.

Fourth, policy makers highlight the importance of setting up RISs. The spatial discrepancies between coastal and inland regions in terms of economic and innovative capabilities have been realised by policy makers. Regional governments are required to propose strategic plans to improve regional innovativeness. How to amplify the contribution of innovators became a critical question for policy makers at the regional level. Meanwhile, given that both the scientific and economic bases of western regions were relatively weaker than eastern regions (Li, 2009), the central government proposed the strategy for the development in western regions in the "*Tenth National Five-year Development Plan (2001–2005)*" in 2000 and proposed specific strategies for the development in western regions in the "*Eleventh National Five-year Plan (2006–2010)*" in 2005. In addition, regional governments are suggested to focus on the establishment of high technology parks, especially for the development of breakthrough technologies. The demonstrative effect of SEZs, as shown in Table 4.4 below, needs to be further strengthened as a driving force for regional economic and innovative development.

Table 4.4 Three types of Special Economic Zones in China

Province	**City**	**Type**
Guangdong	Shenzhen	Special Economic Zone, City
Guangdong	Zhuhai	
Guangdong	Shantou	
Fujian	Xiamen	
Xinjiang	Kashgar	
Hainan	No city	Special Economic Zone, Province
Liaoning	Dalian	Coastal Development Areas
Hebei	Qinhuangdao	
Tianjin	Tianjin	
Shandong	Yantai	
Shandong	Qingdao	
Jiangsu	Lianyungang	
Jiangsu	Nantong	
Shanghai	Shanghai	
Zhejiang	Ningbo	
Zhejiang	Wenzhou	
Fujian	Fuzhou	
Guangdong	Guangzhou	
Guangdong	Zhanjiang	
Guangxi	Beihai	

Source: compiled by the author.

Last but not least, how to improve the comprehensive capabilities of KIBS is highlighted in relevant S&T policies. Because the current strength of these network agents is relatively weak, policy support is particularly directed to the development of KIBS in the form of the National University Science Park, the S&T Company Incubators Basis, the Productivity Promotion Centre, and the Technology Transfer Centre. The objective of KIBS in Chinese RISs is to formulate a networked S&T service agent system. Universities, research institutes, and various organisations are encouraged to play a prominent role in this service system, and government will increase resource investment to improve the professional level of network members in the service systems.

4.2.2 Development path of the Chinese regional IS

Industrial sectors are believed to be an important contributor to economic development and social progress. As analysed in a preceding section, the IS in China is unbalanced, i.e. most capital and human resources have been allocated to heavy industries as these sectors directly relate to the national defence capabilities. In order to promote the national economy, the regional IS has been adjusted and changed during the last three decades. I now analyse this dynamic changing process of the regional IS since 1978. According to the classification proposed by the NBS, an IS can be broadly classified as primary industry (includes agriculture, forestry, herd, fishery), secondary industry (includes mining, manufacturing, electrical power, heating power, gas and water production, construction), and tertiary industry (includes service sectors and sectors that neither belong to the agriculture industry nor the manufacturing industry).[15]

Phase I: development of the primary industry (1978–1984)

The main feature of the dynamic changing process of the IS in this phase is that the

[15] For details, please refer to the introduction of Chapter 3 as well as the website of NBS, available at: http://www.stats.gov.cn/tjsj/tjbz/201301/t20130114_8675.html

proportion of primary industry against national GDP increased dramatically while the share of the secondary industry decreased rapidly. This is mainly because food supply was a critical problem in this phase, i.e. market demand of agricultural products was great and urgent. Against this background, with the introduction of the "*Reform and Opening Up*" policy in 1978, the proportion of primary industry accounted for approximately 28%.[16] This figure increased by 4.1%, reaching 32.2% at the end of 1984. In contrast, the share of the secondary industry dropped from 48.2% in 1978 to 43% in 1984, and the proportion of the tertiary industry was 23.7%, which only increased 1.1% during this phase. These remarkable changes indicate that a series of policies launched by the central and regional governments were very helpful in facilitating the potential of primary industry. Implementation of these policies enhanced the adjustment of the regional IS in China to a more balanced configuration as the gap between the primary industry and secondary industry was much smaller than in the pre-reform period (1949–1977). For instance, the textile industry was a priority in the development strategy: an increasing investment in this sector provided more market demanded products, which facilitated social development.

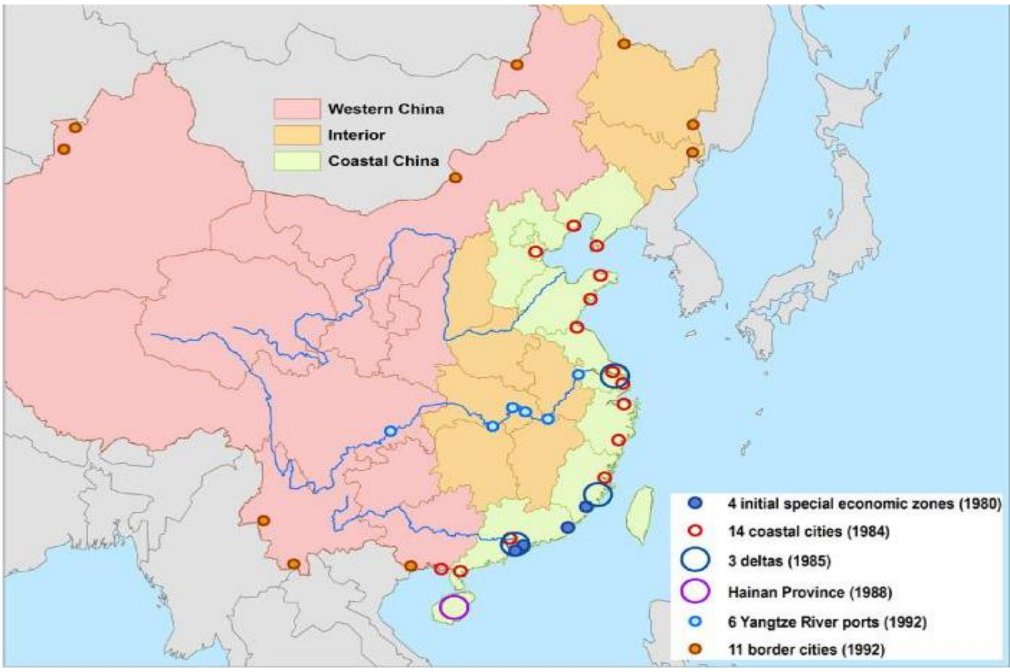
Phase II: development of the secondary and tertiary industries (1985–1992)

The sharp growth of the manufacturing industry and the services industry in terms of the proportion of GDP is the main feature of industrial adjustment in this phase. For instance, the share of the secondary industry increased from 44% in 1985 to 48% at the end of 1992, which means that the secondary industry contributed nearly half of the entire GDP of China in this period. Meanwhile, the proportion of the tertiary industry increased 4% from 25% in 1985 to 29% in 1992; however, the share of the primary

[16] The data reported in this chapter was collected or calculated from various issues of the "*China Statistical Yearthesis*".

industry decreased 8% from 31% to 23% in this period. This result of dynamic change indicates that the national focus of industrial development shifted from the agriculture sector to the manufacturing sector which resulted in huge mobility of human capital from the agriculture industry to the manufacturing industry as well (Wang and Yao, 2003). Moreover, as market demands were increasingly diversified in this period, the development of the secondary industry also facilitated the promotion of the service sector (the services industry) as well.

It is well known that the "*Reform and Opening Up*" policy kicked off the significant transition of the Chinese economic regime from a central planned economic system to a market-oriented economic system. The IS at a regional level is largely dependent on policy orientations. Specifically, at the beginning of the "*Reform and Opening Up*" policy in 1980, the central government proposed the "*Sixth Five-year Development Plan (1981–1985)*" which confirmed that national economic development needed to intensively take advantage of the technology edges of coastal regions and make great effort to reinforce these technology advantages. A series of preferential policies were proposed to support the promotion of coastal regions. The "*Seventh National Five-year Development Plan (1986–1990)*" further proposed that the national economic structure in China can be divided into three special economic areas (see Figure 4.5 below): i.e. eastern area (including Liaoning, Hebei, Tianjin, Beijing, Shandong, Jiangsu, Shanghai, Zhejiang, Fujian, Guangdong, Guangxi, and Hainan); central area (including Heilongjiang, Jilin, Neimenggu, Shanxi, Anhui, Jiangxi, Hubei, Hunan, and Henan); and the western area (including Sichuan, Guizhou, Yunnan, Tibet, Shannxi, Gansu, Qinghai, Ningxia, Xinjiang, and Chongqing). It also pointed out a strategy using the advantages of the eastern area to promote the economic and technical development of the central and western areas.



Source: extract from online source (http://www.hugchina.com/china/facts/chinese-economy/special-economic-zones-of-china-2010-11-01.html).

Figure 4.5 Geographic distributions of special economic areas in China

One plausible reason for this division was that although the economic capability of the eastern areas was the strongest, the central and western areas had much more natural resources. Therefore, one of the key points of the "*Seventh National Five-year Development Plan (1986–1990)*" suggested prioritising economic development of the eastern areas while development of energy and raw materials sectors in the central regions would be supported. Typical privileging policies for the development of the eastern areas included two facets. Firstly, the central government set up four SEZs, i.e. Shenzhen, Zhuhai, Shantou, and Xiamen, and opened 14 coastal cities[17] as Coastal Line Economic Development Zones, where industrial companies could enjoy various

[17] In 1984, China opened 14 other coastal cities to overseas investment (listed from north to south): Dalian, Qinhuangdao, Tianjin, Yantai, Qingdao, Lianyungang, Nantong, Shanghai, Ningbo, Wenzhou, Fuzhou, Guangzhou, Zhanjiang, and Beihai. For more details, please refer to the website of Wikipedia, available at:
http://en.wikipedia.org/wiki/Special_Economic_Zones_of_the_People's_Republic_of_China

favourable policies or regulations. Secondly, the share of national total investment of eastern areas was increased dramatically during the period 1980–1995. For instance, the total fixed assets investment in the eastern areas reached 121.88 billion RMB in 1995, which accounted for over 62% of total fixed assets investments in China.

Overall, policy orientation during the period of 1978 to 1995 made the eastern areas a top priority for regional development. The development of coastal regions was closely related to those policies that focussed on regulating market orders, improving resource allocations, and establishing SEZs. The adjustment of the IS at provincial level, I find, was correlated with the central or regional governments' activities (influence of various policies), for example the promotion of dramatic improvements of the eastern regions' economic and innovative capabilities. More importantly, the prosperity of these coastal regions was an essential driving force that facilitated the restructuring of the IS and economic development of inland regions. For instance, the advanced knowledge absorbed by companies located in coastal regions from foreign investment or overseas knowledge sources could be transferred into inland regions through various channels, e.g. joint S&T projects, skilled worker mobility, etc. (Hong, 2008). The externalities of the development of eastern area is one of the key ideas of the "*Reform and Opening Up*" policy in which Deng Xiaoping emphasised that the strategy of national economic development is to initially support the development in some regions with (economic and/or technical) advantages which then allows these successful regions to help those less developed regions to make economic improvements (*xian fu dai dong hou fu*).

Phase III: further development of the tertiary industry (1993–2000)

Generally, the rapid development of the energy sector, transportation sector, and information and communications equipment sector are the main features of industrial adjustment in this period. In this phase, the policy orientation of the Chinese government had shifted from focussing on the development of the eastern areas to supporting the development of the central and western areas (in 1995). The NPC approved the "*Ninth National Five-year Plan (1996–2000)*" which systematically illustrated the development strategy and the direction of the adjustment of the IS at regional level. In general, the resource-based projects and infrastructure-related projects would be preferentially allocated in the central regions and western regions in order to improve regional social and economic environments. Relevant regulations and policies were implemented to support the transfer of natural resource processing industries and labour intensive industries from coastal regions to central and western regions. The pricing system of energy-related products was refined to make sure that energy industries located in inland regions would not be impeded by unreasonable pricing mechanisms. Moreover, according to the "*Ninth National Five-year Plan (1996–2000)*" the government encouraged more foreign investment into those less developed regions either by providing tax reduction stimulus or financial subsidies.

More essentially, given that the technological capabilities of coastal regions were much stronger than those of inland regions, policy makers began to encourage and support the inter-regional R&D collaborations between innovators located in coastal regions and inland regions. A following and related policy, which was proposed at the 15^{th} CCP National Congress (1997), further pointed out that both domestic and foreign investors were strongly encouraged to invest in the central and western areas, and joint economic collaborations between companies located in less developed regions and developed regions would be continually supported by relevant regulations and policies. Regional governments, especially in those less developed provinces, were required to improve regional attractiveness through the promotion of institutional environment and administration efficiency for the development of the regional economies.

Phase IV: strategic adjustment of the IS (2001–2010)

Since China joined the WTO, increasing foreign investment has poured into the Chinese market. Chinese industrial companies or manufacturers are usually located at the low end of value chains with limited profits (Gao and Liu, 2012; Guo et al., 2013). The focus of industrial structural adjustment for each region shifted toward transforming a labour intensive and traditional sector structure into a high technology and knowledge intensive sector structure. As analysed in a preceding section, S&T policies in this phase were focussed on the question of how to improve indigenous firms' technological capabilities, especially in building up independent innovation capacity. These S&T policies were closely related to the strategic adjustment of the IS as companies' IC became an essential determinant of the technology level at which they operated. The output of the Chinese manufacturing industry accounted for nearly 6% of global manufacturing output while the R&D investment of the manufacturing industry accounted for less than 0.3% of global R&D investment in 2008. A potential reason for this phenomenon is due to the fact that most Chinese manufacturers are only '*producers*' rather than '*innovators*' as the core technologies of productive activities were imported from foreign sources (Abrami et al., 2014).

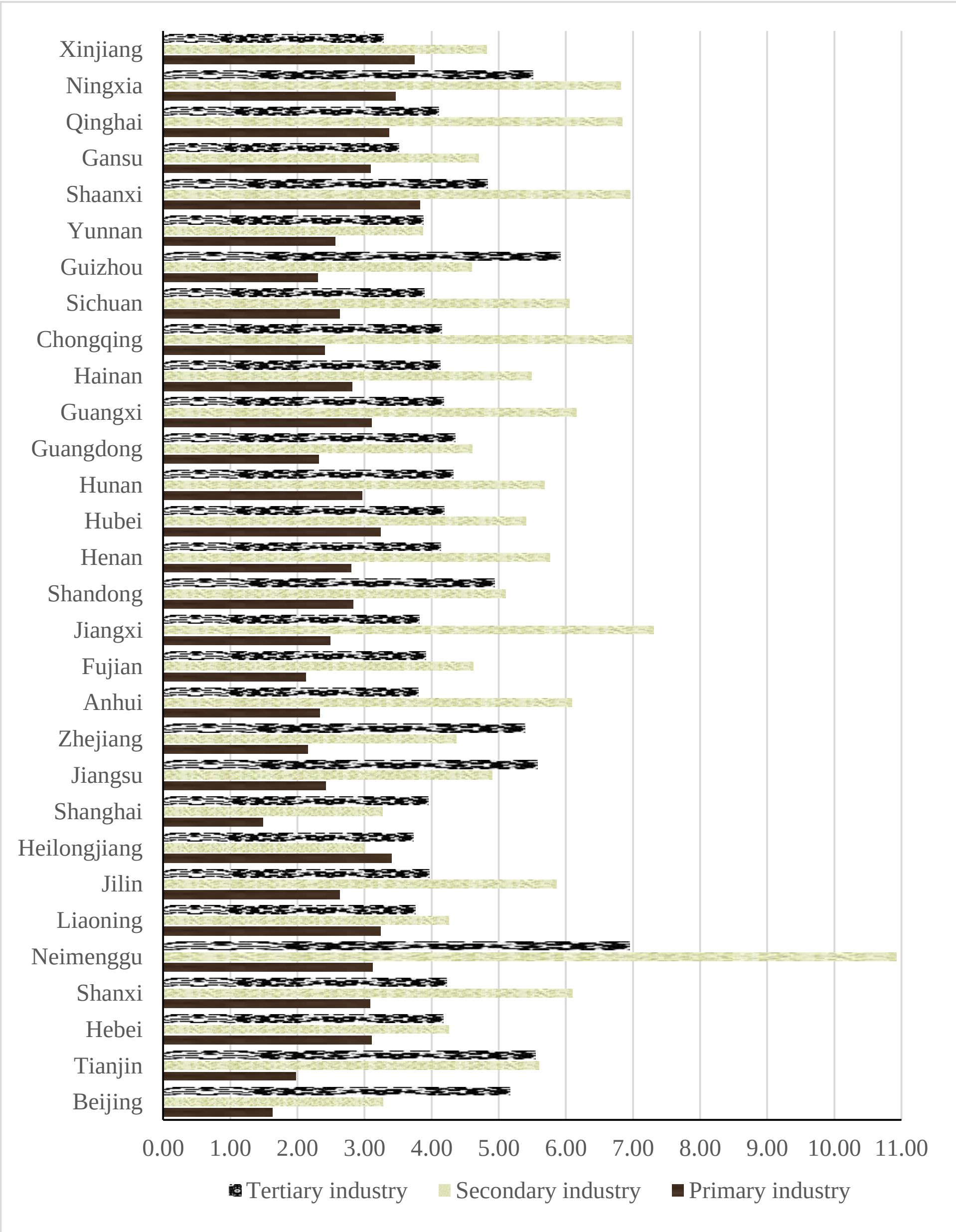
Table 4.5 GDP of three types of industry by province: 2000 and 2010

Province	Primary industry[a] (2000) (1)	Primary industry (2010) (2)	Secondary industry (2000) (3)	Secondary industry (2010) (4)	Tertiary industry (2000) (5)	Tertiary industry (2010) (6)
Beijing	7.658	12.436	103.329	338.838	205.113	1060.084
Tianjin	7.369	14.558	86.383	484.023	76.436	423.865
Hebei	82.455	256.281	251.496	1070.768	170.445	712.377
Shanxi	17.986	55.448	85.837	523.4	80.749	341.238
Neimenggu	35.08	109.528	58.257	636.769	60.574	420.902
Liaoning	50.34	163.108	234.44	997.682	182.12	684.937
Jilin	39.873	105.015	76.889	450.631	78.389	311.112
Heilongjiang	38.315	130.29	173.17	520.411	103.655	386.159
Shanghai	7.668	11.415	220.763	721.832	248.686	983.351
Jiangsu	104.834	254.01	443.589	2175.393	306.946	1713.145
Zhejiang	63.098	136.056	327.393	1429.793	223.612	1206.382
Anhui	74.177	172.902	105.678	643.662	110.354	419.368
Fujian	64.057	136.367	162.845	752.283	149.552	585.062
Jiangxi	48.514	120.698	70.076	512.288	81.717	312.14
Shandong	126.857	358.828	416.445	2123.849	290.445	1434.314
Henan	116.158	325.809	229.415	1322.638	159.726	660.789
Hubei	66.23	214.7	143.738	776.724	144.571	605.337
Hunan	78.492	232.55	129.318	734.319	147.339	636.927
Guangdong	98.632	228.698	499.951	2301.453	475.542	2071.155
Guangxi	53.87	167.506	73.276	451.168	80.858	338.311
Hainan	19.2	53.983	10.397	57.1	23.085	95.367
Chongqing	28.487	68.538	62.383	435.912	69.446	288.108
Sichuan	94.558	248.289	143.311	867.218	154.951	603.041
Guizhou	27.12	62.503	39.12	180.006	36.752	217.707
Yunnan	43.18	110.838	83.325	322.349	74.614	289.231
Shaanxi	25.822	98.845	78.258	544.61	76.32	368.893
Gansu	19.41	59.928	42.165	198.497	43.713	153.65
Qinghai	4.012	13.492	10.883	74.463	11.473	47.088
Ningxia	4.603	15.929	12.143	82.791	12.756	70.245
Xinjiang	28.818	107.863	53.758	259.215	53.78	176.669

Note: [a] the unit of GDP of each type of industry is one billion RMB.
Source: Author's calculations based on *China Statistical Yearthesis* (2001, 2011).

As Table 4.5 illustrates, the general trend of these three types of industry in each Chinese region is upward. Most eastern regions, e.g. Shandong and Guangdong, and some central regions, e.g. Henan and Hubei, have much higher levels of GDP in each industry than that of western regions, such as Qianghai and Ningxia. On the other hand, I notice that the different regions have different areas of focus in terms of the development of these three types of industry. For example, Beijing became more reliant on the services industry as the GDP of its agriculture industry and manufacturing industry were much less than that of its services industry in 2010. In Xinjiang, however, the difference between the three types of industry was much less pronounced and the manufacturing industry was the strongest industry.

Although China has maintained a high speed of economic development, adjusting and transforming the existing IS from dependence on traditional and labour intensive sectors to focussing on high technology and knowledge intensive sectors is a critical factor which policy makers need care about (Abrami et al., 2014). The adjustment of the IS of each region is strategically designed rather than focussing on benefit in the short term. Product innovation is critical for achieving this objective as it enables manufacturers to reap benefits of competitiveness in both domestic markets and overseas markets. Market exploitation and exploration is complementary to companies' R&D activities; successful commercialisation of independent innovation output is an impetus for improving the industry's technology level (Bauer and Leker, 2013). The proportion of the agriculture industry in the whole IS needs to be controlled at a reasonable level, and it is urgent to improve both the quality of agriculture product and the efficiency of the agriculture industry, for example to enhance technical levels of agricultural equipment. Moreover, it is very important to attract foreign investors to set up manufacturing bases in various industries, which can serve as a facilitator for the upgrading of the domestic IS (Ge, 2009). Development of emerging manufacturing sectors and upgrading of existing industrial sectors are supported by regional governments through various encouraging policies and regulations.



Source: Compiled by the author use the data collected from NBS.

Figure 4.6 Growth rate of three types of industry by regions in China (2000 and 2010)

As shown in Figure 4.6, the growth rate of the secondary industry is much higher than that of the primary and tertiary industries in most central and western regions, for instance Neimenggu, Shanxi, Chongqing, Anhui, etc. But I find that the growth rate of the services industry in most developed regions, e.g. Beijing, Shanghai, Jiangsu, Zhejiang, etc., is even greater than the growth rate of the manufacturing industry. This interesting finding indicates that the focus of the IS in different regions is not the same:

this fact is in line with the analysis in a preceding section that Chinese regions experienced industry transfer during the last decade as manufacturing plants originally located in coastal regions moved to inland regions to pursue lower labour and land costs. Relevant sectors of the services industry will be broadly opened to private investors; regulations are needed to ensure a fair and reasonable competition context. As Figure 4.6 shows, the tertiary industry is the most attractive sector which needs much more investment to support its development. Emerging service industries, e.g. the tourist industry, real estate sector, community service sector, etc., can be new facilitators for economic development.

4.2.3 An overview of inward foreign investment in China

Prior studies point out that China became the most attractive destination for FDI in the last decade. Indeed, China has made a series of efforts to increase its openness to overseas investors, and meanwhile proposes lots of policies and regulations to attract FDI to support the development of the domestic economy. Although the benefits and impacts of FDI in China have been examined in some prior studies, little is known about the general development path of FDI in China. More importantly, identifying the characteristics that can be draw from the upward trend of FDI in China during the last three decades is interesting and essential, particularly for the exploration of the role of foreign presence in the Chinese regional and firm innovation system. In addition, few attempts have offered an analysis of a general framework of foreign investment related policies in the Chinese context. Therefore, an overview of not only the features of foreign investment trends in China but also the key points of relevant policies since 1978, the year China began to implement the "*Reform and Opening Up*" policy, is documented in this section.

Phase I: initial stage of the "Reform and Opening Up" policy (1978–1985)

It is not surprising to highlight the Third Plenary Session of the Eleventh Central Committee of the CCP held in 1978 because the central government made a series of '*opening up*' policies and confirmed the reform direction for the following decades. The foundation from the legal perspective of attracting foreign investment was confirmed as the central government promulgated the "*Sino-Foreign Joint Venture Enterprise Law of the People's Republic of China*" in 1980, providing reasonable and practical guidance for foreign investors to invest in China. As mentioned in a previous section, the central government identified four coastal cities, Shenzhen, Zhuhai, Shantou, and Xiamen, as the SEZs which played a role in demonstrating the degree and format of openness in the Chinese market. Six years later, another 14 coastal cities, i.e. Dalian, Qinhuangdao, Tianjin, Yantai, Weihai, Qingdao, Lianyungang, Nantong, Shanghai, Ningbo, Wenzhou, Guagnzhou, Zhanjiang, and Beihai, were opened to overseas investors (see Figure 4.6 for details of geographic position of the coastal cities). These 14 cities, located from the north of China to the south of China, constituted the frontier areas for foreign investment.

Indeed, the opened coastal cities played an important role in attracting foreign investment and contributing to economic development. For instance, the total industrial output value of the 14 coastal cities reached 201.59 billion RMB which accounted for 21.8% of national output value by the end of 1985. Although the number of selected cities is relatively small, all were far more developed than other inland regions in terms of economic strength. The '*opening up*' process of these coastal regions signalled that China welcomed foreign investment, and more importantly, that overseas investors could feel comfortable to conduct business in these cities which therefore encouraged greater foreign investment in the next phase. In general, a total of 8,355 FIEs were established during the period of 1980 to 1985 with an average annual investment of 1.2 billion USD. Although the amount of foreign investment was limited in this phase, the benefits and experience accumulated of attracting FDI in this period encouraged the Chinese government to transform China from a closed economic and innovative system into an opened system.

Phase II: further implementation of the "Reform and Opening Up" policy (1986–1992)

Based on the experience accumulated in the prior phase, a series of policies, regulations and laws were promulgated in this phase. For instance, the State Council issued the "*Regulations Regarding the Encouragement of Foreign Investment*". The legal system of foreign investment was established in this phase, which provided more specific guidance and introductions for foreign business activities in China. Meanwhile, in 1985, learning from the experience of developed countries, like Silicon Valley in the US, the State Council approved a proposal to establish a National Economy and Technology Development Zone in which FIEs could enjoy both favourable policies and clustered economies. In addition, the State Council stipulated Shandong Peninsula and Liaotung Peninsula, which are two coastal areas in northern China, as Open Coastal Economic Areas; approved Hainan province setting up the Hainan SEZ in 1988; and then opened Pudong district in Shanghai in 1990. All of these policies and regulations are in line with the essence of the "*Reform and Opening Up*" policy. And the investment environment of these opened regions improved significantly, which attracted much more foreign investment than in the prior phase. For instance, a total of 35,706 FIEs were approved to set up with an average annual investment of 3.5 billion USD during this period.

Phase III: further development of the 'opening up' trend (1993–2000)

It is worthy to mention the speech by Deng Xiaoping in early 1992, which systematically summarised the experience accumulated in the process of implementing the "*Reform and Opening Up*" policy in prior phases and highlighted the importance of further development of domestic economy through the '*opening up*' of more regions, especially inland regions. Meanwhile, as the socialist market economy system was confirmed as the basic economic regime in China, the central government decided to further open five riverside cities, i.e. Chongqing, Wuhan, Yueyang, Jiujiang, and Wuhu, and 17 inland provincial capital cities.[18] In other words, the trend shifted from coastal regions to the central and western regions in this phase.

This strategic change process not only facilitated inland regions to exploit benefits of foreign presence, but also allowed the host market to grant access to both foreign and domestic companies. Obviously, the further development of the trend stimulated a huge increase of foreign presence in this phase. For instance, the amount of foreign investment in 2007 exceeded the total amount of FDI in the previous 13 years. Meanwhile, in the IS, foreign investment became much diversified than in earlier years, with a dramatic increase of the volume of foreign investment. In general, the spectrum of foreign investment was enlarged from simple processing to information technology and biotechnology related industries, and from labour intensive sectors to capital or technology intensive sectors. This phenomenon is in line with the argument of Luo

[18] The State Council approved 17 inland capital cities as cities open to overseas investment in 1992. These 17 cities are Hefei, Nanchang, Changsha, Chengdu, Zhengzhou, Taiyuan, Xian, Lanzhou, Yinchuan, Xining, Wulumuqi, Guiyang, Kunming, Nanning, Haerbin, Changchun, and Wuhehaote.

(2003) that an essential motivation of foreign investment is to exploit its asset advantages in host markets. Overall, a total of approximately 320,000 FIEs were established with an average annual investment of 35.9 billion USD during this period.

Phase IV: new development in the WTO period (2001–2010)

Before joining the WTO at the end of 2001, China had made efforts toward this objective for more than 15 years. Existing literature contends that the WTO entrance had a fundamental effect on the degree of openness in China (Cheung and Lin, 2004; Hu and Jefferson, 2009; Huang et al., 2004; Liu, 2005a). The mode or mechanism of the '*opening up*' trend in China changed from selectively opening to foreign investors to comprehensively opening to overseas investors. In prior phases, the processes and extent of openness largely depended on the regulations promulgated by policy makers, whilst the scope and timetable of '*opening up*' has been driven by WTO regulations since 2002. Both the volume and the quality of FDI (in terms of embedded knowledge, for example) has improved since China joined the WTO (Hu and Jefferson, 2009). The investment environments of both coastal and inland regions have been upgraded. For instance, the institutional barriers of import and foreign investment have been largely removed since China joined the WTO. The average tariffs on imports declined 6.3% from 16.4% in 2000 to 10.17% in 2006.

Table 4.6 Export and import by province: 2000 and 2010

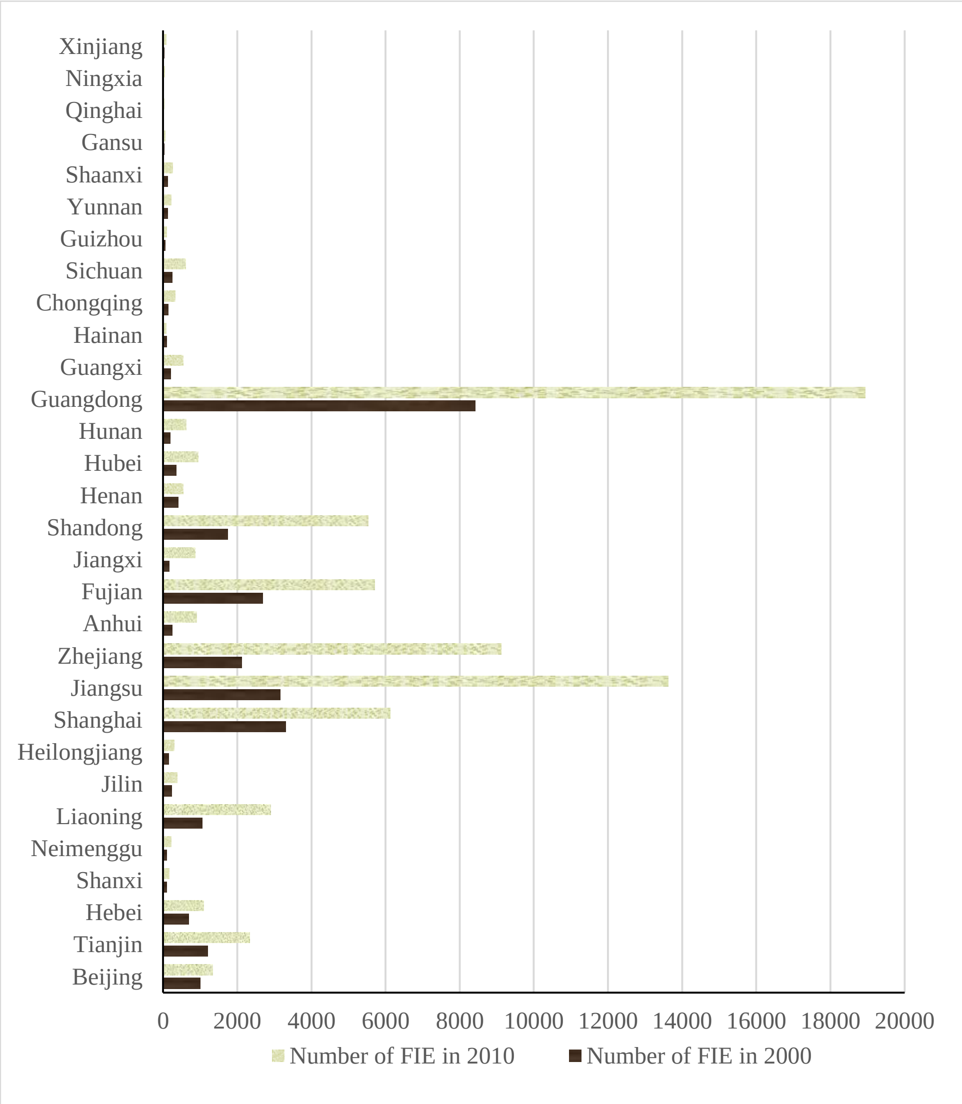
Region	Export value[a] (2000) (1)	Export value (2010) (2)	Export change (2)-(1) (3)	Import value (2000) (4)	Import value (2010) (5)	Import change (5)-(4) (6)	Export surplus (2000) (1)-(4) (7)	Export surplus (2010) (2)-(5) (8)
Beijing	11.97	55.44	43.47	37.65	246.29	208.63	-25.69	-190.85
Tianjin	8.63	37.48	28.86	8.53	44.62	36.09	0.10	-7.13
Hebei	3.71	22.56	18.85	1.53	19.50	17.98	2.18	3.05
Shanxi	1.24	4.70	3.47	0.53	7.87	7.35	0.71	-3.17
Neimenggu	0.97	3.33	2.36	1.65	5.40	3.74	-0.68	-2.06
Liaoning	10.86	43.10	32.24	8.18	37.61	29.44	2.68	5.49
Jilin	1.26	4.48	3.22	1.31	12.37	11.06	-0.06	-7.89
Heilongjiang	1.45	16.28	14.83	1.54	9.23	7.70	-0.08	7.05
Shanghai	25.35	180.71	155.36	29.36	188.24	158.88	-4.00	-7.52
Jiangsu	25.77	270.54	244.77	19.87	195.26	175.39	5.90	75.28
Zhejiang	19.44	180.46	161.02	8.39	73.07	64.68	11.05	107.39
Anhui	2.17	12.41	10.24	1.17	11.86	10.69	1.00	0.55
Fujian	12.91	71.49	58.59	8.31	37.29	28.98	4.59	34.20
Jiangxi	1.20	13.42	12.22	0.43	8.20	7.78	0.77	5.21
Shandong	15.53	104.23	88.70	9.46	84.93	75.47	6.07	19.29
Henan	1.50	10.53	9.03	0.79	7.30	6.52	0.71	3.23
Hubei	1.94	14.44	12.51	1.29	11.49	10.20	0.65	2.95
Hunan	1.65	7.96	6.30	0.86	6.70	5.84	0.79	1.26
Guangdong	91.92	453.19	361.27	78.18	331.70	253.52	13.74	121.49
Guangxi	1.49	9.60	8.11	0.54	8.14	7.59	0.94	1.47
Hainan	0.80	2.32	1.52	0.48	6.33	5.84	0.32	-4.01
Chongqing	1.00	7.49	6.49	0.79	4.94	4.15	0.21	2.55
Sichuan	1.39	18.84	17.45	1.15	13.85	12.70	0.24	4.99
Guizhou	0.42	1.92	1.50	0.24	1.23	0.99	0.18	0.69
Yunnan	1.18	7.61	6.43	0.64	5.82	5.19	0.54	1.78
Shaanxi	1.31	6.21	4.90	0.83	5.89	5.06	0.48	0.31
Gansu	0.41	1.64	1.22	0.15	5.77	5.61	0.26	-4.13
Qinghai	0.11	0.47	0.35	0.05	0.32	0.28	0.06	0.14
Ningxia	0.33	1.17	0.84	0.12	0.79	0.67	0.21	0.38
Xinjiang	1.20	12.97	11.76	1.06	4.16	3.10	0.14	8.81

Note: [a] the unit of export and import value is billion USD.
Source: Author's calculations based on *China Statistical Yearthesis* (2001, 2011).

As international trade is believed as a useful indicator to measure the degree of openness of a country, Table 4.6 above shows the values of regional export and import of 30 provinces and municipalities in 2000 and 2010. It is easy to find that the general trends of both regional export and import are upward during the sample period. Particularly coastal regions, for example Shanghai, Jiangsu, and Guangdong, have greater values of exports and imports than most inland regions, whilst western regions, such as Ningxia, Gansu, and Qinghai, have little exports and imports in both 2000 and 2010. By computing the export surplus of each region (as shown in the last two columns of Table 4.6), I find that most Chinese regions developed a trade-off between import and export in 2000 as their export surplus was less than 1.0. The trend in three developed regions, however, was not the same. Specifically, Beijing was a net importer while Guangdong and Zhejiang were net exporters. Interestingly, I notice that in 2010, except Beijing, Tianjin, and Shanghai, other developed regions became main net exporters, especially Guangdong, Zhejiang, Jiangsu, and Fujian. The absolute value of export surplus of developed regions became greater in 2010 while the export surplus value of less developed regions was relatively small. These results imply that both the pace and emphasis of the opening strategy varied in different regions.

Moreover, the environment of FDI became more open, transparent, and friendly after China entered the WTO; some sectors that were originally monopolised by state-owned enterprises, e.g. finance, insurance, telecommunications, transportation, and so on, were opened to foreign investors. Foreign presence not only occurred in the manufacturing industry but also expanded into service sectors, which further increased the degree of diversity of overseas investment in China. The contribution of FIEs to the development of the Chinese economy has been discussed and confirmed in prior studies as well (Buckley et al., 2007a; Cheung and Lin, 2004; Girma and Gong, 2008; Ito et al., 2012; Wei and Liu, 2006; Yao and Wei, 2007). In general, over 268,000 FIEs were established with an average annual investment of 59.2 billion USD during the period of 2001 to 2007.

Overall, the process of attracting foreign investment in China succeeded and has been sustainable in the three decades since the implementation of the "*Reform and Opening Up*" policy. A total of 632,000 FIEs were approved for establishment in China with an FDI stock of 763 billion USD in this period and China became the highest FDI recipient in 2008.



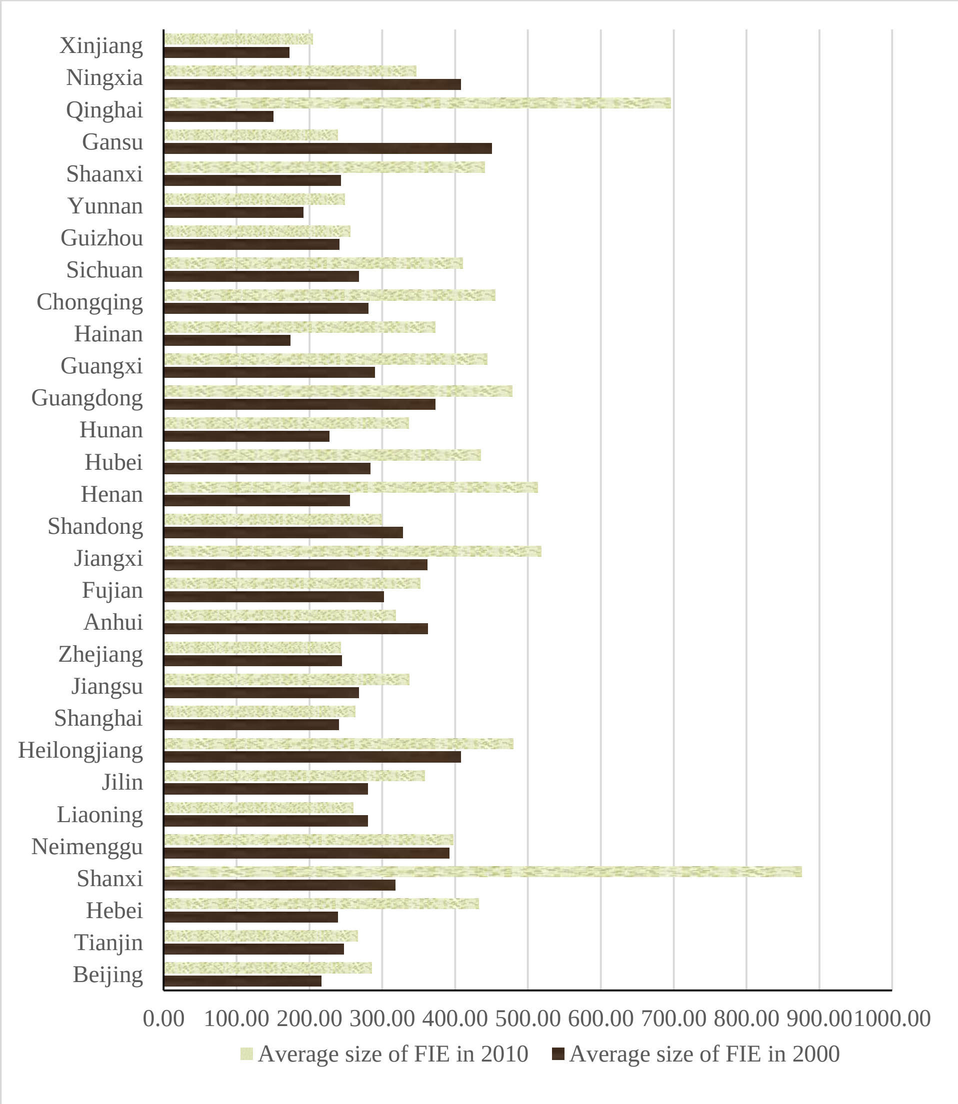
Source: Compiled by the author use the data collected from NBS.

Figure 4.7 Number of foreign invested enterprises (FIE) of 30 regions in China (2000 and 2010)

Figure 4.7 above depicts the regional distribution of foreign presence in terms of FIE numbers. I analysed the historical development path of FDI in China and realised that the majority of FIEs are located in coastal regions: most FIEs are clustered in Guangdong, Shandong, Fujian, Zhejiang, Jiangsu, and Shanghai. Recall that of the 14 opened coastal cities, most are located in these six regions, which is consistent with prior arguments that the 14 opened cities are more advantageous in terms of attracting foreign presence than others. In contrast, western regions, e.g. Ningxia, Qianghai, and Gansu, have low numbers of FIEs. The majority of central regions, e.g. Hubei and Hunan, have no more than 1,000 FIEs although they are adjacent to Guangdong province.

Overall, the features of foreign investment in China in our sample period can be summarised as the following. Firstly, the source of foreign investment is diversified. Since the implementation of a series of opening policies, more than 170 countries have established FIEs in China. From the perspective of accumulated foreign investment, close to half of total foreign investment came from Hong Kong, Macao, and Taiwan, and a quarter of investment came from developed countries, such as the US, European countries, Japan, etc. The remaining investment came from South East Asian countries, Latin American countries, and African countries. Secondly, as analysed in previous sections, the number of FIEs increased during the last three decades even though the growth rate declined in the last decade (as shown in Figure 1.7 in Chapter 1). Since the implementation of the opening policy, a number of roughly 630,000 FIEs have been approved to operate in China; in 2010 there were nearly 440,000 FIEs. Thirdly, foreign investment covers a wide range of industries: for instance, in 2010 only 2% of FDI was invested in the agriculture industry and 28% in the services industry, but nearly 70%

was invested in the manufacturing industry. More specifically, foreign investment in the manufacturing sector exceeded 60% of FDI, and the sum of the capital invested in the automobile, electronic equipment, precision machinery, and telecommunications equipment sectors reached nearly 35%. This feature indicates that foreign investors are not only interested in labour intensive sectors, but also in high technology sectors. Fourth, both the scale and the technological level of foreign investment have gradually increased during the last three decades. Over 480 of the global top 500 multinational companies have set up subsidiaries in China, and an increasing number of R&D centres have been established in China (Liu and Chen, 2012; Von Zedtwitz, 2004). Finally, the foreign investment is largely clustered in coastal regions. By now, although FIEs are active in most Chinese regions, nearly 85% of foreign investment, from the perspective of investment value, is in the eastern area rather than in the central and western areas.

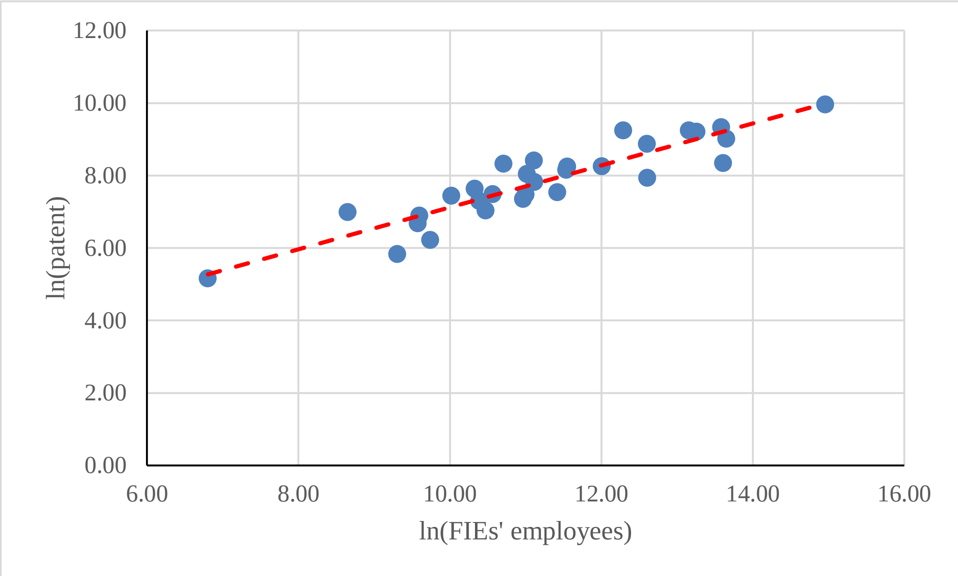


Note: the average size of FIE is measured as the averagel number of FIEs' employees in a province (unit is indiviual per enterprise).
Source: Compiled by the author use the data collected from NBS.

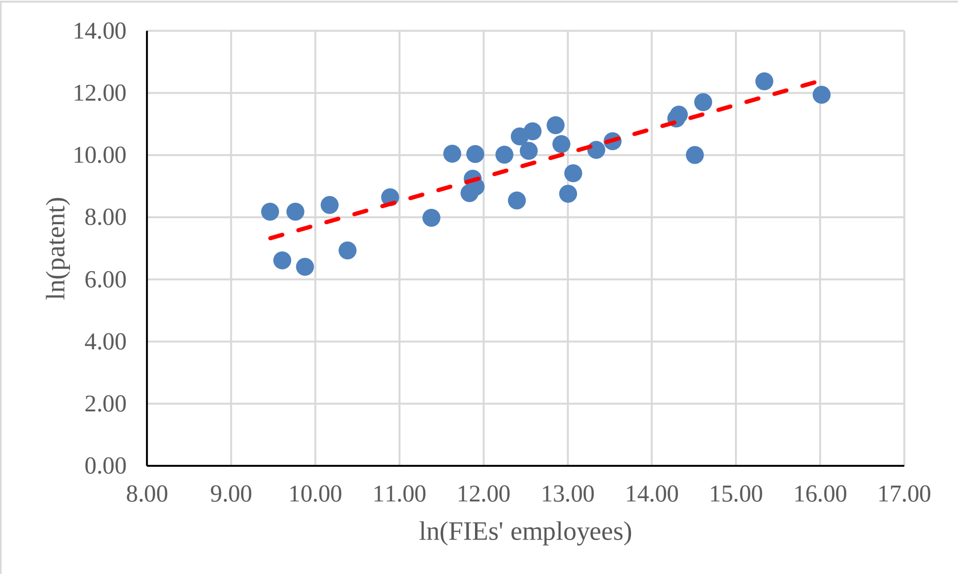
Figure 4.8 Average size of FIEs in 30 regions in China (2000 and 2010)

Figure 4.8 shows the average size of regional FIEs in 2000 and 2010. Obviously, the size of regional FIEs was enlarged, although the increase in degree was not the same, for a majority of Chinese provinces and municipalities. This fact indicates that the overall strength of regional FIEs was advanced in 2010. More interestingly, I notice that FIEs located in most developed regions, e.g. Tianjin, Shanghai, Zhejiang, almost kept the same scale in 2010 compared with the scale in 2000. And Liaoning and Shandong even experienced a minor decline in the average size of FIEs. The average size of FIEs located in most inland regions, for example Shanxi and Qinghai, dramatically increased from approximately 250 individuals per enterprise in 2000 to over 400 individuals per enterprise in 2010. A possible reason for this phenomenon is that foreign investment in less developed regions is mainly focussed on labour intensive industries.

As pointed out by extant literature, foreign investment can bring lots of benefits for the development of a host country's economy and innovation (Ben Hamida, 2013; Buckley et al., 2007a; Driffield and Love, 2007; Girma and Gong, 2008; Ito et al., 2012; Kemeny, 2010; Li et al., 2013; Tian, 2006). I have summarised some key contributions of FDI to China's development. Foremost, FDI is an essential source of investment in fixed assets. This was extremely helpful for the economic development of China in the early stages of implementation of the "*Reform and Opening Up*" policy (i.e. in the 1980s). Secondly, as foreign investment is mainly focussed on industrial projects, the increasing investments from overseas not only facilitated the speed of the IS upgrade (as analysed in previous sections), but also created a huge contribution to national industrial output (Fu and Balasubramanyam, 2005). For instance, the value added by FIEs' output accounted for nearly 28% of the national total value added in 2007. Third, the positive trend of foreign investment created a large number of employment opportunities (Fu and Balasubramanyam, 2005). The training and learning-by-doing opportunities offered by regional FIEs improved the skill levels of the labour force and facilitated the accumulation of human capital (Duanmu and Fai, 2007).



(a) Scatter plot of the number of FIEs’ employees and regional patent applications in ***2000***



(b) Scatter plot of the number of FIEs’ employees and regional patent applications in ***2010***

Source: Compiled by the author use the data collected from NBS.

Figure 4.9 Scatter plot of number of FIEs’ employees and regional patent applications (2000 and 2010)

Figure 4.9 further illustrates the scatter plot of regional FIEs’ employees and regional IC in terms of patent applications. I find that the more employees working in regional FIEs, the greater the number of regional patent applications. This result is in line with prior studies which highlight that MNEs’ workers are an effective channel for local innovators to gain knowledge spillovers, particularly tacit knowledge spillovers

(Cheung and Lin, 2004; Li et al., 2013).

4.3 Comparative analysis of five regions in China

Knowledge creation activities in regions are often geographically bounded due to the scope of knowledge spillover and the tacit nature of knowledge transfer (Döring and Schnellenbach, 2006; Zucker et al., 2007). This geographic agglomeration of innovative activities differs between regions within the NIS, giving innovation systems a regional character and highlighting the importance of each RIS (Cooke et al., 1997b; Jaffe et al., 1993). This in turn has sparked a huge debate on how the impacts of such knowledge, as well as their impact on regional IC, are affected crucially by either a specialised or diversified IS (Buerger and Cantner, 2011; Desrochers and Leppälä, 2011a; Farahmand et al., 2012; Glaeser et al., 1992). Moreover, a large body of previous literature suggests that industrial sectors are the main players in RISs (Bell and Albu, 1999). Industrial enterprises, however, are heterogeneous because of their idiosyncratic features such as ownership, size, technology level, etc. Extant literature has focussed on the role of FDI in contributing to regional innovation (Cheung and Lin, 2004; Fosfuri et al., 2001; Fu, 2008; Ito et al., 2012). Industrial enterprises owned by other types of investors are indeed also playing an important role in facilitating regional knowledge absorption and creation. Although some studies have discussed the concentration of ownership of listed firms and the extent to which they have an impact on the economic return and performance of enterprises (Fahlenbrach and Stulz, 2009; Florackis et al., 2009; Tian and Estrin, 2008), our understanding is still limited regarding how firms with different ownership contribute to regional innovation. This section therefore attempts to link up the two aforementioned strands of the debate – specialisation versus diversity and how firms with different ownership contribute to regional innovation. I focus on two groups of coastal and central regions in China. Beijing and Shanghai are the political and financial centres of China, respectively, and Guangdong is the frontier and experimental district of the "*Reform and Opening Up*" policy implemented throughout the 1980s. The reasons why Hunan and Hubei are focussed on, in comparison with the Beijing, Shanghai and Guangdong provinces were introduced in Chapter 3.

4.3.1 Enterprises with different ownership in the five regions

I compared enterprises with different ownerships in the big-three regions of Beijing, Shanghai and Guangdong with those in the two central regions of Hubei and Hunan by taking two snapshots of the year 2000 and 2010. Table 4.7 below shows the absolute value and share of gross industrial output of state-owned enterprises, FIEs and collective-owned enterprises, limited liability enterprises and private enterprises (POEs). In order to offset the disturbances crated by macro-economic factors, I deflated output values in 2010 to the level of 2000 using the deflator provided by the World Bank dataset.[19]

Table 4.7 Gross industrial output value and proportion of regional industrial enterprises in the five regions

Region	2000				2010			
	SOE	FIE	COE	LLE	SOE	FIE	POE	Others
Beijing	1742.7[a]	1150.3	175.3	164.0	4853.3	3667.3	543.6	123.7
	(0.54[b])	(0.35)	(0.05)	(0.05)	(0.53)	(0.40)	(0.06)	(0.01)
Shanghai	3205.1	3431.2	394.8	464.8	7490.3	12321.1	2331.5	1014
	(0.43)	(0.46)	(0.05)	(0.06)	(0.32)	(0.53)	(0.10)	(0.04)
Guangdong	3126.1	7274.4	1202.5	809.6	8812.8	30468	10844.1	7321.3
	(0.25)	(0.59)	(0.10)	(0.07)	(0.15)	(0.53)	(0.19)	(0.13)

[19] For details, refer to: http://data.worldbank.org/country/china

Hubei	1929.0	336.3	564.5	545.8	5769.2	2909.4	3859.6	1935.1
	(0.57)	(0.10)	(0.17)	(0.16)	(0.40)	(0.20)	(0.27)	(0.13)
Hunan	1077.5	97.1	241.7	238.3	3590.9	938.4	5492.7	2701.5
	(0.65)	(0.06)	(0.15)	(0.14)	(0.28)	(0.07)	(0.43)	(0.21)

Note: [a] The unit of the output is 100 million RMB. [b] Figure in the parenthesis is the share of output in respective to the total output of a region.
Source: Compiled by author.

On the one hand, I found that the gross industrial output value of state-owned enterprises and FIEs in the big-three regions accounted for a huge proportion of the regional industrial output in 2000 and 2010. For instance, 90% of Beijing's industrial output was created by state-owned enterprises and FIEs and this figure increased to a peak of 93% in the year 2010. In contrast, the contribution of regional state-owned enterprises and FIEs in Hubei and Hunan were much less than in the big-three regions. For instance the total proportion of state-owned enterprises and FIEs together decreased from 67% to 60% and 71% to 35% in Hubei and Hunan, respectively. Therefore, the IS of the big-three regions was dominated by state-owned enterprises and FIEs, while the IS in Hubei and Hunan was more balanced, which means the status of state-owned enterprises and FIEs was not overwhelming.

On the other hand, FIEs in Shanghai and Guangdong were the biggest players as they contributed over half of the regional industrial output in 2000 and 2010. Beijing, with some differences, was largely dependent on regional state-owned enterprises as the output of state-owned enterprises account for 54% and 53% of regional industrial output in 2000 and 2010, respectively. Although state-owned enterprises in Hubei were also the greatest contributor, their share of regional IS declined from 57% to 40% while the proportion of FIEs increased 10% during this period. Moreover, the IS of Hunan was reshaped during these 11 years as the dominant contributor changed from state-owned enterprises to POEs, whilst regional FIEs accounted for no more than 10% of

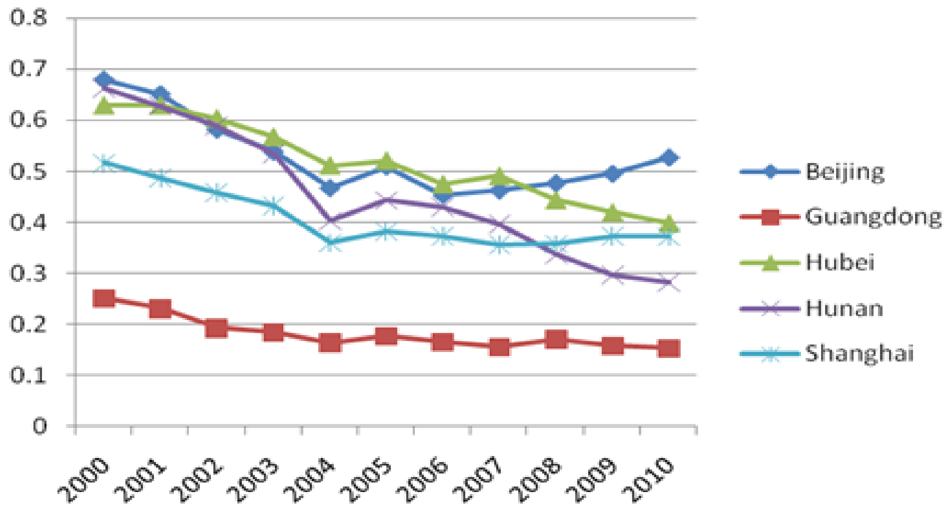
Hunan's industrial output during the sample period. Therefore, the IS in both Beijing and Hubei was state-owned enterprise driven; Shanghai and Guangdong were FIE motivated; and Hunan became POE dominated.

Table 4.8 Number of regional industrial enterprises of different ownerships in the five regions

Region	2000					2010			
	SOE	FIE	COE	LEE	Others	SOE	FIE	POE	Others
Beijing	2430	1007	899	83	152	1009	1342	2465	2068
	(0.53)	(0.22)	(0.20)	(0.02)	(0.03)	(0.15)	(0.19)	(0.36)	(0.30)
Shanghai	2473	3307	1686	68	1039	1013	6128	8065	1478
	(0.29)	(0.39)	(0.2)	(0.01)	(0.12)	(0.06)	(0.37)	(0.48)	(0.09)
Guangdong	3320	8413	4158	265	3538	1250	18941	23015	10183
	(0.17)	(0.43)	(0.21)	(0.01)	(0.18)	(0.02)	(0.35)	(0.43)	(0.19)
Hubei	2965	362	1960	424	570	886	944	9313	4963
	(0.47)	(0.06)	(0.31)	(0.07)	(0.09)	(0.06)	(0.06)	(0.58)	(0.31)
Hunan	2339	197	1364	155	752	833	620	9152	3239
	(0.49)	(0.04)	(0.28)	(0.03)	(0.16)	(0.06)	(0.04)	(0.66)	(0.24)

Note: Figures in the parentheses show the total as a percentage of the full regional sample.
Source: Compiled by author by using China Statistical Yearthesis

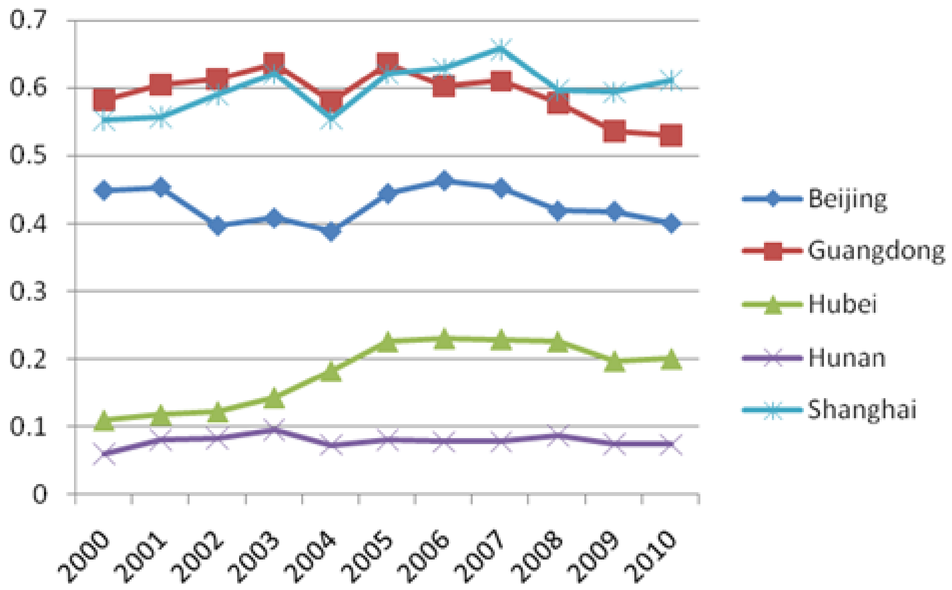
I further analysed the number of regional enterprises of different ownerships, as shown in Table 4.8. From Table 4.8, I draw the similar conclusion that FIEs are clustered in Beijing, Shanghai and Guangdong since the number of FIEs in these regions is much bigger than other two regions in both two snapshots of 2000 and 2010. In contrast, the number of state-owned enterprises declined heavily in Hubei and Hunan, while the POEs grew explosively in these two central regions during the period. For instance, the number of state-owned enterprises in Hubei decreased from 2,965 in 2000 to 886 in 2010.



Source: Compiled by author by using China Statistical Yearthesis

Figure 4.10 Share of SOEs of regional industry output value for the five regions (2000-2010)

Figure 4.10 illustrates the contribution of state-owned enterprises to regional industrial output in the five regions during 2000 to 2010. I notice that state-owned enterprises in Guangdong played a less important role than state-owned enterprises in the other four regions as the share of state-owned enterprises' industrial output in Guangdong was smaller than that of state-owned enterprises in the other four regions. Meanwhile, the contributions of state-owned enterprises in Hubei and Hunan continually declined during the period while state-owned enterprises' contribution in Beijing and Shanghai experienced an increasing trend from 2004. This phenomenon indicates that state-owned enterprises in less developed regions became less important, while state-owned enterprises may have played different roles in different developed regions.



Source: Compiled by author by using China Statistical Yearthesis

Figure 4.11 Share of FIEs of regional industry output value for the five regions (2000-2010)

Figure 4.11 shows that FIEs in the big-three regions played an essential role for regional industrial output, especially in Guangdong and Shanghai as the share of FIEs' contribution to regional industrial output exceeded 50% during 2000 to 2010. Interestingly, I notice that the role of FIEs in the two central regions is not the same. The contribution of FIEs in Hubei increased 10% during the period while the share of FIEs' output to Hunan's industrial output was stably below the level of 10%. This result is consistent with the previous analysis in which it was pointed out that although foreign companies have been immersed in most Chinese regions, most FDI focussed on developed regions.

4.3.2 Large and medium firms and high technology firms in the five regions

Technology level is another key feature of regional IS. Because high technology industries are knowledge intensive and can generate more profit, they are naturally a central focus of the policy makers when they considering how to adjust regional IS (Liu and Buck, 2007; Vang and Asheim, 2006). HTEs are believed to be more innovative than traditional enterprises because of the sophistication of their products and large amount of R&D investment required (Kirner et al., 2009). Generally, the tempo of products and services upgrade of HTEs are faster than enterprises in labour intensive sectors (Liu and Buck, 2007). In order to catch and fulfil the market demand, HTEs keep a certain level of R&D intensity and improve innovativeness of their product. Therefore, HTEs are familiar and inclined to use IPRs to protect their R&D output (Kroll and Liefner, 2008; Yang et al., 2011). A clear worldwide trend is that HTEs are aiming to set up their technology standard as it will bring stable and huge profits for future markets (Berger et al., 2012; Williams et al., 2011). In addition, HTEs are more likely to cluster in geographic scope to reduce costs of transportation and transactions, which in turn will enhance the regional knowledge spillover (Zhou and Xin, 2003).

According to the industrial classification created by the NBS, large and medium enterprises (LMEs) in this research refers to enterprises with more than 300 employees and over 30 million RMB annual sales and over 40 million RMB total assets. HTEs refers to enterprises in the sectors of aircraft and spacecraft, electronic and telecommunication equipment, computers and office equipment, pharmaceuticals, and medical equipment and meters manufacturing.

Table 4.9 Gross industrial output value and proportion of regional LMEs and HTEs in the five regions

Region	2000		2010	
	LME	HTE	LME	HTE
Beijing	1207.7[a]	972.68	7031.7	2003.1
	(0.37[b])	(0.30)	(0.78)	(0.22)
Shanghai	4291.2	1004.1	14821.8	4618.9
	(0.57)	(0.13)	(0.74)	(0.23)
Guangdong	5951.6	2713.5	38081.5	14089.8

	(0.48)	(0.22)	(0.66)	(0.25)
Hubei	1825.0	218.6	9678.6	878.2
	(0.54)	(0.06)	(0.67)	(0.06)
Hunan	956.4	108.2	5839.3	622.9
	(0.58)	(0.07)	(0.46)	(0.05)

Note: [a] The unit of the output is 100 million RMB. [b] Figure in the parenthesis is the share of output in respective to the total output of a region.
Source: Compiled by author.

Table 4.9 shows that, with the exceptions of Beijing and Guangdong, LMEs in the regions were the main contributor to overall industrial output in 2000 as the proportion of LMEs exceeded 50% in Shanghai, Hubei, and Hunan. During the sample period, LMEs raised their status in terms of regional IS in Beijing, Shanghai, Guangdong, and Hubei. The proportion of LMEs increased 41%, 17%, 18%, and 13% in the above four regions, respectively. In contrast, LMEs in Hunan lost the dominant status during this period as the proportion of LMEs decreased 12%. This is coincident with the previous analysis of regional industrial enterprises with different ownership as state-owned enterprises and FIEs are usually LMEs. Therefore, except in Hunan, LMEs play an important role in each IS in the other four regions.

A sharp discrepancy emerges when focussing on the role of regional HTEs in the five regions. Generally, HTEs contributed nearly a quarter of regional industrial output in Beijing, Shanghai, and Guangdong. However, the HTEs in Hubei and Hunan were really weak since the proportion of HTEs was 6% and 7% respectively in 2000. Although the absolute output of HTEs in Hubei and Hunan increased 402% and 576% respectively during the 11 years of the sample period, the status of HTEs in each regional IS was still very low. Therefore I postulate that the IS in each of the big-three regions is inclined to be high technology based while the IS in the two central regions is inclined to be traditional technology based.

Table 4.10 Number and proportion of regional LMEs and HTEs in the five regions

Region	2000		2010	
	LME	HTE	LME	HTE
Beijing	476	575	678	1103
	(0.10)	(0.13)	(0.10)	(0.16)
Shanghai	1367	1467	1750	1423
	(0.16)	(0.17)	(0.10)	(0.09)
Guangdong	2051	2267	7469	5774
	(0.1)	(0.12)	(0.14)	(0.11)
Hubei	848	552	1420	798
	(0.13)	(0.09)	(0.09)	(0.05)
Hunan	597	510	1069	683
	(0.12)	(0.11)	(0.08)	(0.05)

Note: Figures in the parentheses show the proportion of specific type of regional enterprise against regional total number of enterprises.
Source: Compiled by author using China Statistical Yearthesis and China Statistical Yearthesis on High Technology.

Table 4.10 illustrates that although the absolute number of LMEs and HTEs increased during the period of 2000 to 2010, the share of LMEs and HTEs decreased, except for the number of HTEs in Beijing. This result indicates that there is room for the development of LMEs and HTEs in the regional market of the five regions.

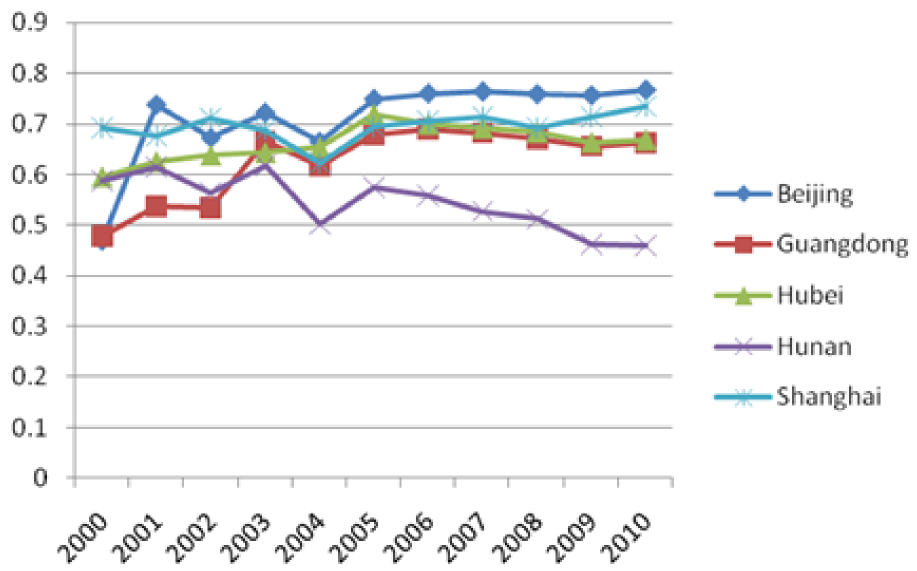
Table 4.11 Number of employees of four types of regional industrial enterprises by the five regions

Region	2000				2010			
	SOE	FIE	LME	HTE	SOE	FIE	LME	HTE
Beijing	77.38	21.77	62.42	15.61	48.42	38.29	74.59	24.99
	(0.68)	(0.19)	(0.55)	(0.14)	(0.39)	(0.31)	(0.60)	(0.20)
Shanghai	101.91	79.37	105.79	21.23	46.72	160.93	160.19	53.18
	(0.50)	(0.39)	(0.52)	(0.1)	(0.16)	(0.55)	(0.55)	(0.18)
Guangdong	104.39	313.32	153.77	81.13	78.89	906.10	939.38	354.75
	(0.18)	(0.55)	(0.27)	(0.14)	(0.05)	(0.58)	(0.60)	(0.23)
Hubei	153.77	10.25	124.76	12.93	79.98	41.08	169.78	21.49

	(0.67)	(0.04)	(0.54)	(0.06)	(0.27)	(0.14)	(0.58)	(0.07)
Hunan	117.1	4.47	86.39	7.45	60.60	20.87	112.14	15.78
	(0.70)	(0.03)	(0.52)	(0.04)	(0.22)	(0.08)	(0.41)	(0.06)

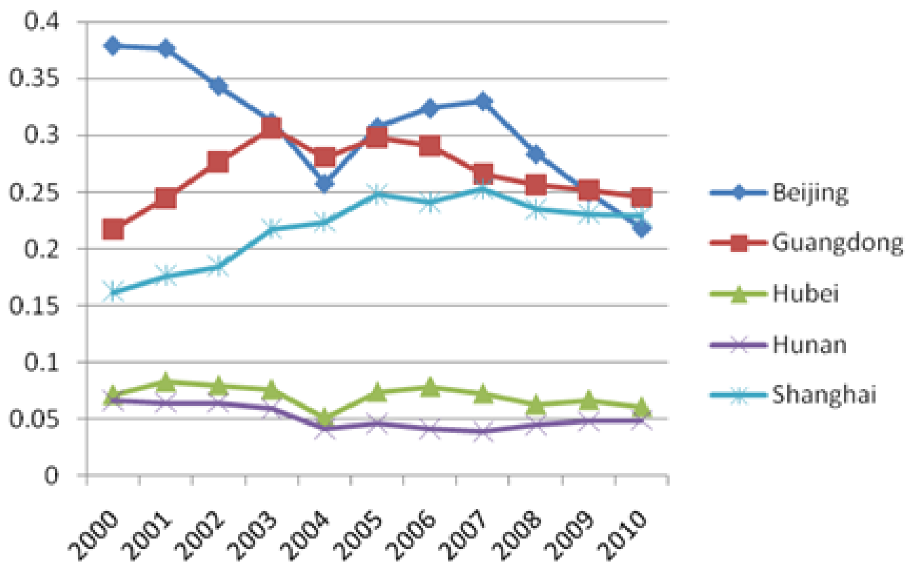
Note: Figures in the parentheses show the percentage of specific type enterprises against the full regional sample. SOE: State owned enterprise; FIE: Foreign invested enterprise; LME: Large and medium enterprise; HTE: High technology enterprise. Unit: 10,000 personnel.
Source: Compiled by author using China Statistical Yearthesis and China Statistical Yearthesis on High Technology

Table 4.11 shows the average number of employees in four types of regional enterprises, i.e. SOEs, FIEs, LMEs, and HTEs, in 2000 and 2010. Obviously, the number of employees in FIEs located in Shanghai and Guangdong is much greater than other regions. The gap between the central regions, Hubei and Hunan, in terms of FIEs became smaller from 2000 to 2010. In contrast, the number of employees in state-owned enterprises experienced a declining trend in all five regions. Meanwhile, the numbers of employees in both LMEs and HTEs grew, especially in Guangdong, indicating that LMEs and HTEs became the most active players within each regional economy.



Source: Compiled by author using China Statistical Yearthesis
Figure 4.12 Share of LMEs of regional industrial output value by the five regions (2000-2010)

Figure 4.14 further illustrates the changing process of LMEs' contribution to regional industrial output during the period of 2000 to 2010. Although the initial level of LMEs' contribution varied in different regions, the general trend of the contribution in Beijing, Guangdong, Hubei, and Shanghai, is upward. However, the contribution of LMEs in Hunan declined from nearly 60% in 2000 to 48% in 2010. This phenomenon indicates that the evolutionary path of IS is different between developed and less developed regions in China.



Source: Compiled by author using China Statistical Yearthesis

Figure 4.13 Share of HTEs of regional industrial output value by the five regions (2000-2010)

A much more complicated picture is shown in Figure 4.15 which presents the changing process of HTEs' contribution to regional industrial output during the period of 2000 to 2010. As analysed in previous sections, HTEs are aimed to be developed as the new engine to promote both regional and national economies. I find that HTEs' contribution to the regional industrial output of Beijing decreased dramatically from 38% in 2000 to nearly 22% in 2010 while HTEs' contribution in Shanghai grew gradually from 16% to 23% during the sample period. And interestingly, although the trajectories of the changing processes of the big-three regions are not the same, HTEs' contribution in these regions was 22%–24% in 2010. In contrast, HTEs in the two central regions were relatively weaker than those in developed regions as their contribution was smaller than 10%.

4.3.3 Dynamic externalities of IS of the five regions

Regional industrial specialisation is a measure of the regional concentration of an industry at the beginning of the sample period. The formula is:

$$S_{ij} = (\frac{y_{ij}}{y_{i.}}) / (\frac{y_{.j}}{y_{..}}), \quad (1)$$

where y_{ij} is gross industrial output value in industry[20] j in region i, $y_{i.}$ is the total industrial output in region i, $y_{.j}$ is the national industrial output in industry j, and $y_{..}$ is the total national industrial output. Hence, S_{ij} measures industry j's share of output in region i relative to that in the entire country. A higher value of S_{ij} indicates that region i is more specialised in industry j (Gao, 2004).

[20] The industries used in this thesis for calculating industrial specialisation and diversity are 3-digit level.

Table 4.12 Top three specialized industries in the five regions (2000, 2008)

Region	2000			2008		
		Production.	SPE.		Production.	SPE.
Beijing						
	Electronic and Telecommunication Equipment	1199.03	2.90	Electronic and Telecommunication Equipment	2378.29	2.58
	Oil and Refinement	115.44	1.68	Instrument & Meter	208.48	2.01
	Beverage Production	77.16	1.43	Electricity & Heat	1242.39	1.94
Shanghai						
	Transportation Equipment	813.09	1.75	Electronic and Telecommunication Equipment	5158.73	2.49
	Ferrous metal	450.27	1.53	General Machinery	2183.02	1.89
	Chemical Fibers	159.66	1.43	Transportation Equipment	2552.21	1.61
Guangdong						
	Instrument & Meter	321.92	2.28	Electronic and Telecommunication Equipment	14956.36	3.07
	Electronic and Telecommunication Equipment	3490.78	2.06	Instrument & Meter	1316.22	2.41
	Electrical Machinery Equipment	1368.12	1.67	Electrical Machinery Equipment	6964.17	2.07
Hubei						
	Transportation Equipment	451.77	2.24	Transportation Equipment	2397.03	2.64
	Food Process	164.88	1.46	Nonmetal Minerals Mining & Dressing	114.36	2.28
	Pharmaceutical Production	114.16	1.40	Tobacco Processing	257.6	2.10
Hunan						
	Tobacco Processing	59.65	3.91	Tobacco Processing	412.86	4.00
	Nonferrous Metal	86.05	2.83	Nonmetal Minerals Mining & Dressing	123.56	2.92
	Oil and Refinement	56.79	1.91	Nonferrous Metal	177.82	2.90

Note: The unit for the production is 100 million RMB as 1990's price. SPE.=specialization
Source: Compiled by author from China Industry and Economy Statistical Yearthesis

Table 4.12 shows the top three specialised regional industries in the five regions in 2000 and 2008. Generally, the overall level of the top three industries in the five regions became more specialised as the value of most specialisation (SPE.) increased during this period. Secondly, Hunan had the most specialised industry among the five regions as its biggest SPE. was between 3.9 and 4.0 (‘*Tobacco Processing*’). For the big-three regions, Guangdong became more specialised than Beijing and Shanghai since the SPE. of its top three industries were bigger than the SPE. of Beijing and Shanghai. In general, from the perspective of specific industries in Table 4.10, the big-three regions were specialised in ‘*Electronic and Telecommunications Equipment*’ in 2008. The change of Beijing’s top three specialised industries, from ‘*Oil and Refinement*’ and ‘*Beverage Production*’ to ‘*Instrument and Meter*’ and ‘*Electricity and Heat*’, indicates that the IS of Beijing was becoming more specialised, i.e. more high technology based. Similar deductions can be applied in Shanghai and Guangdong as well. For those two central regions, the industry of ‘*Transportation Equipment*’ was the most specialised industry in Hubei while ‘*Non-metal Minerals Mining and Dressing*’ and ‘*Tobacco Processing*’ exchanged status with ‘*Food Process*’ and ‘*Pharmaceutical Production*’ at the end of the sample period. Meanwhile, the industries of ‘*Tobacco Processing*’ and ‘*Non-ferrous Metal*’ were the key industries in Hunan. As a whole, although there was a little difference in the concrete industries of the top three specialised industries, the big-three regions specialised in technology intensive industries while the two central regions specialised in labour intensive industries. The degree of specialisation of specific industries of the five regions in 2000 and 2008 is illustrated in Table 4.13 and Table 4.14, respectively.

Table 4.13 Industrial output and specialization of each industry of the five regions in 2000 (20 industries)

Industry	Beijing		Shanghai		Guangdong		Hubei		Hunan	
	Production.	SPE.	Production.	SPE.	Production.	SPE.	Production.	SPE.	Production.	SPE.
Total	2383.3	NA	5257.84	NA	9749.93	NA	2279.41	NA	1031.74	NA
Nonmetallic Minerals	77.11	0.61	100.78	0.36	502.5	0.98	148.68	1.24	86.09	1.59
Chemical Materials	119.43	0.58	378.27	0.83	560.5	0.66	196.21	0.99	122.9	1.37
Food Process	41.19	0.35	64.38	0.25	250.35	0.52	164.88	1.46	57.63	1.13
General Machinery	42.76	0.37	317.3	1.26	197.43	0.42	99.01	0.91	35.54	0.72
Textile	38.89	0.21	195.37	0.48	477.17	0.63	217.74	1.23	47.7	0.60
Special Equipment	113.59	1.39	148.85	0.83	98.91	0.30	75.68	0.97	36.18	1.02
Transportation Equipment	88.08	0.42	813.09	1.75	467.71	0.54	451.77	2.24	100.1	1.09
Electrical Machinery Equipment	99.05	0.49	475.17	1.07	1368.12	1.67	94.04	0.49	52.62	0.61
Paper and Printing	15.72	0.29	56.89	0.48	229.53	1.05	47.49	0.93	30.48	1.32
Nonferrous Metal	10.87	0.15	72.48	0.47	166.98	0.58	49.37	0.74	86.05	2.83
Metal product	54.16	0.59	231.1	1.13	594.07	1.57	76.9	0.87	16.23	0.41
Ferrous metal	131.19	0.99	450.27	1.53	103.32	0.19	166.79	1.31	73.44	1.28
Food Production	56	1.14	81.74	0.76	200.22	1.00	39.2	0.84	14.03	0.66
Beverage Production	77.16	1.43	61.19	0.52	167.45	0.76	64.59	1.26	20.75	0.89
Pharmaceutical Production	56.91	0.67	194.78	1.04	209.98	0.60	114.16	1.40	32.12	0.87
Electronic and Telecommunication Equipment	1199.03	2.90	1248.5	1.37	3490.78	2.06	105.68	0.27	73.32	0.41
Instrument & Meter	38.12	1.11	98.07	1.29	321.92	2.28	17.51	0.53	10.65	0.71
Tobacco Processing	4.62	0.13	33.61	0.43	50.62	0.35	76.01	2.25	59.65	3.91
Chemical Fibers	3.98	0.08	159.66	1.43	133.65	0.64	24.38	0.50	19.47	0.89
Oil and Refinement	115.44	1.68	76.34	0.50	158.72	0.56	49.32	0.75	56.79	1.91

Note: The unit for the production (output) is 100 million yuan as 1990's price. Source: Compiled by author from China Industry and Economy Statistical Yearthesis.

Table 4.14 Industrial output and specialization of each industry of the five regions in 2008 (27 industries)

Industry	Beijing		Shanghai		Guangdong		Hubei		Hunan	
	Production.	SPE.	Production.	SPE.	Production.	SPE.	Production.	SPE.	Production.	SPE.
Total	9780.68	NA	21937.25	NA	55230.19	NA	12571.99	NA	10585.43	NA
Nonferrous Metal	0	0.00	0	0.00	88.64	0.30	33.14	0.46	177.82	2.90
Nonmetallic Minerals	293.83	0.67	470.77	0.48	2112.1	0.91	578.12	1.03	607.21	1.28
Chemical Materials	299.47	0.42	1855.66	1.16	3006.22	0.80	952.77	1.04	907.37	1.18
Food Process	233.43	0.46	286.22	0.25	1430.83	0.54	730.82	1.13	786.77	1.45
Textile	70.75	0.16	338.8	0.34	1688.12	0.71	538.11	0.93	269.13	0.55
Clothes and Hats	94.77	0.48	469.87	1.06	1669.26	1.61	208.99	0.83	84.13	0.39
Special Equipment	414.34	1.38	828.14	1.23	1098.87	0.69	180.6	0.47	722.47	2.22
Transportation Equipment	1138.64	1.61	2552.21	1.61	3380.71	0.91	2397.03	2.64	522.35	0.68
Electrical Machinery Equipment	377.25	0.59	1703.63	1.19	6964.17	2.07	432.63	0.53	385.02	0.56
Paper and Printing	72.03	0.44	211.5	0.57	1283.9	1.48	141.79	0.67	261.88	1.47
Nonferrous Metal	66.79	0.15	417.27	0.43	1741.13	0.75	420.24	0.75	1059.73	2.24
Metal Product	207.04	0.66	963.73	1.36	2995.26	1.80	293.05	0.72	200.34	0.59
Ferrous Metal Exploitation	30.16	0.39	0	0.00	92.94	0.23	119.54	1.20	69.44	0.83
Food Production	144.71	0.90	334.65	0.93	727.73	0.86	189.09	0.92	265.72	1.53
Beverage Production	131.78	1.01	150.93	0.52	482.61	0.70	296.66	1.77	159.79	1.13
Pharmaceutical Production	241.55	1.50	274.28	0.76	457.67	0.54	254.92	1.23	235.94	1.36
Electronic and Telecommunication Equipment	2378.29	2.58	5158.73	2.49	14956.36	3.07	460.21	0.39	148.88	0.15
Instrument & Meter	208.48	2.01	342.56	1.47	1316.22	2.41	57.13	0.43	105.19	0.94
Tobacco Processing	29.82	0.31	327.91	1.53	274.73	0.55	257.6	2.10	412.86	4.00
Chemical Fibers	3.31	0.04	45.72	0.24	150.21	0.34	32.55	0.30	25.74	0.29
Oil and Refinement	763.08	1.59	1201.52	1.12	1888.59	0.75	454.39	0.74	470.14	0.91
Oil and Gas Exploitation	88.82	0.44	19.55	0.04	743.63	0.69	161.27	0.62	0	0.00
Coal Exploitation	255.97	0.83	0	0.00	0	0.00	36.41	0.09	367.78	1.10
Ferrous Metal Smelt and Flat	594.65	0.63	594.65	0.28	1436.71	0.29	1657.27	1.37	1129.22	1.11
General Machinery	395.75	0.77	2183.02	1.89	1471.71	0.54	447.3	0.67	452.49	0.81
Electricity & Heat	1242.39	1.94	1205.93	0.84	3631.87	1.08	1126	1.37	634.46	0.92
Nonmetal Minerals Mining & Dressing	3.58	0.09	0	0.00	140	0.68	114.36	2.28	123.56	2.92

Note: The unit for the production is 100 million yuan as 1990's price.

Source: Compiled by author from China Industry and Economy Statistical Yearthesis.

Besides the specialisation of each industry in the focal region, I employed the concept of diversity to mirror the extent to which regional IS was diversified. Let $\varphi_{ij} = (y_{ij} / y_{i.})$ be industry j 's share of industry in region i . Then a Hirschman-Herfindahl index can be used as a measure of regional industrial diversity:

$$D_{ij} = \sum_{k \neq j} \varphi_{ik}^{2} . \tag{2}$$

The greater the value of D_{ij}, the less level of diversity of the IS in the region. This definition follows that found in previous studies (Gao, 2014; Henderson, 1997). In order to make the measure of diversity have positive monotonicity, D_{ij} can be subtracted from 1. Therefore:

$$d_{ij} = 1 - \sum_{k \neq j} \varphi_{ik}^{2} . \tag{3}$$

Thus, the higher the value of d_{ij}, the more diversified the regional IS is. Since diversity is a regional level indicator, I adopted the average of specialisations of all regional industries to display overall specialisation of IS at regional level. Therefore:

$$RS_{i} = \sum_{j=1}^{n} S_{ij} / n , \tag{4}$$

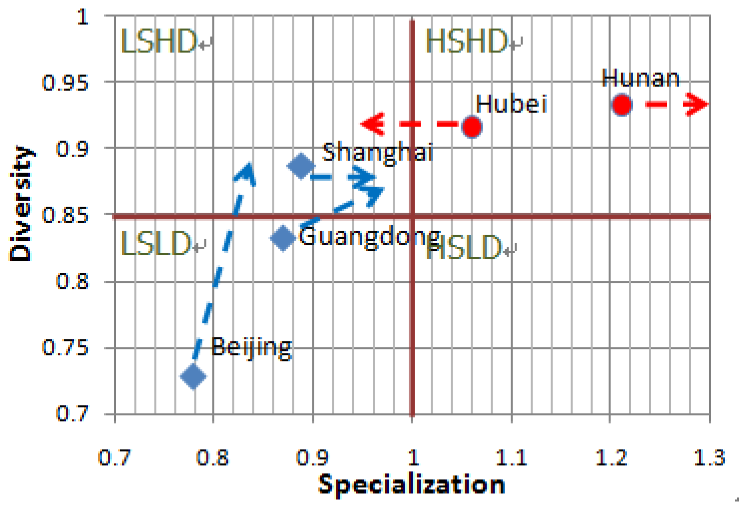
where n is the number of regional industries.

Table 4.15 Specialization and diversity of regional industrial structure in the five regions

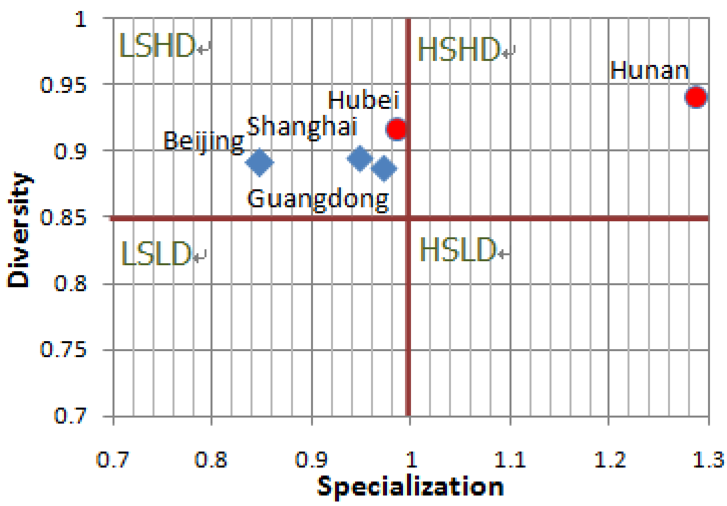
Region	Specialization		Diversity	
	2000	2008	2000	2008
Beijing	0.78	0.85	0.73	0.89
Shanghai	0.89	0.95	0.89	0.90
Guangdong	0.87	0.97	0.83	0.89
Hubei	1.06	0.99	0.92	0.92
Hunan	1.21	1.29	0.93	0.94

Source: Compiled by author using data collected from China Industry and Economy Statistical Yearthesis

Data in the left two columns in Table 4.15 shows evidence for the previous deduction, namely that except for Hubei, the regions were more specialised from 2000 to 2008. The level of specialisation of the IS in Hunan is the highest. The two columns on the right of Table 4.15 show diversity of regional IS. Basically, Beijing and Guangdong became more diversified as diversity increased 0.16 and 0.06, respectively. Diversity of the big-three regions increased 0.01 or so. Moreover, the overall level of diversity of the two central regions is greater than in the big-three regions in 2000 and 2008.



(a) 2000



(b) 2008

Figure 4.14 Five regions in the matrix of specialization and diversity (2000, 2008)

To advance understanding of the changing process of the IS in terms of specialisation and diversity, two plots illustrate the positions of the five regions in two matrices (year 2000 and year 2008) in Figure 4.16. Specifically, I denote the circles represent two central regions and the diamonds represent the big-three regions in Figure 4.16 and set the level of specialisation (horizontal axis) of 1.0 and the diversity (vertical axis) of 0.85 as criteria to get four quadrants within the matrix. The four quadrants can be defined as low specialisation and low diversification (LSLD), low specialisation and high diversification (LSHD), high specialisation and low diversification (HSLD), and high specialisation and high diversification (HSHD). All these four quadrants show the relative degree of high or low, not an absolute meaning. The two types of arrows in plot (a) of Figure 4.16, blue and red, indicate the direction the big-three regions and the two central regions move in the matrix, respectively.

From 2000 to 2008, Hunan was located stably in the area of HSHD while Hubei shifted from HSHD to LSHD. This means the IS of Hubei was reshaped and fluctuated during this period and it became less specialised but with a similar level of diversity. The situation for the big-three regions is a bit more complex. Firstly, Beijing and Guangdong were located in LSLD in 2000 (plot a); the IS of Beijing especially had much lower specialisation and lower diversification than Shanghai and Guangdong. However, after nine years of reshaping and adjustment of the regional IS, both Guangdong and Beijing edged into LSHD in which area Shanghai was located. The change of IS in Beijing was quite substantial, as specialisation and diversity increased 0.07 and 0.16, respectively. From the evolution process displayed in plot (a) and plot (b), I deduce that LSHD is the most favoured area since Beijing, Guangdong and Hubei made endeavours to shift into it during the sample period and Shanghai left this area with a small step toward high specialisation. It seems that there is a favoured area/portfolio of specialisation and diversity at regional level (Huallacháin and Lee, 2011).

4.3.4 Regional innovation of the five regions

Table 4.16 below compares Hubei and Hunan with Beijing, Shanghai and Guangdong in terms of R&D expenditure, R&D personnel and numbers of patents, as a proxy for inputs into R&D and an indicator of outputs. Hubei and Hunan are ranked more lowly in terms of patents than in terms of R&D expenditures and personnel, suggesting that the kinds of R&D being undertaken do not translate into such valuable outputs as for the coastal regions.

Table 4.16 R&D inputs and output of the five regions in 2010

Region	R&D Exp. (100m yuan[a])	%	Rank	R&D Staff (1000PY[b])	%	Rank	Patent	%	Rank
China	7062.6	100	NA	2553.8	100	NA	1109428	100	NA
Beijing	821.8	12	2	193.7	7.6	4	57296	5.2	6
Shanghai	481.7	6.8	6	135	5.3	6	71196	6.4	5
Guangdong	808.7	11	3	344.7	14	1	152907	14	2
Hubei	264.1	3.7	9	97.9	3.8	8	31311	2.8	10
Hunan	186.6	2.6	14	72.6	2.8	13	22381	2	15

Source: China Statistical Yearthesis on Science and Technology and SIPO website

Note: a: 100 million yuan (current price); b: 1,000 personnel-year; Jiangsu ranked 1, Shandong ranked 4 and Zhejiang ranked 5 in terms of R&D expenditure; Jiangsu ranked 2, Zhejiang ranked 3 and Shandong ranked 5 in terms of R&D staff; Jiangsu ranked 1, Zhejiang ranked 3 and Shandong ranked 4 in terms of patents.

Secondly, in terms of intensity of R&D, suggested by staff numbers as a proportion of expenditures, the more extensive types of R&D involving large numbers of people relative to expenditures are based in Guangdong, Hubei and Hunan (ratios of 43%, 37%, 39%) whereas Beijing and Shanghai perhaps may be thought to be undertaking more intensive forms of R&D with lower proportions of labour compared with expenditures (ratios of 24% and 28% respectively). This may carry a different interpretation, depending on what kind of R&D staff are involved in the R&D projects. Higher education sectors of China have two main functions: teaching and research; R&D activities mainly occur in key universities and are held by key staff members. Specifically, I use the number of seniors (professors or '*zhenggao*') and sub-seniors (associate professors or '*fugao*') as indicators of key human resources of higher education. There are two significant higher education development projects in China: the '*211*' project and the '*985*' project, and both education expenditure and relevant policies are more likely to favour those universities which are on the project list. Therefore I look at the number and share of higher education institutions (universities and colleges) by region on the lists of these projects as an indicator of the quality of R&D expenditure and facilities. I compare Hubei and Hunan with both national level and the big-three regions relating to their innovative outputs (patent application numbers and proportions).

Table 4.17 Human resources and patent applications of universities by five regions (2010)

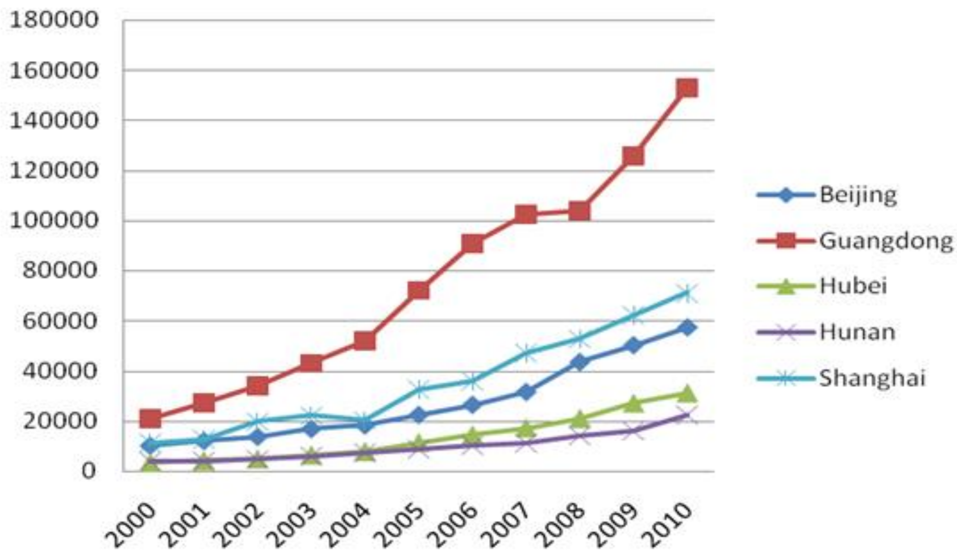
Region	Seniors (person)	Rk[a]	Sub-seniors (person)	Rk	'211' (unit)	Rk	'985' (unit)	Rk	Pa[b] (unit)	%[c]
China	138161	NA	360675	NA	116[21]	NA	39	NA	61579	12.7
Beijing	11424	1	19113	5	26	1	8	1	6935	17.4
Shanghai	5876	10	11017	16	10	3	4	2	8699	15.8
Guangdong	7815	5	19141	4	4	7	2	5	3029	4.7
Hubei	8297	4	21608	3	7	5	2	5	2364	13.7
Hunan	6038	9	16471	8	4	7	3	3	1333	15.3

Notes: a. The rank of each region within whole China; b. Number of patent applications from universities and colleges; c. Proportion of the patent applications from universities and colleges to all patent applications from regional organizations
Source: China Statistical Yearthesis; Website of Ministry of Education of China and SIPO

Table 4.17 suggests that in terms of key '*211*' and '*985*' university resources, Hubei and Hunan come well behind Beijing and Shanghai, but are roughly on a par with Guangdong. In particular the concentration of '*211*' projects that Beijing has, with 26 projects, far outnumbers the 4 of Guangdong and Hunan. Hubei, with 7, is closer to Shanghai in this respect. The split between the top two regions and Hubei, Hunan and Guangdong is mirrored in the division between senior and junior professors: Hubei, Hunan, and Guangdong have a far lower ratio of senior to junior professors (around 40%) compared with Beijing at 60% or Shanghai at 53%.

However, when looking at patent applications and the proportion of those deriving from universities and colleges, Hubei and Hunan have a high share of patents from higher education, above China's average and in line with Shanghai. Guangdong by contrast derives its patents more from the industrial sector than from local universities (with 95% of those patents coming from the non-university sector). Hunan lags behind Hubei in terms of numbers of patents, although not in terms of its share coming from the university sector.

[21] Since there are four universities that have two campuses in different regions, here I count 116 '*211*' project universities but not 112.

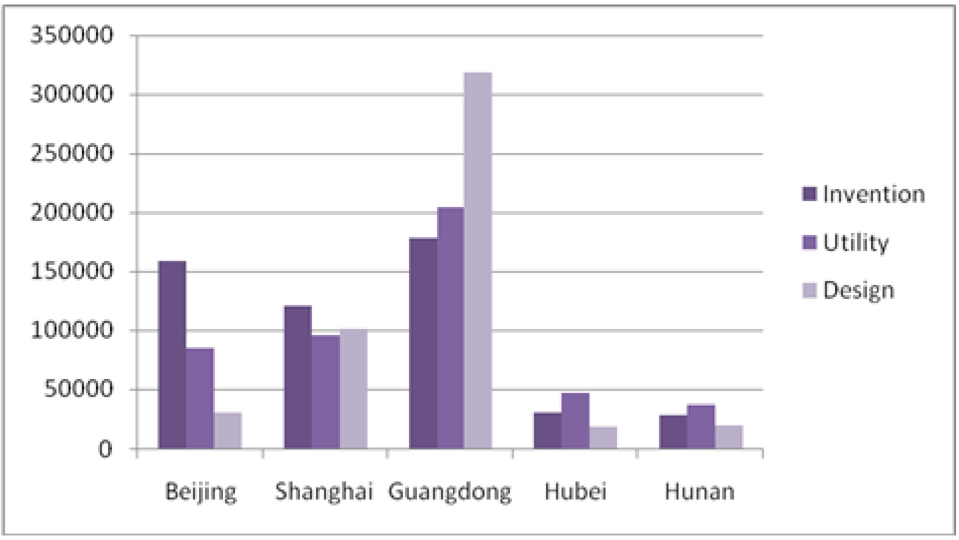


Source: Compiled by author by using China Statistical Yearthesis

Figure 4.15 Number of patent applications for the five regions (2000-2010)

Figure 4.15 shows the general trend of patent applications of the five regions during 2000 to 2010. Although all of these five regions experienced an increasing number of patent applications, the degree of growth rate is varied in different regions. Obviously, Guangdong is the most passionate patentor as the figure of patent applications increased nearly 7.5 times during the period. Meanwhile, both two other developed regions and the two central regions kept a similar growth curve although the number of patent applications in the latter group is smaller than the first group.

As discussion in previous sections, the number of granted patents is used according to their application date as proxy for regional innovation output. The patents registered in SIPO can be classified into three categories, i.e. invention, utility model, and external design. The consensus in existing literature regards invention and utility models as encompassing more novel knowledge or economic knowledge than external design (Li, 2012). I therefore illustrate all three types of SIPO patents in the five regions to investigate the component of regional innovation performance.



Source: Compiled by author using collected data from SIPO website.

Figure 4.16 Total number of three types of patents by the five regions (2000-2010)

Figure 4.16 shows that the numbers of each type of patent in Beijing, Shanghai, and Guangdong are much larger than those in Hubei and Hunan. This is coincident with the status of the big-three regions and two central regions in the NIS of China. Specifically, Beijing and Shanghai are driven by invention patents, while Guangdong, though the absolute volume of each type of patent is greater than in the other two coastal regions, is dominated by external designs. Those two central regions have more utility models than inventions and designs. Thus, I postulate that the five regions reflect three different regional innovation structures.

Table 4.18 Number and share of the three types patents in 2000 and 2010

Region	2000			2010		
	Invention (%)	Utility (%)	Design (%)	Invention (%)	Utility (%)	Design (%)
Beijing	3176	3778	1683	32471	17188	4490
	(37)	(44)	(19)	(60)	(32)	(8)
Shanghai	4406	2263	2373	23446	20699	13585
	(49)	25	(26)	(41)	(36)	(23)
Guangdong	1705	5025	11792	38789	42708	49622
	(9)	(27)	(64)	(30)	(32)	(38)

Hubei	699 (26)	1529 (56)	491 (18)	6613 (32)	10090 (48)	4137 (20)
Hunan	707 (23)	1713 (57)	603 (20)	5434 (31)	7782 (24)	4053 (45)

Note: Figures in the parentheses show the total as a percentage of the full regional sample.
Source: Compiled by author by using data collected from the website of SIPO.

Table 4.19 Growth rate and change of share of the three types of patent from 2000 to 2010

Region	Increase rate (%)			Change of share (%)		
	Invention	Utility	Design	Invention	Utility	Design
Beijing	922	355	167	23	-12	-11
Shanghai	432	815	472	-8	11	-3
Guangdong	2180	750	321	21	5	-26
Hubei	846	560	743	6	-8	2
Hunan	669	354	572	8	-33	25

Source: Compiled by author using collected data from SIPO website.

Table 4.18 and 4.19 display dynamic changes of the regional innovation structures during 2000 to 2010. Basically, each type of patent experienced a surge in numbers during these 11 years. The biggest jump occurred in the amount of inventions in Guangdong, which increased 2,180% (from 1,705 in 2000 to 38,789 in 2010). Although the increased rate of invention patenting in Beijing, Hubei and Hunan is lower than that of Guangdong, invention patenting is still the key area to facilitate in those three regions. The three columns on the right display the change of share of each type of patent in the sample period. For the big-three regions, the increased share of invention patents in Beijing (from 37% to 60%) and in Guangdong (from 9% to 30%) is much greater than for other types of patent. The adjustment of the shares in Shanghai was not substantial as the share of utility model increased 11% (25% to 36%). For the two central regions, changes in Hubei were much smaller than in Hunan. Unlike Shanghai, Hunan decreased the share of utility model patents dramatically (from 57% to 24%) but stimulated a huge growth of external design patents (from 20% to 45%). Therefore, I deduce that adjustment of regional innovation structure in Beijing, Guangdong and Hunan was substantive and with different directions. Regional innovation structures in Shanghai and Hubei were more stable.

Table 4.20 Accumulated number and proportion of patent applications (1996-2010)

Region	Organizations					Individuals (%)	Total[d]
	HE (%[a])	RI (%)	IS (%)	PG (%)	Total[b] (%[c])		
China	303052 (11.3)	139774 (5.2)	2194387 (81.9)	41578 (1.6)	2678791 (48.2)	2876691 (51.8)	5555482
Beijing	37570 (17.5)	37645 (17.5)	138070 (64.1)	1970 (0.9)	215255 (65.5)	113258 (34.5)	328513
Shanghai	42992 (12.7)	16201 (4.8)	263195 (77.5)	17411 (5.1)	339799 (84.2)	63571 (15.8)	403370
Guangdong	16598 (4.1)	6157 (1.5)	379448 (93.9)	1913 (0.5)	404116 (46)	473569 (54)	877685
Hubei	15429 (19)	5063 (6.2)	57797 (71.2)	2904 (3.6)	81193 (50.7)	78996 (49.3)	160189
Hunan	6919 (15.4)	1679 (3.7)	35947 (80)	399 (0.9)	44944 (36.7)	77363 (63.3)	122307

Notes: HE: Higher Education Institutions; RI: Research Institutions; IS: Industrial Sectors; PG: Public Group; a: the proportion is the number of patent from HE to total number of patents from organizations at national or regional level; b: the total is the sum of patents from HE, RI, IS, PG at national or regional level; c: the proportion is the number of patents from organizations to the overall number of patents at national or regional level; d: the total here is the overall number of patents at national or regional level.
Source: Compiled by author from website of SIPO.

Table 4.20 shows accumulated data on patent applications from individuals and organisations from 1996 to 2010. Firstly, for Guangdong and the central regions of Hubei and Hunan, the majority of patents were taken out by individuals as opposed to organisations which was not the case for Beijing and Shanghai. Secondly, considering different organisational categories, industrial sectors was the largest contributor to patent applications for all the five regions, particularly for Guangdong where the share of the industrial sectors accounted for 93.9% of all regional patent applications, exceeding the national average level of 81.9%. Last but not least, the higher education institutions performed much better in Beijing (17.5%), Hubei (19%) and Hunan (15.4%), which were even above the national average level of 11.3%. These phenomena indicate that each RIS is heterogeneous in terms of active inside players.

4.3.5 Policy highlights of the five regions

The policy framework relating to each RIS is critical in any country, but particularly so for China as a transition country with such strong state intervention in directing resources within the economy and with such an emphasis on building up its innovation capacity (see previous sections for details). I begin here to tease out some of the differences in emphasis between the different regions in terms of their focus on the various types of policy intervention. This is done through a template analysis of regional government work reports for each region over a ten year period.

In the international context, the reform of public S&T systems in post-socialist countries also occurred in some central and eastern European countries. The challenges facing the authorities in those countries and in China were similar, i.e. to transform the R&D system which was detached from industry and to foster the IC of the enterprises which were not main agents of innovation under the socialist planning economy.

The government work reports for each region include comprehensive aspects of regional development. I here focus on six key aspects: inter-regional collaboration; international collaboration; the importance given to attracting foreign investment; high technology industry development; undertaking industrial transfer; and cooperation of industry, academia, and research.

Table 4.21 Highlights of regional policies of the five regions (2002-2011)

Region	Inter-region collaboration	Inter-nation collaboration	Importance of Foreign investment	High tech industry develop	Industrial transfer	IAR
Beijing	++++	++	+++++	++++++++		++++
Shanghai	++++	+++++++	+++	++++++++	++	+++++
Guangdong	++++++	+++	++++++	++++++++++	++++	+++++++
Hubei	+	++	+++++++	++++++++++	+++++	++++++++
Hunan	++	++	+++++++	++++++++++	+++++	++++++

Note: IAR: Industry, academia and research institutions.
Source: Compiled by author from Government Work Report of Beijing, Shanghai, Guangdong, Hubei and Hunan (2002 to 2011).

A plus symbol was added in Table 4.21 if any key point is emphasised as a main task/plan in the government work report in a given year. For Hubei and Hunan, there is much less emphasis on inter-regional and international collaboration and more on attracting FDI, on developing high technology industry, and on transforming industry and fostering cooperation between industry, research institutions, and higher education. This is consistent with my previous analysis that Hubei and Hunan have strength in their resources in higher education, whereas their linkages between education and industry are relatively weak and the potential for cooperation is not fulfilled.

There are further distinctions from the other regions: first is the targeting in Hubei and Hunan of leading companies in the car, steel, petrochemical, and equipment industries such as Sany Heavy Industry Co., and Zhuzhou Electric Locomotive Co. The second distinction is the continuing role of agriculture and seeking to introduce innovations and technology into the agricultural sector, reflecting the continuing role that agriculture plays in these regional economies. And parallel with this there is an emphasis in the reports on industrial and high technology development zones. For example, Hubei is focussing on building the East Lake High-Tech Development Zone and Hunan is concentrating on building the Changsha High-Tech Development Zone.

In addition both Hubei and Hunan are trying to build their new economies in the '*two-oriented mode*', namely for a resource-conserving and environment-friendly society. So a series of regional government policies are aiming to decrease the number of those environmental harming firms/factories and encourage more high technology based enterprises.

4.4 Concluding remarks

Overall, in order to answer the first specific research question (RQ1), "*Why are FDI and IS two critical factors in a **regional** innovation system?*", this chapter systematically analyses the development path of each Chinese RIS, IS, and foreign investment. Both the historical development trend and the key points of relevant policies have been documented, which is very helpful for us to understand the idiosyncratic features of Chinese NIS, FDI and IS. I also made several descriptive analyses based on the regional level dataset collected from the China's NBS, which not only complements the findings based on various documents and archives but also advances the understanding about the exact trends of dynamic changing processes of each RIS, FDI and IS. Additionally, the findings of this chapter indicate that the developments of the Chinese RIS, FDI and IS, especially since the implementation of the "*Reform and Opening Up*" policy in 1978, are closely connected with each other, and the changing processes in the last decade provide me with a reasonable context to further investigate the question as to whether (and how) the association between foreign presence and regional innovativeness will be affected by regional IS.

The following descriptive studies on RISs are comprehensive and comparable analyses on two groups of regions in China from the perspectives of foreign presence, regional

IS and innovation output. I found that state-owned enterprises and FIEs are the main contributors to regional economies as the proportion these enterprises contribute exceeds half of the regional gross industrial output value. For Beijing, Shanghai, and Guangdong, the role played by state-owned enterprises and FIEs was stable and important. Meanwhile, FIEs in Shanghai and Guangdong were extremely active compared with other regions. For the two central regions, Hubei and Hunan, the regional IS is more balanced than in the big-three regions. POEs become the main contributor to the regional economy in Hunan in 2010. Considering that POEs usually do not have enough R&D expenditure and R&D personnel, their innovation strategies are more likely to focus on temporal economic profit and their innovation quality might be lower than those of state-owned enterprises and FIEs. This is the reason why the share of regional utility models of Hunan declined 33% while the share of external designs soared up to 25% during 2000 to 2010.

In addition, the shares of the LMEs' industrial output in Beijing, Shanghai, Guangdong, and Hubei increased dramatically from 2000 and 2010 (see analyses in previous sections). This supports the expectation that LMEs in China are more likely to gain economic advantages and profits through R&D activities because their ambitious strategies require them to merge into the bigger market and build up their technology edges. This potential effect on regional innovation reflects the large amount of invention patents in Beijing and Shanghai, and also the huge jump in the amount of invention patents in Guangdong from 2000 to 2010. Although innovation performance in Hubei was lower than that of the big-three regions, LMEs in Hubei play a very essential role in facilitating regional innovation.

The importance of HTEs for regional R&D activities has been discussed in previous sections and is evidenced by the data analysis for the five regions. Generally, the share of gross output of HTEs of the big-three regions was around 20% during the sample period. These HTEs clustered in Beijing, Shanghai and Guangdong had become the R&D centre of the whole of China. For instance, the gross output and amount of patent applications of '*Electronic and Telecommunications Equipment*' manufacture in Guangdong accounted for 36% and 71% of total output and number of patent applications of this industry in the whole China, respectively. In other words, HTEs' potential effects have emerged in some clustered regions in China (Hu et al., 2005; Zhou & Xin, 2003). As HTEs are more likely to be concerned about the novel knowledge creation and utilised technology, the share of inventions and utility models of the big-three regions indicates the potential linkage of HTEs and high quality R&D outputs. Hubei and Hunan were more traditional industry based as HTEs in these regions occupied very limited proportions. In turn the contributions to regional innovation output made by regional high technology industries were not significant.

More importantly, I find that the big-three regions were more specialised in technology intensive industries, like '*Electronic and Telecommunications Equipment*' and '*Instrument and Meter*' or '*General Machinery*'. In contrast, Hubei and Hunan were more specialised in those labour or capital intensive industries, such as '*Tobacco Processing*' and '*Non-metal Minerals Mining and Dressing*'. By focussing on the evolution process of each regional IS, I notice that the majority of these five regions favoured the mode of LSHD. To further investigate precisely the roles of FDI and IS in affecting regional IC, I conducted an empirical study at regional level in Chapter 5.

Chapter 5 FDI, industrial structure, and regional innovation capability: evidence from Chinese provinces

5.1 Introduction

In the last chapter, I answer the first specific research question (RQ1) and highlighted that regional foreign presence and industrial structure (IS), i.e. specialisation and diversity, are two critical factors within a Chinese RIS. This chapter is designed to examine the roles of regional foreign presence and IS in affecting regional innovativeness through theoretical analysis and panel regression estimates, thus answering the second specific research question (see Chapter 1 for details of RQ2).

As previous literature noted, FDI brings technology spillovers but little is known about the interactive effects of IS at regional level on how FDI works to bring spillovers. This is particularly relevant in the context of China as the leading recipient of FDI, which is both regionally skewed regarding distribution of FDI and unevenly distributed by industry. I tried to examine the effects of FDI through regional IS on innovation at the regional level in China. Adopting an 11 years panel (2000 to 2010) of data on FDI in China, this chapter empirically investigates the spillover effects of inward FDI and industrial externalities on regional innovativeness. More importantly, I investigated the moderating roles of industry specialisation and diversity in affecting the association between foreign presence and regional innovation capabilities. The results indicate that inward FDI has positive effects on regional innovation capabilities, but industrial specialisation diminishes the positive effects of FDI whilst a more diversified IS enhances spillovers from inward FDI.

In general, technology innovation activities in developing countries are weaker than those in developed nations due to lack of frontier knowledge and sufficient R&D investments (Bell and Albu, 1999). Both the economic base and the scientific base constrain technology innovation and upgrading at the regional level in emerging countries, such as China (Prevezer et al., 2013). To facilitate national technology capability and knowledge transfer, policy makers designed attractive stimuli and perfect infrastructure to attract overseas investments (Asiedu, 2002). For instance, Deng Xiaoping, as the leader of Chinese government in the 1980s proposed the "*Reform and Opening Up*" policy in 1980s, and relevant policies such as that on markets for advanced technology, to enrich channels of overseas capital and technology. In recent years, FDI has poured into the Chinese market and during the last three decades China has overtaken the US and become the prime destination of FDI (UNCTAD, 2011).

Moreover, as extant literature has pointed out, regional development, especially in the context of a developing country, can gain benefit from overseas investments (Ben Hamida, 2013; Driffield, 2004; Fu, 2008; Girma and Wakelin, 2002; Padilla-Pérez, 2008; Vang and Asheim, 2006). Attracting FDI from developed countries, e.g. the US, or in the EU or eastern Asia, is an effective way to facilitate development in terms of domestic economic strength and innovativeness in emerging markets (Lu et al., 2011; Marin and Bell, 2006; Tian, 2006; Wei and Liu, 2006). During this process, not only is foreign capital helpful in upgrading regional infrastructure and equipment but the advanced knowledge embodied in the FDI can also spillover to innovators through various channels, for instance via the demonstration effect and vertical linkages with domestic firms (see Chapter 2 for details).

Both streams of literature regarding international business and the RIS have realised the essential role played by FDI in enhancing regional innovativeness. An increasing number of studies have pointed out that the amount of FDI itself may not directly determine whether regional innovators can gain benefit from spillover knowledge of foreign presence. Regional idiosyncratic features, e.g. infrastructure, science base, and technology markets, etc., can influence the effect of foreign spillovers on regional innovation (Fu, 2008; Fu et al., 2011; Girma and Wakelin, 2002; Kemeny, 2010). Such an argument is particularly important in the Chinese context since there are huge regional discrepancies in terms of economic strength and innovation capacity: for instance, Chinese coastal regions are much more prosperous than those inland regions in terms of economic strength and innovativeness (Gao et al., 2011; Li, 2012; Prevezer et al., 2013).

Numerous prior studies have focussed on the effects created by the sources of FDI, e.g. from Organisation for Economic Co-operation and Development (OECD) countries or from transition economies (Buckley et al., 2002; Filatotchev et al., 2009); by various types of linkages, e.g. horizontal or vertical linkages (Liu et al., 2009); by indicators of foreign existence, e.g. based on assets or on employment (Tian, 2006); by the process of foreign presence, e.g. pace and irregularity (Wang et al., 2012); and by the linkages with foreign investors (Girma and Gong, 2008; Iršová and Havránek, 2013). According to the review of related literature in Chapter 2, much less emphasis has been given to the relationship between the host industrial environment in which FDI is engaged and the effect of industrial specialisation and diversity associated with FDI. Industrial diversity contrasts with industrial specialisation, whereby a region has a greater concentration of a particular industry within compared with the whole of country, measuring the spread of industries within a region. The emphasis on the IS is particularly relevant in the Chinese context. China has been making efforts to restructure its industrial composition in establishing the NIS since the end of the 1990s (Sun and Liu, 2010). As analysed in Chapter 4, the majority of Chinese industrial sectors have been opened to overseas investors gradually since China joined the WTO at the end of 2001. Meanwhile, the Chinese government launched various policies at both national level and regional level to facilitate the development of S&T.[22] On the other hand, manufacturers in coastal regions began to move into inland regions as the advantages of low labour and land costs in coastal regions diminished during the last decade. This provides a valuable opportunity to investigate the roles of FDI and industrial externalities and their potential effects on regional innovativeness.

Prior studies have focussed on the effects of FDI on regional economic performance or productivity, but there is little empirical evidence related to the roles of industrial specialisation and diversity in moderating the relationship between knowledge spillovers of FDI and regional innovation capabilities, and none for China (see Chapter 2 for more review results). This chapter therefore aims to explore the effect of IS on regional innovativeness by region and the impact of FDI by region. In particular, I expect that association between foreign presence and regional innovativeness is contingent on the degree of industrial specialisation and diversity. This research addresses a gap in the literature, as most studies on the impact of FDI were conducted in developed countries, and few empirical studies explored the effects of industrial specialisation and diversity in emerging economies (Beaudry and Schiffauerova, 2009). This chapter contributes to this literature on FDI impacts and on IS and to the MAR

[22] Typical S&T policies at national level and regional level are discussed in Chapter 4.

versus Jacobs debate.

5.2 Hypothesis development

5.2.1 Inward FDI and regional innovation

Innovation is a process of knowledge recombination and creation (Cohen and Levinthal, 1990a). FDI is believed to be a carrier of advanced technology and managerial knowledge (Buckley et al., 2002; Fu, 2012). This knowledge, whether embedded as tacit knowledge, or codified knowledge in technology processes, is usually novel to those host innovators. A large body of prior studies claims that regional innovators can benefit from knowledge spillovers of FDI through several channels (Ben Hamida, 2013; Ito et al., 2012; Sasidharan and Kathuria, 2011; Wei and Liu, 2006). Firstly, new products and services launched by FIEs or MNEs give domestic firms access to advanced technology and fresh ideas which are essential for them to improve and update their products (Buckley et al., 2007b). Regional IC can benefit from this demonstration effect due to the knowledge accumulation of domestic firms and individuals, i.e. from imitation of foreign firms' demonstrations. Secondly, the challenges of MNEs create competition effects on domestic firms. To protect their market share, regional firms have to invest more in R&D (Girma et al., 2009). It is common to find that MNEs adapt their products for regional consumer demands through product innovation strategies (Yamin and Otto, 2004). This competition effect, created by foreign presence, enhances regional innovativeness (Ben Hamida, 2013). One of the main objectives of foreign investors is to enlarge their global market share; therefore counterparts in host countries will be challenged to protect their domestic markets.

A suggested way to increase domestic firms' competitiveness is to increase their R&D investments and upgrade their technical strength. At regional level, as Marrocu et al. (2013) pointed out, government needs to propose specific policies to increase R&D inputs, especially to increase the endowments of a well-educated labour force and therefore their knowledge base, which is helpful for regional knowledge production and competitiveness enhancement. Thirdly, vertical and horizontal links between MNEs and regional suppliers create networked channels for knowledge spillovers. Buckley et al. (2007b) find that collaborations between MNEs and domestic firms are beneficial to regional firms' technology upgrades and also enhance knowledge transfer from overseas markets. Various types of link, vertical versus horizontal linkages, formal versus informal linkages, between firms undertaking FDI and regional players, create knowledge spillovers that enhance regional knowledge creation (Barrutia et al., 2014; Girma and Gong, 2008; Liao and Yu, 2013). Finally, employee turnover and job mobility from MNEs to domestic firms has proved to be important for local firms in absorbing tacit knowledge from FDI (Fosfuri et al., 2001; Liu et al., 2009). This is because tacit knowledge is embedded in employees and is hard to exploit except by face-to-face communication or learning-by-doing (Breschi and Lissoni, 2001a, b). I thus propose the first hypothesis as the follows.

Hypothesis 1: Inward FDI has a positive effect on regional IC.

5.2.2 Industrial externalities and regional innovation

Research regarding industrial externalities has mainly been inspired by the seminal work of Marshall (1890) and Jacobs (1969) in which industrial specialisation and diversity, respectively, were first introduced. Specifically, industrial specialisation indicates that a region has a greater concentration of a particular industry compared with the whole of the country, while industrial diversity measures the spread of industries within a region. The MAR model (industrial specialisation) claims that the concentration of an industry in a region promotes knowledge spillovers between firms and facilitates innovation in that particular industry (Beaudry and Schiffauerova, 2009). Studies supporting the MAR model contend that knowledge transfer within the same or similar industries in a spatial proximity is an important way to enhance innovation in the cluster (Giuliani and Bell, 2005). Their rationale for this argument is the following. First, tacit or codified knowledge can be shared among cluster members with much lower transmission costs within the same sector (Saxenian, 1996). Secondly, advanced technology can be embedded through the mobility of skilled workers (Edler et al., 2011), collaborative R&D activities (Yeung et al., 2006) or face-to-face communications (Storper and Venables, 2004). Proximity between cluster members facilitates these knowledge transfers. Thirdly, industrial localisation is preferably carried out in a less competitive or more monopolistic environment (Glaeser et al., 1991) in which valuable R&D resources are concentrated, and this kind of knowledge concentration fosters the creation of new technologies or products.

Empirical studies offer a series of successful cases for agglomeration economies, such as the clustering of economies at regional level in most developed as well as emerging markets (Porter, 1990b); the frequently cited case of the industrial system of Silicon Valley (Saxenian, 1994); as well as the Zhongguancun Park in Bejing (Tan, 2006); and the rapid economic growth of networked SMEs in the '*Third Italy*' (Asheim, 2000), etc. The rationale behind these successful cases is that spatial agglomeration provides a wonderful platform in which regional innovators are more likely to learn from their neighbours as '*sticky*' knowledge is embedded in social interactions (Asheim and Coenen, 2005). Additionally, studies argue that an insular environment protects innovation and that powerful companies within a regional cluster can reallocate R&D resources more efficiently and pursue frontier technologies (Frenken et al., 2004; Mukkala, 2004). This argument has been supported by various cases in both developed countries and emerging markets (Jaffe et al., 1993; Sun and Liu, 2010; Venables, 1996). Finally, the intense use of infrastructure by a highly specialised industry within a certain geographical region is more efficient than its use by scattered industrial configurations (Beaudry and Schiffauerova, 2009). Therefore, I argue that a specialised regional IS is beneficial for innovative activities.

Hypothesis 2: Regional industrial specialisation has a positive effect on regional IC.

In contrast to the MAR model, Jacobs (1969) argues that diversity is the major engine for fruitful innovation, because "*the greater the sheer number of and variety of division of labour, the greater the economy's inherent capacity for adding still more kinds of goods and services*" (Jacobs, 1969). Supporters of the Jacobs model claim that the most important sources of knowledge spillovers are external to the industry within which the firm operates (Beaudry and Schiffauerova, 2009). The interactive communication between different industries, especially interactive linkages between manufacturing and complementary sectors, is thought to be a crucial platform for knowledge recombination and recreation. Emerging technology fields usually benefit from a more diverse economy since they promote greater skill exchange between sectors (Harrison et al., 1996). Greater opportunities to imitate, share, and recombine ideas and practices across industries are believed to be embedded within a more diverse regional economy

(Beaudry and Schiffauerova, 2009). Thirdly, knowledge and information from various disciplines at a regional level give regional producers and service providers new perspectives to explore possible directions for radical innovation (McDermott and O'Connor, 2002). In other words, a more dynamic and diversified range of customers stimulates regional innovators to research and develop personalised products and services, and this demand is more likely to be realised in a diversified context (Driessen et al., 2013). For instance, the demand for smartphones tailored to many functions and personalities is causing mobile phone producers to adopt various technologies from different industries. Regions with more diversified innovation capabilities will benefit from these trends. Thus, I propose the following hypothesis:

Hypothesis 3: Regional industrial diversity has a positive effect on regional IC.

5.2.3 The moderating roles of industrial specialisation and diversity

Although a highly specialised industry clustered in a geographical area may enhance knowledge sharing and exchange among cluster members, it may also create many factors that prevent FDI spillovers from being realised. First of all, a more specialised region is usually one with less flexibility to adjust its economic structure in the face of external shocks such as financial crises, and so with less capacity to weather exogenous changes (Beaudry and Schiffauerova, 2009; Frenken et al., 2004). Since inward FDI usually brings novel knowledge compared with the knowledge base of regions in a host country, the inflexibility of the region may impede regional innovators to access knowledge spillovers from foreign presence (Ernst and Kim, 2002). By contrast, a diversified regional environment with broader customer demands and technology fields may increase region attractiveness to overseas investors with long term development plans. For instance, Cheng (2001) found that regions with huge market potential and good regional infrastructure were more likely to have higher foreign presence in the Chinese context during 1985–2005, and Chung (2002) contends that technology diversity is a critical factor when firms make efforts to acquire knowledge through overseas investment. Moreover, one of the goals of foreign investors is to create a new market in the host country and face less excessive market competition. A new industry is more likely to emerge in a diversified environment where MNEs have greater opportunity to become market leaders than from a specialised IS.

Secondly, compared with domestic firms, FIEs usually carry more advanced and novel technologies than domestic firms, especially in the developing countries. Buckley et al. (2002) observe higher FDI spillovers in China from non-Chinese (OECD) firms than from overseas-Chinese firms. New ideas and knowledge are more likely to be explored and exploited by regional innovators if the regional knowledge base is strong and compatible with this advanced knowledge (Kuemmerle, 1999). Specialised regions are usually more vulnerable to locking in, i.e. "*closing upon themselves, becoming insular and impermeable, and preventing knowledge and fresh innovative ideas from outside to flow in*" (Beaudry and Schiffauerova, 2009). A region with highly clustered industrial sector(s) may resist novel technologies and managerial knowledge from outside industries which is as well a critical source of regional knowledge creation. In contrast, regions with multiple industries and technology fields may be more open and welcome to external ideas and knowledge. Knowledge spillovers from foreign presence may be less likely to be accepted in a specialised region, but are more likely to be absorbed in diversified regions.

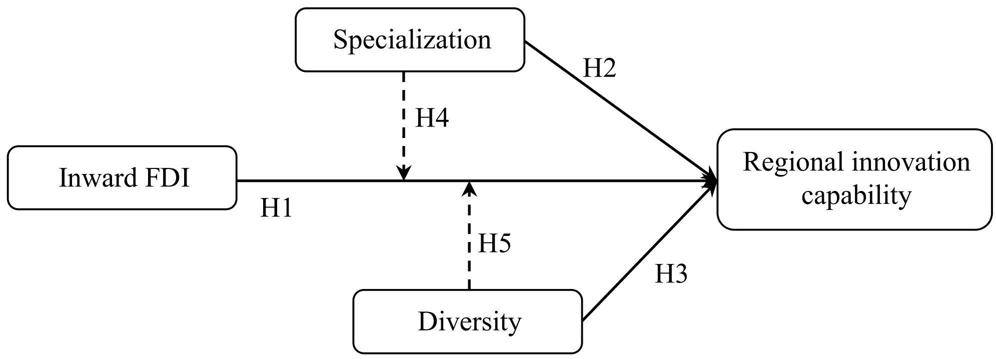
Thirdly, once FDI has been introduced into the regional economy, regional innovators need a relevant knowledge base to explore, assimilate, exploit, and apply those advanced technologies embedded in FDI (Cohen and Levinthal, 1990a). Since more specialised regions have developed more specialised knowledge bases than diversified regions, the chances of regional absorptive capacity being compatible with foreign technologies are greater for diversified regions than for specialised regions. More diversified regions will have a broader knowledge base that plays a crucial role in absorbing technology spillovers from regional MNEs (Gao, 2004).

Finally, since parts and service suppliers in diversified regions cover a wide scope of fields, vertical and horizontal links between MNEs and those suppliers are more likely to be created and maintained (Boschma and Iammarino, 2009). Therefore, regional innovators have more channels to learn tacit knowledge from MNEs in diversified regions than in specialised regions (Asheim et al., 2011). Based on these arguments I put forward the following hypotheses.

> **Hypothesis 4:** Industrial specialisation negatively moderates the association between FDI and regional IC, i.e. the positive effect of FDI on regional IC will be mitigated with the increase of the degree of regional industrial specialisation.

> **Hypothesis 5:** Industrial diversity positively moderates the association between FDI and regional IC, i.e. the positive effect of FDI on regional IC will be enhanced with the increase of the degree of regional industrial diversity.

The above hypotheses are summarised in Figure 5.1



Notes: The arrow with solid line represents the impacts of FDI and industrial structure on innovation capability, the arrow with dashed line represents moderating effect of industrial structure on the relationship between FDI and innovation capability.

Figure 5.1 Empirical framework of the regional level study

5.3 Results

5.3.1 Descriptive analysis

As prior studies highlighted that there is a high discrepancy of geographic distribution of economic and innovative elements in China (Fu and Mu, 2014), Table 5.1 illustrates the differences of population, industrial output, and patents between coastal regions and inland regions.

Table 5.1 Shares of regional employment, output and patent (2000, 2010)

Province	Population share (2000)	Output share (2000)	Output share (2010)	Patent share (2000)	Patent share (2010)
Coastal	0.389	0.707	0.763	0.697	0.665
Northern Coastal	0.178	0.261	0.194	0.247	0.260
Eastern Coastal	0.109	0.233	0.390	0.272	0.248
Southern Coastal	0.102	0.214	0.179	0.179	0.156
Inland	0.611	0.293	0.237	0.303	0.335
Far West	0.046	0.019	0.009	0.025	0.020
Northern Inland	0.124	0.079	0.046	0.085	0.085
Central Inland	0.252	0.112	0.113	0.126	0.155
Southern Inland	0.188	0.083	0.070	0.067	0.075

Source: Author's calculations based on *China Statistical Yearthesis* (2001, 2011).

Note: The seven regions in the table are the Northern Coastal region (Liaoning, Hebei, Beijing, Tianjin, and Shandong), the Eastern Costal region (Jiangsu, Shanghai, and Zhejiang), the Southern Coastal region (Fujian, Guangdong, and Hainan), the Far Western region (Xinjiang, Qinghai, Gansu, and Ningxia), the Northern Inland region (Heilongjiang, Jilin, Neimenggu, Shaanxi), the Central Inland region (Henan, Anhui, Jiangxi, Hubei, and Hunan), and the Southern Inland region (Sichuan, Guizhou, Yunnan, and Guangxi).

It can be seen in Table 5.1 that a large proportion of industrial output was produced by firms located in coastal regions while the population of these coastal regions account for no more than 40% of China's total population. Meanwhile, nearly 70% of patents were granted to coastal regions while the IC of inland regions in terms of patent applications was merely half as strong as coastal regions in 2000. However, an increase of patent share (3.2%) of inland regions and the decline of the share of coastal regions from 69.7% to 66.5% might indicate that inland regions are making efforts to catch up in technology innovation. More specifically, the balanced configuration of industrial output of the three coastal regions was broken, i.e. industrial output became more centralised in the eastern coastal region, with the share increasing 15.7% during the sample period while the share in the northern coastal region and southern coastal region dropped 6.7% and 3.4% from 2000 to 2010, respectively. However, the dominant role of IC in the eastern coastal region seems to have been replaced by the northern coastal region as the patent share of the northern coastal region increased to 26% while in the eastern coastal region it was 24.8% in 2010. The circumstances of the four inland regions are a bit monotonous. The central region had the largest proportion of population (25.2%) and also had the strongest power in terms of industrial production and innovation. The comparison between different regions in terms of industrial production capability and IC indicates that regional IC is not completely in accordance with regional production capacity: there are some other determinants that impact on the regional innovativeness.

Table 5.2 Shares of industrial output and granted patent by province (2000, 2010)

Province	Eastern(E)/ Central(C)/ Western(W)	Output share[a] (2000) (1)	Output share (2010) (2)	Output change (2)-(1) (3)	Patent share[b] (2000) (4)	Patent share (2010) (5)	Patent change (4)-(5) (6)
Shandong	E	0.097	0.120	0.023	0.074	0.071	-0.003
Neimenggu	W	0.009	0.019	0.010	0.008	0.003	-0.006
Jiangsu	E	0.122	0.132	0.010	0.066	0.195	0.129
Henan	C	0.041	0.050	0.009	0.030	0.024	-0.006
Jiangxi	C	0.011	0.020	0.009	0.013	0.009	-0.004
Sichuan	W	0.024	0.033	0.009	0.035	0.035	0.000
Hunan	C	0.019	0.027	0.008	0.029	0.020	-0.009
Anhui	C	0.019	0.027	0.007	0.014	0.035	0.021
Hebei	E	0.040	0.045	0.005	0.032	0.015	-0.018
Shanxi	C	0.014	0.018	0.004	0.014	0.009	-0.005
Liaoning	C	0.050	0.052	0.002	0.051	0.025	-0.025
Shaanxi	W	0.014	0.016	0.002	0.016	0.018	0.001
Guangxi	W	0.012	0.014	0.002	0.013	0.005	-0.007
Chongqing	W	0.011	0.013	0.002	0.014	0.019	0.005
Fujian	E	0.031	0.031	0.001	0.033	0.023	-0.009
Ningxia	W	0.003	0.003	0.000	0.003	0.001	-0.002
Qinghai	W	0.002	0.002	0.000	0.001	0.001	-0.001
Hainan	E	0.002	0.002	0.000	0.004	0.002	-0.002
Jilin	C	0.020	0.019	-0.001	0.018	0.007	-0.011
Guizhou	W	0.007	0.006	-0.001	0.007	0.004	-0.003
Xinjiang	W	0.010	0.008	-0.002	0.008	0.004	-0.004
Gansu	W	0.010	0.007	-0.003	0.006	0.003	-0.003
Yunnan	W	0.012	0.009	-0.003	0.014	0.006	-0.008
Zhejiang	E	0.077	0.074	-0.004	0.080	0.127	0.047
Hubei	C	0.036	0.031	-0.005	0.026	0.024	-0.002
Tianjin	E	0.030	0.024	-0.006	0.021	0.019	-0.002
Beijing	E	0.030	0.020	-0.010	0.083	0.064	-0.019
Heilongjiang	C	0.029	0.014	-0.015	0.022	0.010	-0.012
Guangdong	E	0.146	0.123	-0.023	0.177	0.154	-0.023
Shanghai	E	0.072	0.043	-0.029	0.086	0.068	-0.019

Source: Author's calculations based on *China Statistical Yearthesis* (2001, 2011).
Notes: According to the classification of the National Bureau of Statistic of the P.R.C., the Eastern region includes Beijing, Tianjin, Hebei, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong and Hainan; the Central region includes Shanxi, Anhui, Jiangxi, Henan, Hubei, Hunan, and I aggregate three East Northern regions (Liaoning, Jilin, Heilongjiang) into this category as well; the Western region includes Neimenggu, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Shaanxi, Qinghai, Gansu, Ningxia and Xinjiang.
[a] Output share=region i's industrial output in year t/national industrial output in year t
[b] Patent share= region i's industrial output in year t/national industrial output in year t

Table 5.2 above shows regional proportion of industrial output and patents against national total of industrial output and patents, respectively. Developed regions, e.g. Beijing, Shanghai, and Guangdong, decreased much more than those developing regions, e.g. Henan, Jiangxi, and Neimenggu, in terms of industrial output. From the last column of Table 5.2, I find that only five regions increased their share of granted patents during the period from 2000 to 2010. And more interestingly, Jiangsu and Zhejiang, two eastern coastal regions, increased their patent share much more than other regions, rising 12.9% and 4.7% respectively.

As discussed in the previous section, China was the largest recipient of FDI in last decade, yet the amount of FDI in different regions varied. In addition, given that regional heterogeneity, e.g. regional population and area, is believed to be an important factor related to regional economic and knowledge bases, IC in this study is measured as patent applications per 10,000 inhabitants, which can offset the impact of regional heterogeneity on the estimation of the effects of FDI and industrial externalities. Table 5.3 and Table 5.4 below list both average patent applications and foreign presence in 30 Chinese regions in 2000 and 2010, respectively.

In addition, the economically developed regions, such as Beijing, Shanghai, Jiangsu, Zhejiang, and Tianjin, were the most innovative regions as patent applications per 10,000 inhabitants in these regions increased by over 15 patent applications per 10,000 inhabitants while the majority of other regions increased no more than 5. Moreover, I find that the members of the top ten regions are very similar for each indicator, suggesting that traditional developed regions are more innovative than other regions.

Table 5.3 Average patents by province (2000, 2010)

Province	Patents[a] (2000) (1)	Rank	Patents (2010) (2)	Rank	Pat.change (2)-(1) (3)	Rank
Beijing	7.485	**1**	29.203	**3**	21.718	**3**
Tianjin	2.786	**3**	19.995	**5**	17.208	**5**
Hebei	0.571	18	1.709	20	1.138	20
Shanxi	0.447	22	2.218	19	1.771	18
Neimenggu	0.479	21	1.178	26	0.699	28
Liaoning	1.687	**6**	7.821	**10**	6.133	**10**
Jilin	0.917	**10**	2.346	18	1.429	19
Heilongjiang	0.842	11	2.679	16	1.837	17
Shanghai	6.772	**2**	30.914	**1**	24.142	**2**
Jiangsu	1.104	**8**	29.975	**2**	28.871	**1**
Zhejiang	2.206	**5**	22.167	**4**	19.961	**4**
Anhui	0.314	28	7.911	**9**	7.598	**7**
Fujian	1.213	**7**	5.956	12	4.742	13
Jiangxi	0.376	26	1.413	22	1.037	23
Shandong	1.104	**9**	8.433	**7**	7.33	**9**
Henan	0.413	23	2.674	17	2.261	16
Hubei	0.578	15	5.466	13	4.888	12
Hunan	0.639	12	3.407	15	2.767	15
Guangdong	2.444	**4**	14.645	**6**	12.201	**6**
Guangxi	0.393	25	1.11	29	0.717	27
Hainan	0.638	13	1.173	27	0.535	30
Chongqing	0.576	17	7.912	**8**	7.336	**8**
Sichuan	0.54	20	5.001	14	4.461	14
Guizhou	0.28	30	1.269	24	0.989	24
Yunnan	0.399	24	1.227	25	0.828	25
Shaanxi	0.577	16	6.144	11	5.567	11
Gansu	0.311	29	1.39	23	1.078	21
Qinghai	0.336	27	1.069	30	0.733	26
Ningxia	0.607	14	1.167	28	0.561	29
Xinjiang	0.565	19	1.629	21	1.064	22

Source: Author's calculations based on *China Statistical Yearthesis* (2001, 2011).
Notes: [a] Average patent=region *i*'s amount of patent applications in year t/region *i*'s 10,000 inhabitants in year *t*.

Table 5.4 Regional foreign presence by province (2000, 2010)

Province	Foreign presnce[a] (2000) (1)	Rank	Foreign presence (2010) (2)	Rank	Foreign presence.change (2)-(1) (3)	Rank
Beijing	44.84	**5**	52.155	**7**	7.315	19
Tianjin	45.876	**4**	55.766	**6**	9.889	18
Hebei	10.878	17	22.481	17	11.603	14
Shanxi	4.994	26	6.6	27	1.606	26
Neimenggu	7.284	22	14.163	19	6.879	21
Liaoning	19.902	**7**	37.674	**10**	17.773	11
Jilin	18.581	**10**	39.164	9	20.582	**8**
Heilongjiang	5.249	25	12.263	23	7.014	20
Shanghai	55.302	**3**	83.128	**1**	27.827	**3**
Jiangsu	27.714	**6**	67.256	**4**	39.542	**2**
Zhejiang	18.662	**9**	46.157	**8**	27.495	**4**
Anhui	12.834	13	22.8	16	9.966	17
Fujian	61.359	**1**	81.399	**2**	20.04	**9**
Jiangxi	10.39	18	37.45	11	27.06	**5**
Shandong	14.117	11	29.905	14	15.788	12
Henan	7.374	21	11.039	24	3.665	23
Hubei	10.975	16	30.06	13	19.085	**10**
Hunan	5.962	23	16.07	18	10.109	16
Guangdong	58.284	**2**	80.008	**3**	21.724	**6**
Guangxi	11.416	14	32.84	12	21.424	**7**
Hainan	19.696	**8**	61.449	**5**	41.753	**1**
Chongqing	13.407	12	29.145	15	15.738	13
Sichuan	8.045	19	14.119	20	6.074	22
Guizhou	2.937	28	5.485	28	2.548	24
Yunnan	5.666	24	8.092	25	2.426	25
Shaanxi	11.221	15	12.526	22	1.306	27
Gansu	3.558	27	2.459	30	-1.099	30
Qinghai	2.464	29	13.782	21	11.318	15
Ningxia	7.55	20	7.089	26	-0.461	29
Xinjiang	1.606	30	2.77	29	1.164	28

Source: Author's calculations based on *China Statistical Yearthesis* (2001, 2011).
Notes: [a] Foreign presence= region *i*'s FIEs' industrial output.

Meanwhile, as shown in Table 5.4, foreign presence in most Chinese regions, except Gansu and Ningxia, increased during the period of 2000 to 2010. The degree of these increases is varied: for example, foreign presence in Hainan increased 41.753% while Shaanxi grew only 1.306% during the same period. The overall circumstances of the change in foreign presence indicates that developed or coastal regions usually have a much higher proportion of foreign presence (above 15%) than those less developed or western regions (below 10%). Such geographic discrepancies provide a suitable context for us to empirically test the effect of FDI on regional innovativeness.

Table 5.5 Industrial specialization by province (2000, 2010)

Province	Spe.[a] (2000) (1)	Rank	Spe. (2010) (2)	Rank	Spe.change (2)-(1) (3)	Rank
Beijing	0.976	29	0.757	29	-0.219	18
Tianjin	0.975	30	0.791	27	-0.184	17
Hebei	1.454	16	0.878	24	-0.576	27
Shanxi	5.267	**1**	2.443	**6**	-2.823	30
Neimenggu	2.366	**5**	2.293	**7**	-0.073	14
Liaoning	1.068	25	0.789	28	-0.279	20
Jilin	1.661	11	1.077	19	-0.584	28
Heilongjiang	1.592	13	1.898	**9**	0.306	**8**
Shanghai	1.095	24	0.711	30	-0.384	24
Jiangsu	1.24	19	0.917	22	-0.322	22
Zhejiang	1.35	17	1.122	18	-0.228	19
Anhui	1.491	15	1.496	14	0.006	11
Fujian	1.039	28	0.957	21	-0.082	15
Jiangxi	1.197	22	4.271	**2**	3.073	**1**
Shandong	1.242	18	0.91	23	-0.331	23
Henan	1.523	14	1.889	10	0.366	**6**
Hubei	1.22	20	0.797	26	-0.423	25
Hunan	1.206	21	2.061	**8**	0.855	**5**
Guangdong	1.068	26	1.073	20	0.005	12
Guangxi	1.788	**7**	1.639	12	-0.148	16
Hainan	2.685	**2**	1.358	16	-1.327	29
Chongqing	1.7	**8**	1.236	17	-0.464	26
Sichuan	1.152	23	0.856	25	-0.295	21
Guizhou	1.665	**10**	1.638	13	-0.028	13
Yunnan	2.14	**6**	3.529	**4**	1.389	**4**
Shaanxi	1.057	27	1.421	15	0.365	**7**
Gansu	1.698	**9**	3.943	**3**	2.245	**2**
Qinghai	2.467	**4**	4.592	**1**	2.125	**3**
Ningxia	2.503	**3**	2.726	**5**	0.223	**9**
Xinjiang	1.653	12	1.837	11	0.184	**10**

Source: Author's calculations based on *China Industry Economy Statistical Yearthesis* (2001, 2011).
Notes: [a] Regional industrial specialization is calculated using equation (8).

Table 5.5 above and Table 5.6 below show the degree and difference of industrial specialisation and diversity of 30 Chinese regions in 2000 and 2010, respectively. Generally, developed regions, such as Beijing, Hebei, Liaoning, Jilin, Shanghai, Jiangsu, etc., became less specialised during the sample period while most of them were more diversified in 2010 than before. In other words, the IS of Chinese developed regions adjusted during the last decade with the majority of them heading towards increased industrial variety. This phenomenon may have been due to the original industrial base of these regions being much weaker than that of developed regions; agglomeration economics is beneficial for regional development and industrial variety is also helpful to improve the strength of regional industry bases.

Table 5.6 Industrial diversity by province (2000, 2010)

Province	Diversity[a] (2000) (1)	Rank	Diversity (2010) (2)	Rank	Div.change (2)-(1) (3)	Rank
Beijing	0.84	25	0.899	18	0.059	**4**
Tianjin	0.894	22	0.917	14	0.023	**6**
Hebei	0.927	11	0.875	25	-0.053	28
Shanxi	0.888	23	0.799	30	-0.089	30
Neimenggu	0.901	19	0.909	15	0.008	12
Liaoning	0.919	14	0.931	**8**	0.013	10
Jilin	0.831	26	0.847	28	0.016	**9**
Heilongjiang	0.801	29	0.904	16	0.103	**1**
Shanghai	0.92	13	0.895	20	-0.025	27
Jiangsu	0.927	10	0.924	10	-0.003	18
Zhejiang	0.928	**9**	0.932	**7**	0.005	14
Anhui	0.942	**2**	0.933	**6**	-0.008	21
Fujian	0.918	15	0.94	**5**	0.022	**7**
Jiangxi	0.934	**5**	0.919	11	-0.015	24
Shandong	0.941	**3**	0.94	**4**	-0.001	16
Henan	0.943	**1**	0.941	**3**	-0.002	17
Hubei	0.931	**7**	0.919	12	-0.011	23
Hunan	0.937	**4**	0.942	**2**	0.005	13
Guangdong	0.9	21	0.892	21	-0.008	22

Guangxi	0.924	12	0.917	13	-0.007	20
Hainan	0.918	16	0.838	29	-0.08	29
Chongqing	0.842	24	0.859	27	0.018	**8**
Sichuan	0.933	**6**	0.945	**1**	0.012	11
Guizhou	0.906	18	0.887	23	-0.019	26
Yunnan	0.821	28	0.899	19	0.078	**3**
Shaanxi	0.93	**8**	0.924	**9**	-0.006	19
Gansu	0.906	17	0.891	22	-0.015	25
Qinghai	0.828	27	0.885	24	0.056	**5**
Ningxia	0.9	20	0.902	17	0.002	15
Xinjiang	0.784	30	0.866	26	0.083	**2**

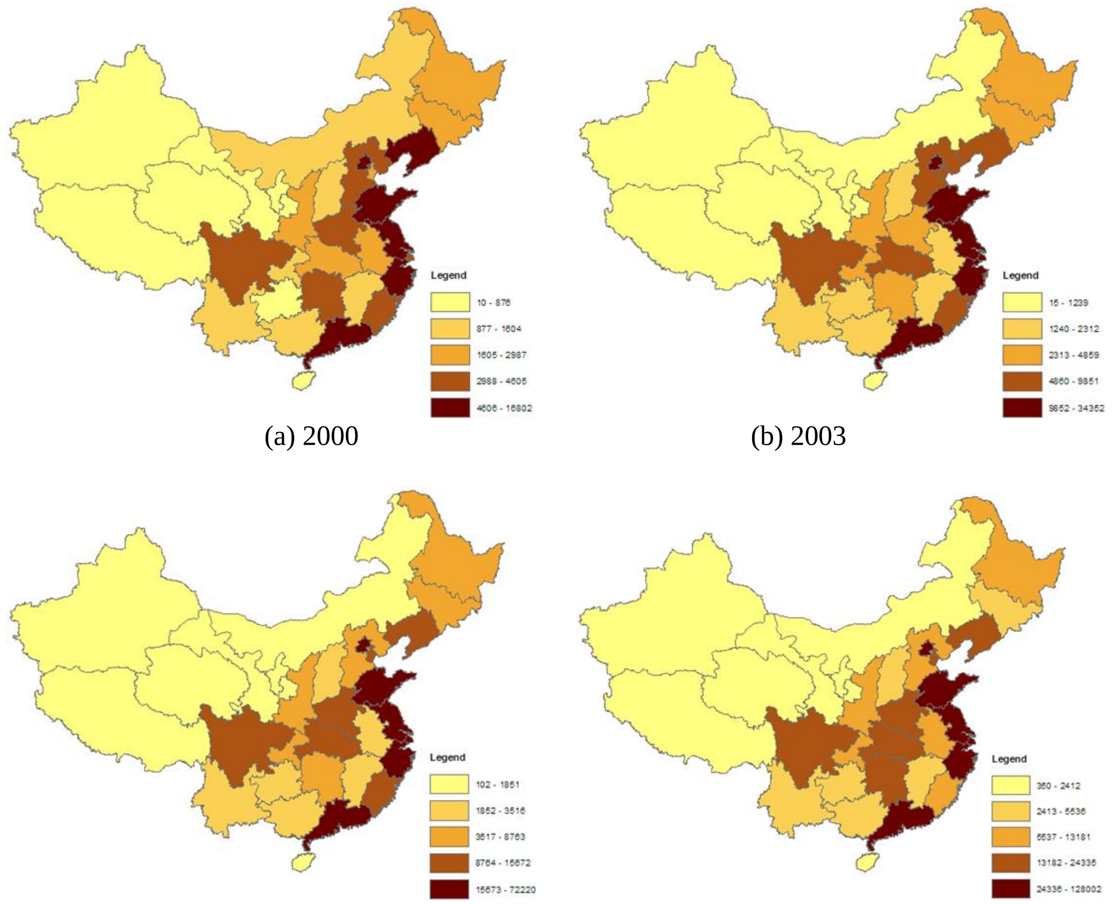
Source: Author's calculations based on *China Industry Economy Statistical Yearthesis* (2001, 2011).
Notes: [a] Regional industrial diversity is calculated using equation (9).

Additionally, I also find some regions that become less specialised and less diversified during the period of 2000 to 2010. For instance the degree of industrial specialisation of Shanxi province dropped dramatically from 5.267 in 2000 to 2.443 in 2010 while its diversity decreased from 0.927 to 0.875 in the same period. This is mainly because Shanxi is the main producer of coal in China, and its geographic location may inhibit its participation in international trade and R&D collaboration.[23] Overall, the regional IS in Chinese regions is complicated and dynamically changing.

5.3.2 Mapping of spatial distribution of patents, FDI, and IS

Although I examined key regional features in the preceding section, only two snapshots of the sample period were taken and the longitudinal trend of dynamic changing of regional patenting, foreign presence and IS in China during the sample period cannot be fully understood. Before estimating the specific effect of key variables, I employed a geographic information system to map out the spatial distribution of patent applications, FDI, and IS as follows.

[23] For more information about the industrial and economic structure of Shanxi province, please refer to: http://en.wikipedia.org/wiki/Shanxi#Industrial_zones



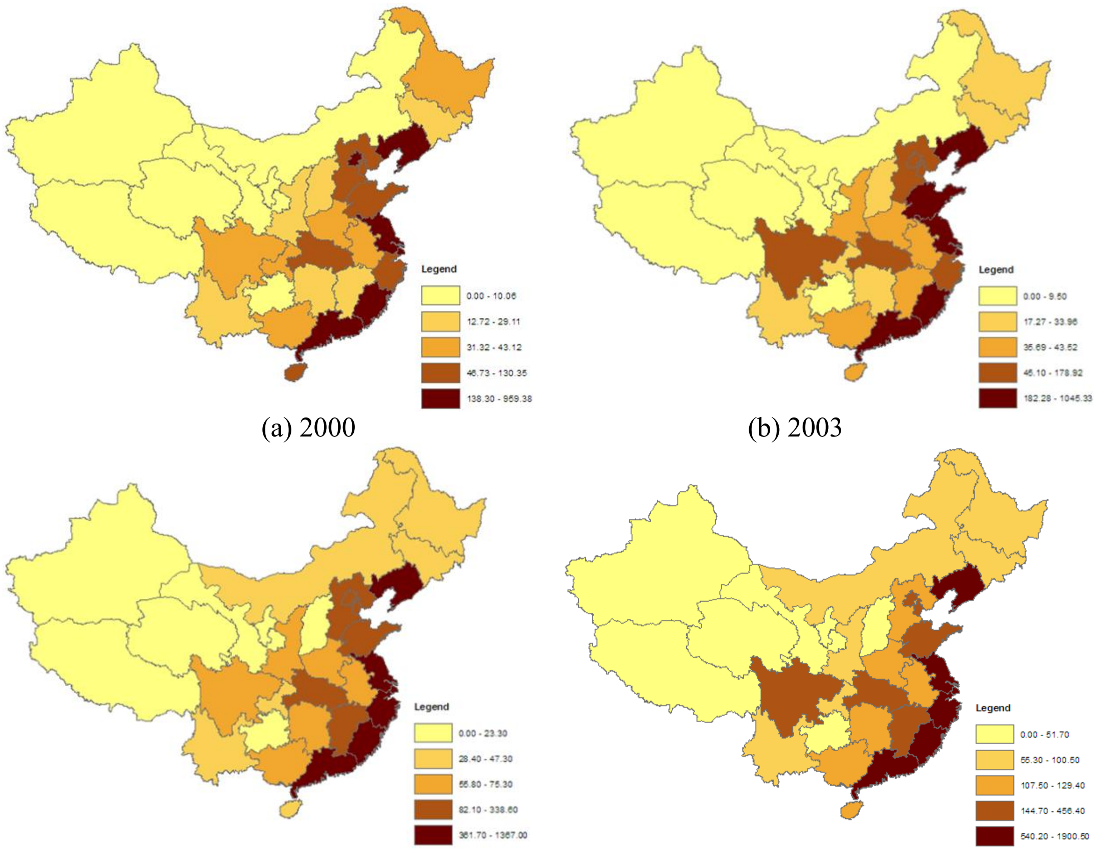
(a) 2000 (b) 2003

(c) 2006 (d) 2010

Source: Compiled by the author.

Figure 5.2 Spatial distribution of patent applications (2000, 2003, 2006, 2010)

Figure 5.2 illustrates spatial distribution of patent applications in each of the Chinese regions through four snapshots. Regions with deeper colours have more patent applications than other regions. It is worth noting that the leading regions for patenting are Jiangsu, Guangdong, Zhejiang, Shandong, Shanghai, and Beijing (see the geographic position for each region in Figure 1.12 in Chapter 1); these six regions have the deepest colour during the sample period, implying that the gap between the leading regions and other less developed regions in terms of technology innovation is large and noteworthy. This is mainly due to these leading regions have much more R&D inputs than other regions (Prevezer et al., 2013), and also due to the fact that technology innovation is a path dependent activity (Patel and Pavitt, 1997). In addition, other coastal regions, e.g. Fujian, Liaoning, and Jilin, have a larger number of patent applications than most inland regions except Sichuan, Hubei, and Henan, etc. This phenomenon is consistent with the level of regional economic development and also similar to the spatial distribution of FDI attraction in China which is shown in Figure 5.3 below.



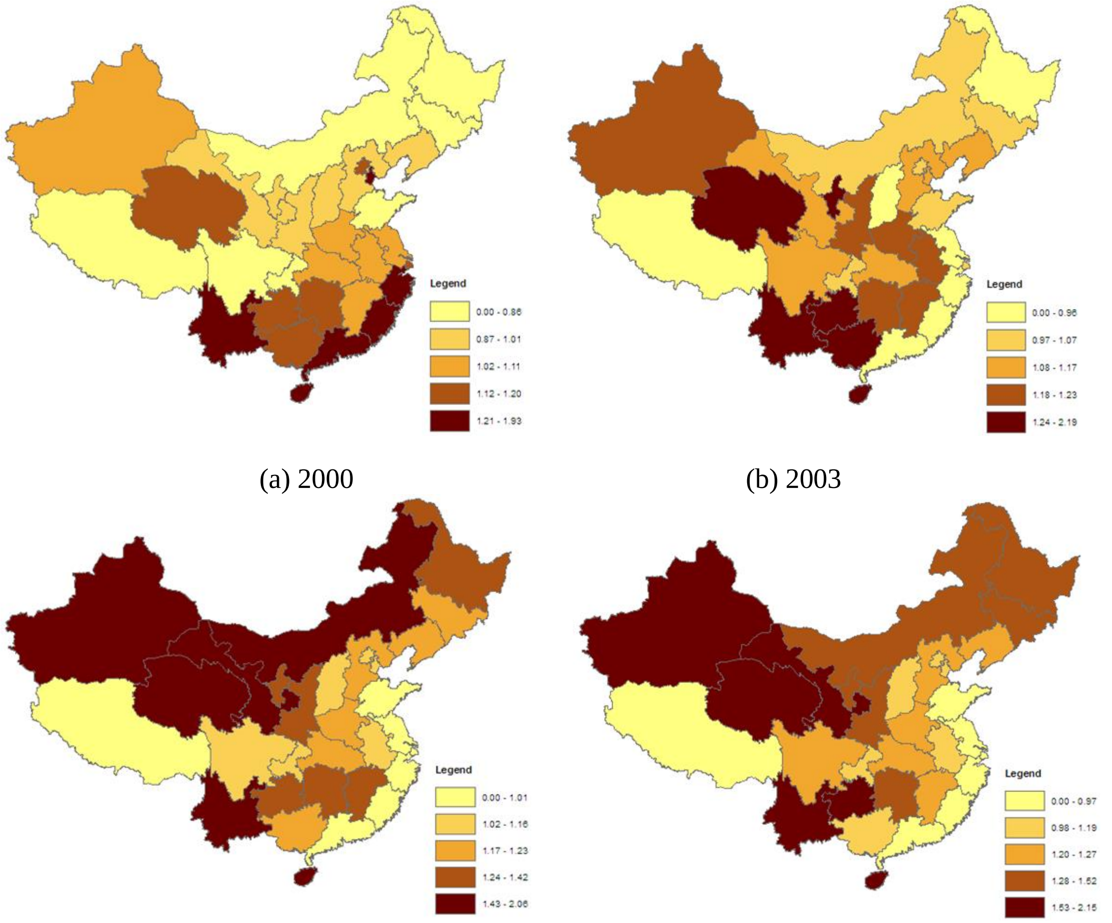
(a) 2000 (b) 2003

(c) 2006 (d) 2010

Source: Compiled by the author.

Figure 5.3 Spatial distribution of inward FDI flow (2000, 2003, 2006, 2010)

Figure 5.3 shows that the leading FDI attractors in China are Guangdong, Fujian, Shanghai, Jiangsu, and Liaoning as they have the deepest colour in all snapshots. Other regions, such as Zhejiang, are also important destinations of foreign investment. Most inland regions have much lower volume of FDI flow than the leading regions. Regions adjacent to coastal regions usually have a larger amount of FDI than those inland regions; less developed regions have the lowest volume of FDI. This distribution may be due to the weakness of both institutional regimes and infrastructure which impede foreign investors' interests and the fact that inland regions are usually lagging in terms of international trade and communications. When comparing the spatial distributions of patents and FDI, the similar pattern provides preliminary support for the Hypothesis 1 which claims that regional FDI has a positive effect on innovation.



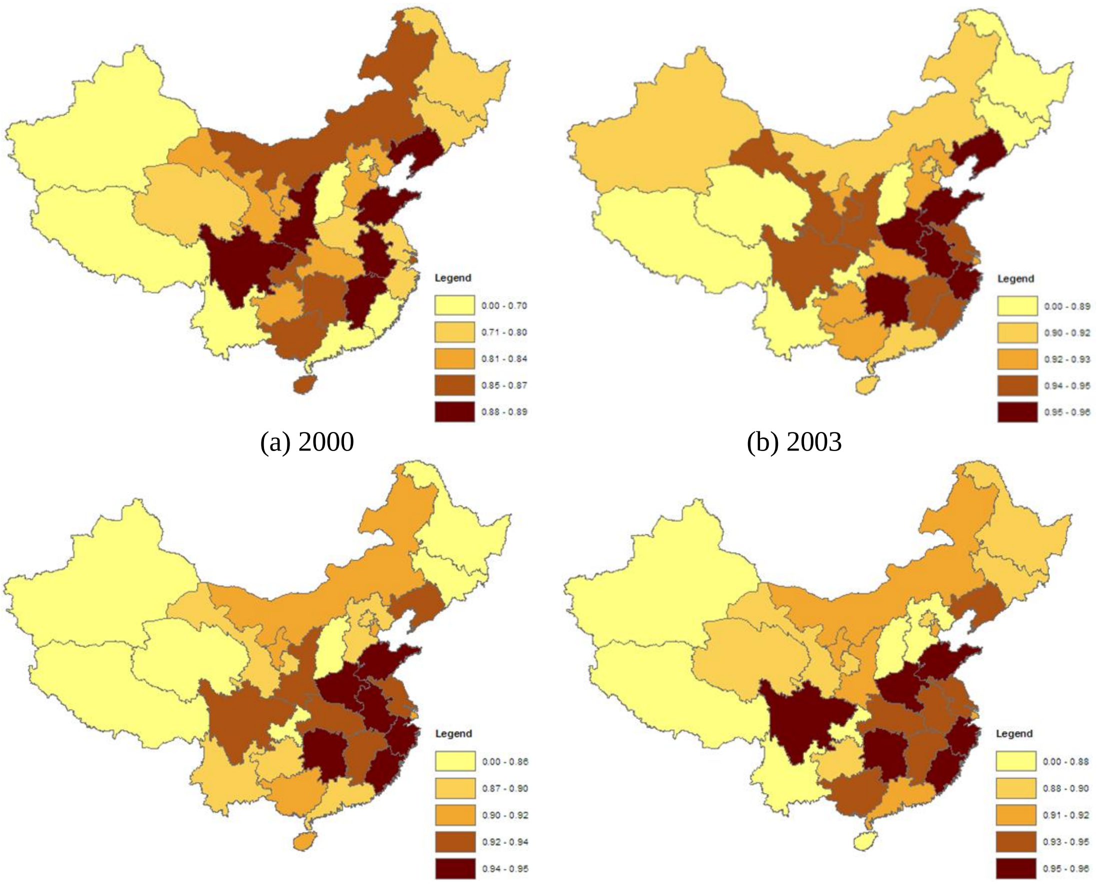
(a) 2000 (b) 2003

(c) 2006 (d) 2010

Source: compiled by the author.

Figure 5.4 Spatial distribution of regional industrial specialization (2000, 2003, 2006, 2010)

Figure 5.4 shows the dynamic change of regional industrial specialisation. From plot (a) I find that eastern coastal regions, e.g. Hainan, Guangdong, Fujian, and Yunnan are the most specialised regions. In other words, regions that are neighbouring the opening (in terms of policy) regions (e.g. Shenzhen in Guangdong province) were the most specialised regions before China entered the WTO. From 2002, as shown in plot (b), developed regions become less specialised than inland regions. It is clear that specialisation is concentrated in the central and western regions and that this has became more accentuated during the 2000s. The coastal areas were the least specialised in terms of concentration of particular industries within the region. During the sample period, I find that most of the less developed regions, especially those western inland regions, are much more specialised than inland and eastern regions, which contrasts with the spatial distribution of patent applications and FDI flow. Such spatial distribution of specialisation provides preliminary support for Hypothesis 4.



(a) 2000 (b) 2003

(c) 2006 (d) 2010

Source: compiled by the author.

Figure 5.5 Spatial distribution of regional industrial diversity (2000, 2003, 2006, 2010)

The spatial distribution of industrial diversity is also in line with the expectations. This contrasts starkly with the maps showing industrial specialisation over time during the 2000s. One can see from this that: industrial diversity has increased over time; this diversity is strongest in the coastal regions; and that feature – the relative diversity of the coastal regions – has become more accentuated over time. When one compares these pictures with the distribution of FDI over time, the positive relationship between the distribution of FDI and distribution of diversity becomes apparent. It is this that the econometric results explore further. This is in line with the expectations for Hypothesis 3 and Hypothesis 5. I further verify the hypothesis using regression models described in Section 3.5.2.

5.3.3 Estimation results

Table 5.7 below reports the correlation matrix and descriptive statistics for all variables. The relatively high correlation coefficient between independent variables and dependent variable shows a reasonably good selection of the variables to reflect the hypothesised effects. The greatest value of correlation coefficient among explanatory variables is 0.59, which is lower than the threshold of 0.70. Following prior studies, I further computed variance inflation factors (VIF) to ensure the results would not be affected by multicollinearity. All values of variables are within an acceptable range with a mean of 2.12 (Belsley, 1980).

Table 5.7 Descriptive statistics and correlation matrix of variables for the regional level study

	Mean	S.D.	1	2	3	4	5	6	7	8	9	10
1. avgpat	3.66	5.84	1.00									
2. fdi	25.86	23.45	0.70	1.00								
3. specialization	1.77	0.90	-0.44	-0.53	1.00							
4. diversity	0.89	0.04	0.13	0.20	-0.43	1.00						
5. rdi	1.12	0.99	0.74	0.48	-0.48	0.18	1.00					
6. hrc	7.15	4.98	0.72	0.43	-0.21	-0.06	0.59	1.00				
7. gdpg	12.09	2.44	0.35	0.32	-0.08	0.10	0.20	0.31	1.00			
8. emp	2190.63	1495.33	0.12	0.12	-0.35	0.41	0.17	-0.31	-0.02	1.00		
9. govst	1.83	1.15	0.68	0.57	-0.47	0.11	0.59	0.47	0.02	0.17	1.00	
10. stecm	0.75	1.43	0.49	0.30	-0.34	-0.06	0.57	0.50	-0.01	-0.11	0.48	1.00

Note: The panel consists of 30 regions from 2000 to 2010. Correlation (absolute) value that bigger than 0.11 is at 0.05 significance.

Moreover, the average value of VIF for each estimation is provided in Table 5.8 below; all are smaller than 2.2. Therefore, the multicollinearity problem is not a serious concern for the estimations. Following prior studies, I carried out Lagrange multiplier and Hausman tests to determine the choice between random- and fixed-effects models. The results of the Hausman test were significant (Chi=65.19, $p<0.001$), indicating that it was appropriate to adopt a fixed-effects model for the estimations.

Table 5.8 provides the regression results of all models using patent applications per 10,000 inhabitants with *t+1*, *t+2* and *t+3* as the dependent variable with fixed effects. All estimates are corrected for heteroskedasticity using Huber–White robust standard errors clustered by regions. An *F* test for each model indicated that all models are effective. Models 1–4 illustrate estimates using a one-year lag of all independent variables; regression results for two-year lag and three-year lag of all independent variables are shown in models 5–8 and models 9–12, respectively. In Model 1, patents are regressed on a set of control variables which shows a significantly positive relation between patents and R&D intensity (*lrdi*), human capital (*lhrc*), GDP growth rate (*lgdpg*), and the region scale (*lemp*). The magnitudes of estimated coefficients are 0.982, 0.982, 0.686, and 0.186 at or below the 0.05 significance level, respectively. This result suggests that regions with greater regional R&D expenditure, higher level of human capital, and faster pace of economic development, will have greater IC. These regional characteristics are crucial for knowledge creation. Larger regional economies also demonstrate a greater degree of innovation activities, but this positive effect diminishes with the increase of time length until it becoming insignificant in Model 9 which uses a three-year lag of all independent variables.

Table 5.8 Panel regressions (fixed effects) using patent applications in *t+1, 2, 3* as dependent variable

	$Patents_{it+1}$				$Patents_{it+2}$				$Patents_{it+3}$			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Constant	-3.923***	-4.600***	-4.352***	-3.580***	-3.337***	-3.977***	-3.778***	-2.685**	-3.997***	-4.633***	-4.455***	-3.218**
	(0.943)	(1.047)	(0.922)	(0.855)	(1.010)	(1.045)	(0.992)	(1.085)	(1.335)	(1.394)	(1.157)	(1.262)
lrdi	0.982***	0.757**	0.770**	0.576*	1.230***	0.979***	0.982***	0.897***	0.809**	0.524	0.532	0.415
	(0.296)	(0.314)	(0.303)	(0.312)	(0.271)	(0.278)	(0.305)	(0.285)	(0.332)	(0.346)	(0.331)	(0.312)
lhrc	0.982***	0.886***	0.876***	0.877***	0.845***	0.677***	0.679***	0.677**	0.685***	0.512**	0.520**	0.540**
	(0.259)	(0.239)	(0.237)	(0.238)	(0.246)	(0.238)	(0.227)	(0.257)	(0.217)	(0.211)	(0.199)	(0.214)
lgdpg	0.686***	0.541**	0.565**	0.513**	0.755***	0.611**	0.639**	0.563*	1.306***	1.115***	1.151***	1.055***
	(0.231)	(0.232)	(0.238)	(0.250)	(0.269)	(0.281)	(0.227)	(0.296)	(0.371)	(0.359)	(0.352)	(0.367)
lemp	0.186**	0.204**	0.193***	0.207***	0.152*	0.164	0.156**	0.154**	0.101	0.106	0.104	0.101
	(0.069)	(0.074)	(0.066)	(0.056)	(0.076)	(0.080)	(0.072)	(0.068)	(0.086)	(0.092)	(0.090)	(0.083)
lgovst	-0.042	-0.028	-0.006	-0.022	-0.056	-0.034	-0.004	0.006	-0.057	-0.025	0.010	0.013
	(0.123)	(0.123)	(0.121)	(0.117)	(0.112)	(0.295)	(0.105)	(0.104)	(0.088)	(0.081)	(0.073)	(0.083)
lstecm	0.076	0.080	0.086	0.079	0.113*	0.123*	0.127*	0.121*	0.093	0.116**	0.120*	0.125**
	(0.068)	(0.068)	(0.066)	(0.061)	(0.063)	(0.063)	(0.063)	(0.059)	(0.062)	(0.060)	(0.062)	(0.060)
lfdi		0.369***	0.355**	0.448***		0.414***	0.392***	0.496***		0.478***	0.447***	0.583***
		(0.128)	(0.128)	(0.119)		(0.097)	(0.095)	(0.109)		(0.131)	(0.115)	(0.147)
lspe			-0.028	-0.036			0.078	-0.051			0.130	-0.066
			(0.228)	(0.032)			(0.277)	(0.037)			(0.239)	(0.042)
ldiv			1.349	0.126***			1.695	0.155**			2.204	0.202**
			(1.034)	(0.037)			(1.435)	(0.056)			(1.760)	(0.079)
lfdi×lspe				-0.078***				-0.064***				-0.082***
				(0.025)				(0.021)				(0.023)
lfdi×ldiv				0.140***				0.126***				0.159***
				(0.034)				(0.036)				(0.050)
R^2	0.6202	0.6383	0.6409	0.6591	0.5616	0.5861	0.5916	0.6067	0.5058	0.5408	0.5513	0.5767
F test	42.85***	33.94***	37.14***	32.16***	33.25***	27.28***	23.57***	22.45***	34.43***	32.67***	30.58***	26.27***
VIF	1.89	1.95	1.97	1.90	1.92	1.96	1.99	1.91	1.95	1.97	2.02	1.92
Obs.	330	330	330	330	300	300	300	300	270	270	270	270

Note: The panel consists of 30 regions from 2000 to 2010. Robust standard errors clustered by regions in parentheses.
* p<0.1, ** p<0.05, *** p<0.01.

In contrast, I find the positive effect of regional GDP growth rate is greater in the medium (Model 5, two-year lag) and long term (Model 9, three-year lag) as the coefficient reached 0.755 and 1.306 below significance level of 0.01, respectively. In addition, regional technology markets play a role of significant fertiliser to patents as its coefficient become significantly positive above the medium term. Moreover, the R^2 of the base model in each lagged format is higher than 50%, which further proves that the selection of control variables appears to be appropriate for this study.

In Hypothesis 1, I expected inward FDI to have a positive relationship with regional innovation capabilities measured by patents per 10,000 inhabitants. Model 2 shows that FDI is significantly and positively associated with the number of patents at the 0.01 significance level. Moreover, the coefficient of FDI is constantly positive at the 0.01 significance when introducing IS in Model 3 and interactive effects in Model 4, providing robust support for Hypothesis 1 that inward FDI brings a positive spillover effect to a region's innovativeness. Meanwhile, I notice that the effect of FDI is even greater in the longer term, for instance the coefficient of FDI is 0.392 (Model 7) and 0.447 (Model 11) on patents in $t+2$ and $t+3$ respectively, both of which are greater than the coefficient of FDI on patents in $t+1$ (0.355, Model 3). This result implies that the knowledge spillover from foreign presence is an important source of knowledge for domestic innovators, and that this positive effect may be even stronger over longer terms.

In Hypothesis 2 and 3, I expected industrial specialisation and diversity to be beneficial for regional innovativeness. Model 3 and Model 4 present the estimations for Equation (6) and Equation (7) in Chapter 3, with a one-year lag of all independent variables. The expectation of the positive effect of specialisation on regional innovation cannot be supported as the estimated coefficient of specialisation is insignificant and negative. Similarly, the effect of specialisation in the medium and long term is also insignificant. Therefore Hypothesis 2 cannot be supported. Meanwhile, the coefficient of diversity is positive at the 0.01 significance level in Model 4, which takes interactive effects between industry structure and FDI into account. The positive main effect of diversity is also reported in the medium (Model 8) and long term (Model 12), although the significance decreased to 0.05 level. Overall, the robust estimated result of the effect of diversity on patents in various lagged formats supports the expectation in Hypothesis 3.

In Hypothesis 4 and 5, I expected that the FDI spillover effect is conditional on regional IS, i.e. industrial specialisation and diversity. In Model 4 the two interactions of FDI, and industrial specialisation and diversity, are introduced into the full regression model, see Equation (7) in Chapter 3. FDI has a positive and statistically significant effect across all models. In Model 4, I find a negative interaction term between specialisation (*lspe*) and inward FDI intensity (*lfdi*) which is significantly negative (β=-0.078 at the 0.01 significance level). This regression result indicates that regions with a higher level specialisation are more likely to gain a lower knowledge spillover effect from inward FDI. The negative moderating effect of specialisation on the association between FDI and patents is also found in the medium (β=-0.064 at the 0.01 significance level in model 8) and long term (β=-0.082 at the 0.01 significance level in Model 12). These results support the expectation in Hypothesis 4 that industrial specialisation negatively moderates the relationship between FDI and regional IC. In contrast, in Model 4, the interaction term between inward FDI intensity and diversity is significantly positive (β=0.140 at the 0.01 significance level). This implies that regions are more likely to be able to benefit from inward FDI to improve their IC if their IS is more diversified (Saxenian, 1996). Similarly, I find a positive moderating effect of diversity on the association between FDI and regional patent applications in both medium (β=0.126 at the 0.01 significance level in Model 8) and long term (β=0.159 at the 0.01 significance level in Model 12). These results support my expectation in Hypothesis 5 that industrial diversity positively moderates the relationship between FDI and regional IC. Taken together, these results suggest that a less specialised and more diversified IS promotes innovative activity in a particular region.

The bottom lines of Table 5.9 report additional information for each estimation model. Except Model 11 (VIF=2.02), the VIF of other models is smaller than 2.0, suggesting that the estimations are unlikely to be affected by the multicollinearity problem. Furthermore, the R^2 of the full model in $t+1$ (Model 4), $t+2$ (Model 8), and $t+3$ (Model 12) is greater than the R^2 of the base model in $t+1$ (Model 1), $t+2$ (Model 5), and $t+3$ (Model 9), indicating that the econometric configuration improves the explanatory power of the variation of patents in each laggged format.

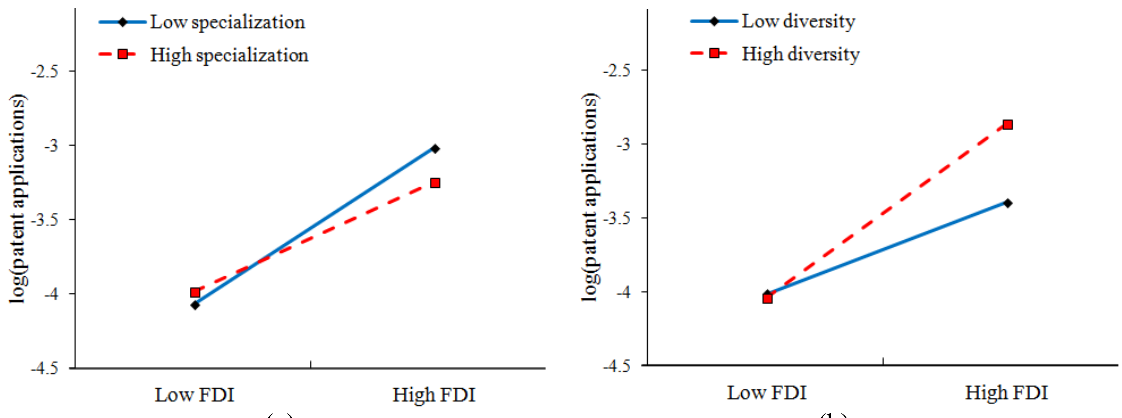
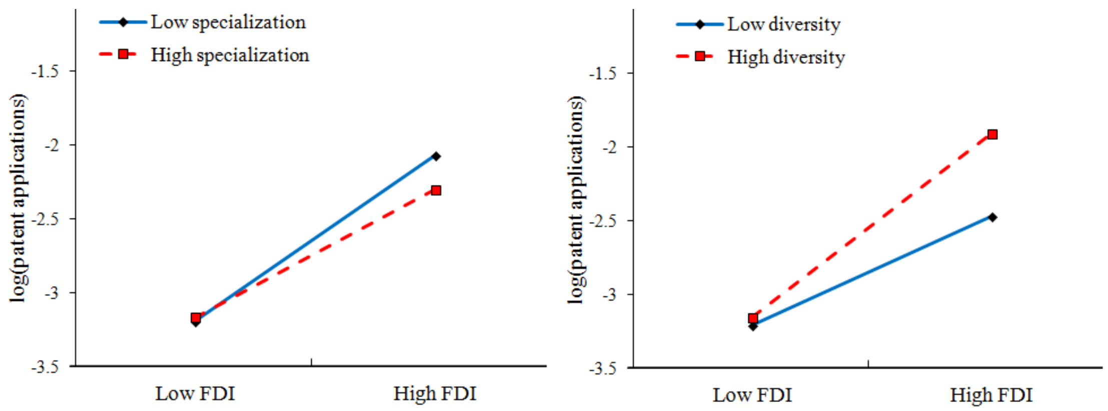
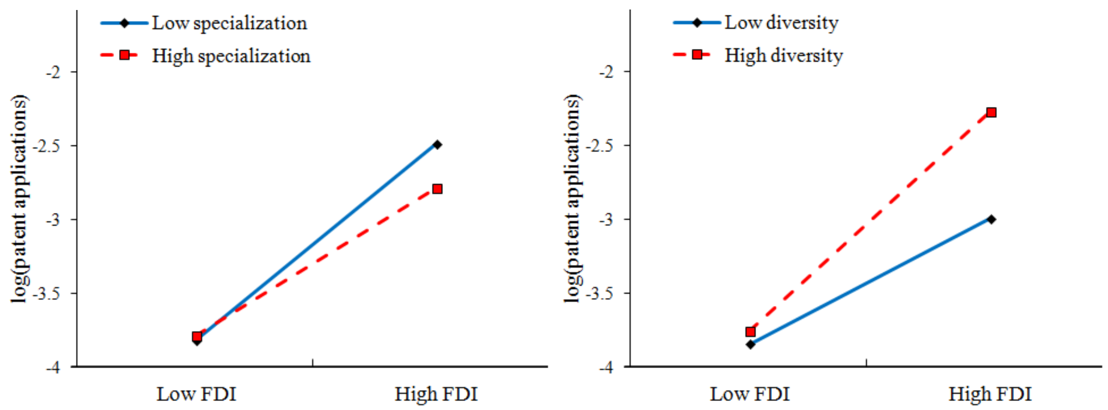


Figure 5.6 Moderating plots of specialization and diversity on association between FDI and ***$Paten_{t+1}$***



(a) (b)

Figure 5.7 Moderating plots of specialization and diversity on association between FDI and ***Paten***$_{t+2}$



(a) (b)

Figure 5.8 Moderating plots of specialization and diversity on association between FDI and ***Paten***$_{t+3}$

To illustrate the patterns of the significant moderating effects that support the hypotheses 4 and 5 in Table 5.8, I visually demonstrated the effect of the interactions in *t+1*, *t+2*, and *t+3* as shown in Figure 5.6, Figure 5.7, and Figure 5.8, respectively. Figure 5.6 shows the interaction plot of FDI and specialisation (plot a) and FDI and diversity (plot b) respectively in *t+1*. I use one standard deviation below and above the mean to denote the high and low levels of moderation variables respectively. The coefficients are taken from Table 5.8 for Figure 5.6, for instance plot (a) and plot (b) are based on the results reported in Model 4 (*t+1*). In plot (a) of Figure 5.6, the slope of '*low specialisation*' (blue and solid line) is steeper than the slope of '*high specialisation*' (red and dashed line). This is consistent with the Hypothesis 4 and indicates that regions with a lower level of specialisation gain more from the inward FDI to improve their regional innovation capabilities.

Similarly, in plot (b) of Figure 5.6 the slope of '*high diversity*' (red and dashed line) is greater than the slope of '*low diversity*' (blue and solid line), implying that industrial diversity enhances the positive relationship between FDI and regional IC, consistent with the Hypothesis 5. In addition, the pair of plot (a) and (b) of Figure 5.7 shows the moderating effect of specialisation and diversity on two years lagged of independent variables while pairing of plot (a) and (b) in Figure 5.8 shows the moderating effect of specialisation and diversity on three years lagged of independent variables. Both of these pairs indicate similar patterns of slopes as shown in the pair of plot (a) and (b) of Figure 5.6. Therefore, the moderating roles of specialisation and diversity in affecting the association between FDI and regional patents are verified in various settings.

5.4 Concluding remarks

The first objective of this chapter was to investigate the answer of the question '*Do foreign presence and industrial structure (i.e., specialization and diversity) exert direct and interactive effects on* ***regional*** *innovation capability?*' (RQ2). To achieve these research objectives, I used panel data incorporating 30 Chinese provinces during the period of 2000 to 2010. The empirical results reveal the extent to which regional innovation capabilities are stimulated by the presence of foreign investment in Chinese provinces and municipalities. The empirical evidence also indicates that FDI spillover effect is in fact affected by the variation of regional IS, i.e. a highly specialised industry structure is found to be an obstacle for regional innovators to benefit from advanced knowledge embedded in foreign presence, while a multidisciplinary industry structure (diversity) can facilitate the beneficial effect from FDI spillovers. The empirical estimates of foreign presence, and industrial specialisation and diversity, at a regional level are summerized in Table 5.9 below.

Table 5.9 Summary of hypotheses and corresponding estimates at **regional** level study

Hypothesis	Estimated effect			Result
	Patents$_{it+1}$	*Patents*$_{it+2}$	*Patents*$_{it+3}$	
Regional level (Chapter 5)				
H1: Inward FDI has a positive effect on regional innovation capability.	0.448*** (0.119)	0.496*** (0.109)	0.583*** (0.147)	Supported
H2: Regional industrial specialization at regional level has positive effect on regional innovation capability	-0.036 (0.032)	-0.051 (0.037)	-0.066 (0.042)	Not Supported
H3: Regional industrial diversity has positive effect on regional innovation capability	0.126*** (0.037)	0.155** (0.056)	0.202** (0.079)	Supported
H4: Industrial specialization negatively moderates the relationship between FDI and regional innovation capability	-0.078*** (0.025)	-0.064*** (0.021)	-0.082*** (0.023)	Supported
H5: Industrial diversity positively moderates the relationship between FDI and regional innovation capability	0.140*** (0.034)	0.126*** (0.036)	0.159*** (0.050)	Supported

In this chapter, I used patent applications per 10,000 regional inhabitants as the indicator of regional innovativeness since patents are more likely to reflect the impact of R&D than new product sales in the Chinese context (Li, 2011; Wang and Zhou, 2013). FDI in China has not, as yet, been directly associated with R&D activities (Cantwell, 1995; Buckley et al., 2002). Although there exist some differences between the degree of direct effects of foreign knowledge spillovers in different lagged settings (*t+1*, *t+2*, *t+3*), the overall impact of foreign presence on regional innovation capabilities are positive and consistent in different settings. The results in various lagged settings are in accordance with prior studies (Fu, 2008; Cheung and Lin, 2004).

The second aim was to explore whether regional IS has a direct effect on regional innovations. Estimates for the specialisation in various lagged settings do not support the expectation that a specialised industry structure has a positive effect on regional innovativeness as I find no significant estimates. Although this result does not support the expectations, it is consistent with the review results reported in Beaudry and Schiffauerova (2009) in which the authors highlighted that the effect of specialisation is largely dependent on the specific methodology and context. I contend that possible reasons for this outcome include the many types of innovators other than industrial sectors in a province scope, for instance regional universities, research institutions, and public organisations such as hospitals, etc. All of these innovators contribute to regional innovativeness, while industrial sectors are the most vulnerable to the impact of a specialised industry structure. It is sensible to investigate the specific effect of industrial specialisation at a micro level, namely to examine the role of a specialised context in affecting local firms' IC. The estimates for diversity in various lagged settings illustrate a positive impact on regional patent applications which is consistent with the prediction of Hypothesis 3. However, as argued before, still little is known about whether this positive effect of diversity is really a source of resource and opportunities for local firms as each RIS incorporates various types of innovators while firms are more likely to be affected by industrial diversity than other non-business sectors.

The third aim of this chapter was to investigate how industrial specialisation and diversity (giving rise to MAR and Jacobs externalities respectively) affect the relationship between FDI and regional innovativeness. On the one hand, the estimates in different lagged settings suggest that industrial specialisation hinders FDI knowledge spillover for regional patent applications. This suggests that although regions with a highly specialised IS can benefit from low transportation costs and specialised regional labour pools, this specialisation also hinders the introduction of new ideas and advanced knowledge brought by regional foreign presence. In other words, specialisation or MAR externalities create barriers for exploring and exploiting knowledge spillovers from foreign presence.

On the other hand, I found significantly positive effects created by Jacobs externalities or industrial diversity. This positive effect is stronger in the short term (*t+1*) and long (*t+3*) term than for patent applications (*t+2*), which means that knowledge spillovers from FDI are more pronounced in a diversified region for current and future innovations. This result is consistent with the Jacobs model which argues that diverse knowledge sources and various technology disciplines are critical stimulants for innovative activities. The result further suggests that a multi-IS will enhance regional absorptive capacity and be more efficient in exploiting technology spillovers from FDI. This fleshes out the ideas from previous studies, namely that initial absorptive capacity and complementary assets are critical for the positive spillovers from FDI to take effect (Fu, 2008). The results of this chapter suggest that the form of that absorptive capacity and complementary assets arise through a diversified IS. This finding also contributes to the existing literature and debate over MAR and Jacobs externalities.

Based on these findings, I can draw some policy implications from this chapter. Firstly, FDI in an emerging economy plays a significant role in promoting both regional technology development and innovation leading to patenting. Chinese policies that highlight the importance of FDI attraction is essential for not only improving the domestic economy but also helpful for cultivating regional innovation capabilities. Secondly, it is in those coastal regions where FDI is concentrated that there is both high diversity and lower or falling specialisation. This is particularly marked in Guangdong, Shanghai, Tianjin, Fujian, and Jiangsu regions, with high FDI presence, falling specialisation and rising industrial diversity. Another way of seeing it is that FDI is attracted into those regions which are beginning to diversify and are less industrially specialised and that FDI itself is likely to contribute to that diversification within the regional economy. These are also regions with the highest concentrations of high technology industries – the five leading industries associated with technological development (see also descriptions of high technology sectors in Chapter 4). High regional industrial specialisation tends to be associated with low levels of high technology industrial development. So when speaking of the benefits of regional diversity for regional innovation, I am pointing towards benefits particularly through the synergies between high technology industries and diversification in the IS. Finally, for those inland regions with much lower levels of FDI, regional innovativeness does appear to benefit from that foreign investment. However, an IS with a lower level of specialisation will help regional innovators to reap knowledge spillovers from inward FDI.

This research has limitations which future research could overcome. Firstly, the indicator of specialisation of this Chapter is originally a regional industry level measurement, although this was transformed by adopting weighted indicators to offset the potential measurement bias from taking industry averages; future researches are strongly recommended to understand the role of particular industries within both specialisation and diversity. Secondly, further studies need to integrate the issues relating to the sources and different types of FDI – the distinction between non-Chinese and overseas-Chinese inward FDI leading to different spillovers – and what the attracting factors are for those different sources. Further work would be able to match up the different types of FDI into the very different types of IS between the Chinese regions. Finally, as IC varies according to different industrial and geographic factors, whether MAR and Jacobs externalities affect foreign presence and innovation capabilities at firm level is another essential question that deserves to be investigated. Examination of the effect of FDI and IS on firms' IC can not only validate the argument at regional level but also advance the understanding about the MAR versus Jacobs debate in extant literature.

Chapter 6 Foreign presence, regional industrial structure and domestic firms' innovation capability

6.1 Introduction

In Chapter 4 and Chapter 5, I found that both regional foreign presence and IS are two critical factors affecting regional innovativeness and also examined the interactive effect of FDI and IS on influencing regional IC. In this chapter, I attempt to answer the fifth specific research question (RQ3): "*Do foreign presence and industrial structure (i.e., specialization and diversity) exert direct and interactive effects on innovation capability of* ***domestic firms****?*"

Innovation has become a critical concern for business practitioners as market competition pushes them to develop new products or services to gain competitiveness (Clark and Guy, 1998; Evangelista and Vezzani, 2010; Guan and Ma, 2003). How to improve a firm's IC is an interesting question that inspired great efforts in prior studies. Determinants of firms' IC are complex: both individual level and firm level factors have been examined by the literature (Balkin et al., 2000; Mihalache et al., 2012; Romijn and Albaladejo, 2002; Yam et al., 2011). For instance, Daellenbach et al. (1999) contend that the technical orientation of the top management team and CEO is positively related to a firm's R&D intensity; Choi et al. (2011) adopt a lens of corporate governance and point out that firms' foreign ownership and group affiliation are the most influential factors for IC. In addition, Cohen and Levinthal (1990b) suggest that a firm's absorptive capacity directly determines whether the firm can successfully acquire, assimilate, and apply external knowledge for technology upgrades.

More recently, an increasing number of studies emphasise the importance of contextual factors in the studies of firm innovation and entrepreneurship. For example, Wang and Lin (2013) contend that taking regional contextual factors into firms' innovation processes is necessary and essential because firms cannot carry out any innovative activities without associating with contextual factors, such as regional infrastructure, industrial environment, policies and regulations, etc. Zahra et al. (2014) further point out that it is unnecessary to include all contextual factors when examining firm level research questions; the important question here is which regional factors are worthy to be taken into account when examining determinants of a firm's IC?

Based on the literature review in Chapter 2 and findings of Chapter 4 and Chapter 5, I find that regional inward FDI and IS, i.e. industrial specialisation and diversity, are two important factors of regional innovativeness. Both foreign presence and industrial structure may influence indigenous firms' IC since firms in developing countries, such as in China, are typically lacking sufficient knowledge accumulation and sources to cultivate their R&D capabilities (Fu et al., 2011). In the Chinese context, this is mainly because of the relatively weak NIS and regional science base, and also due to little experience of technology development (Motohashi and Yun, 2007; Prevezer et al., 2013; Sun and Liu, 2010). FDI is found to be an effective way for gaining advanced knowledge and establishing accesses to overseas markets and technology sources (Branstetter, 2006). Many developing countries have made great efforts to attract foreign investment during the last few decades (Kinda, 2010); China, for example, has been gradually opened to overseas investors since the 1980s. The "*Reform and Opening Up*" policy created by Deng Xiaoping and participation in the WTO are two milestones of China's S&T development. Thus, inward FDI needs to be taken seriously within the research framework.

Secondly, the agglomeration economy has been highlighted in prior studies. As Beaudry and Schiffauerova (2009) point out, there is no consensus for the debate on whether industrial specialisation or diversity are beneficial to regional economies and innovativeness. Methodological and contextual factors are believed to be the main reasons for the mixed results (Beaudry and Schiffauerova, 2009). Firms, especially industrial enterprises (manufacturers), are active innovators in each regional IS. A comprehensive examination of the effect of industrial specialisation and diversity on firms' innovation capacity is helpful to advance the understanding about industrial externalities (MAR versus Jacobs externalities). In China, a province or municipality usually has a larger industrial base than European regions, which may provide new evidence for the literature of industrial externalities.

Moreover, China has declared its intention to shift from being a '*global manufacturer*' to the leader of global innovation (Abrami et al., 2014). The upgrade and adjustment of each regional IS has been inspired by the Chinese government during the last decade: such dynamic change is not only closely related to a region's IC, but also essential for firms' innovative activities. Therefore, I believe IS is an important factor for Chinese firms' IC. Finally, firms are the main receivers of FDI knowledge spillovers (García et al., 2013; Sánchez-Sellero et al., 2014) and industrial externalities (Tanriverdi and Lee, 2008). Yet although I examined the effects of FDI and IS on regional innovativeness, the findings at regional level cannot show the exact effect of foreign presence and IS on indigenous firms' IC. More importantly, a further investigation of the role of firms' ownership in affecting the effect of foreign presence and IS on the firms' IC can advance the understanding of the impacts of FDI and IS.

The examination of the conceptual model in this chapter used a panel dataset of Chinese PLCs during the period of 2000 to 2010. As prior studies suggested, Chinese PLCs play a dominant role in the Chinese economy (Tian and Estrin, 2008) and most PLCs are the key players in corresponding industrial sectors, for instance SINOPEC in the oil sector and SANY in the concrete machinery sector (Chen, 2004). Moreover, the financial data of PLCs are reliable since they have to obey strict accounting rules and under the supervision of CSRC (China Securities Regulatory Commission) (Ching Chi Heng and Noronha, 2011).

The remainder of this chapter is organised as follows. The theoretical background and empirical hypotheses are developed in Section 6.2; Section 6.3 reports the results of descriptive analysis and panel regression estimations. Theoretical and practical implications of findings are discussed in Section 6.4.

6.2 Hypothesis development

6.2.1 Foreign presence, IS and firm innovation

FDI has been highlighted in the literature for its positive knowledge spillover effect on host countries (Buckley et al., 2002; Kinda, 2010; Padilla-Pérez, 2008). In fact, foreign presence brings not only capital, but also advanced technology, new ideas, and firms' access to global markets in the host country (Buckley et al., 2002; Crespo and Fontoura, 2007; Kokko et al., 1996). It is possible that MNEs come into emerging markets for potential market and asset-augmenting (Dunning, 2000; Luo, 2003); the increasing global competition they are facing has inspired them to improve the technology level of their products in recent years (Damanpour, 2010). Indigenous firms in host countries can not only gain benefits from importing foreign technical knowledge but also improve their management capability through learning from MNEs' managerial knowledge, both of which are critical for the development of indigenous firms (Fu, 2012).

However, foreign presence itself cannot guarantee that indigenous firms can gain benefits or opportunities from foreign knowledge spillovers. Some studies contend that the source of foreign investment is closely related to its influence on indigenous firms' innovation. For example, FDI from OECD countries is found to be more likely to bring positive spillover effects on domestic technology-intensive sectors' innovation while investments from Hong Kong, Macao and Taiwan are commonly found in labour intensive sectors (Buckley et al., 2007c). The reason behind this phenomenon is that investments from these areas either originate from mainland China or aim to reap low labour and land costs, rather than search for new markets using advanced technologies; in contrast, MNEs from OECD countries usually focus on emerging sectors or high technology industries rather than traditional industries: these MNEs are more likely to launch new products with advanced knowledge to compete with competitors in the host country (Buckley et al., 2007c). Firms' characteristics have been highlighted in prior studies as well. For instance, absorptive capacity is found to be an important factor that determines whether a firm can successfully absorb advanced knowledge from foreign presence (Ferragina and Mazzotta, 2013; Girma, 2005). Durham (2004) empirically proved that firms with higher levels of absorptive capacity more easily gain technical opportunities from foreign presence. Other studies conducted in both developed and developing countries suggest similar conclusions (Zhang et al., 2010). However, what is missing in the literature is that little is known about whether the effect of FDI spillover on indigenous firms' innovation is contingent on contextual factors, such as IS, besides other features, such as absorptive capacity and infrastructure (Fu, 2008).

Another stream of prior studies focuses on whether and how regional industrial factors, usually named as industrial externalities, play influential roles in affecting economic activities (Henderson, 1997). The majority of these studies investigated the role of two dimensions of IS (specialisation and diversity) of regional economic compositions in affecting economic and innovative capabilities. On the one hand, as Marshall (1890) contended, three favoured factors exist in a clustered economy, i.e. low transportation cost, efficient labour mobility, and regional knowledge spillovers. Following studies, such as Arrow (1962b) and Romer (1986), extended this idea and provided further empirical evidence on the question of whether agglomeration economies are beneficial for economic development. Glaeser et al. (1992) summarised these studies which also became known as the MAR externalities. On the other hand, Jacobs (1969) suggested that a city with multiple disciplines is more likely to have a strong knowledge base and innovators can more easily gain fresh ideas and novel technology from a multidisciplinary setting. This argument has become popular in recent years as customers' flavour has changed rapidly and become more uncertain than before, implying that product innovation is more likely to rely on the integration of cross disciplinary knowledge (Nieto and Santamaría, 2007; Tatikonda and Rosenthal, 2000). Both industrial specialisation and diversity are highlighted in prior studies for their specific effects in different settings, but there is no consensus on the question of which type of IS is more productive for innovation.

More recently, Beaudry and Schiffauerova (2009) reviewed a number of recent studies and suggested that reasons behind the mixed empirical results in prior literature are due to the difference of specific contexts and methodologies adopted in these studies. Particularly, only four studies focus on the effect of industrial specialisation in developing countries with no studies conducted in the Chinese context; six studies examined the role of diversity in emerging markets with only one study focussed on China (Beaudry and Schiffauerova, 2009: 328). Moreover, there almost no relevant studies examined or discussed the contingent role of industrial specialisation and diversity, although IS has very close relations with both economic and innovative activities in regional scope. To bridge this void in the existing literature, the present study investigates the roles of industrial specialisation and diversity in affecting local firms' IC by integrating the aforementioned two streams of literature. Moreover, to complement the findings in the regional level study in Chapter 5, I adopted and empirically examined the hypotheses in the following sections using a panel of Chinese firms, with data from 2000 to 2010.

6.2.2 Foreign presence and domestic firms' innovation

Firms in host countries can gain opportunities and knowledge from FDI. MNEs in host markets provide opportunities for indigenous firms to collaborate with foreign firms or become MNEs' regional suppliers or commercial agents, etc. Collaborations with MNEs help indigenous firms to learn both managerial and technical knowledge that are transferred from MNEs' regional subsidiaries (Jindra et al., 2009). Since the technical gap between most domestic enterprises in emerging markets and foreign enterprises is wide, domestic enterprises can imitate their foreign counterparts through R&D cooperation or be a supplier of MNEs (Glass and Saggi, 1998). In addition, foreign firms may care about their influence on the environment and may require their host suppliers to obtain ISO 14001 certification to guarantee that such collaboration is consistent with their managerial objectives (Javorcik, 2004), which in turn may push indigenous firms to improve their environmental cognition and managerial practices.

Indeed, rather than collaborating with foreign counterparts, the majority of domestic firms are more likely to compete with local foreign subsidiaries in the host market because one of the overseas investors' objectives is to explore new markets in host countries (Meyer and Sinani, 2009). Products launched by foreign firms are competitive since their products usually incorporate advanced technology, with high quality, as well as brand effect (Chang and Park, 2012). To take up such big challenges posed by foreign firms, indigenous firms can either imitate foreign firms' products or develop competitive products by enhancing their R&D capability (Buckley et al., 2007a). Each of these two methods needs great efforts and investments, and technology innovation therefore becomes the core issue in this business battle.

Inward FDI in China brings both opportunities and challenges. Chinese domestic firms are the main contributor to the huge economic development and also the main players in the industrial system (Tian and Estrin, 2008). Since implementation of the "*Reform and Opening Up*" policy in the early 1980s, Chinese firms have not only gained autonomous rights in operations but also channels to global markets (Luo et al., 2010)see Chapter 4 for details). Meanwhile, foreign firms have been gradually become the main player in the Chinese economy. FDI not only enriches and enlarges the Chinese market, but also brings significant challenges to domestic firms as well. In particular, a huge volume of overseas investment has poured into China since 2002 as

China became a formal member of WTO (see Figure 1.6 in Chapter 1); several key industrial sectors were thus gradually opened to foreign firms (see Figure 1.8 in Chapter 1), which threatens Chinese domestic firms' '*quasi monopoly status*' in the host market. Therefore, based on the above analyses, I postulate the following.

> **Hypothesis 1:** Regional foreign presence is positively related to domestic firms' IC.

6.2.3 IS and local firms' innovation

The MAR model suggests that manufacturers clustered in the same or similar industrial sectors can reap benefits from spatial proximity (Viladecans-Marsal, 2004). The short geographic distance between cluster members enables them to decrease transportation costs and in turn increase their profits. Moreover, as prior studies highlighted, knowledge can be more easily diffused and spills over into the community of cluster members (Owen-Smith and Powell, 2004). A relatively specialised IS means that the nature of cluster members' knowledge base is compatible, which is helpful for knowledge sharing and communication (Malmberg and Maskell, 1997). Another advantage of a specialised structure for innovation is that R&D staff in cluster members are more likely to have face-to-face communication, which is especially helpful for tacit knowledge spillovers and beneficial for joint problem-solving and R&D collaborations (Pinch et al., 2003). A labour pool of knowledge workers is easier established in a specialised sector, which enables cluster members to recruit proper knowledge staff with lower search costs (McCann and Simonen, 2005). Cluster firms may invest more resources in R&D activities if they have higher profitability. Additionally, the giant manufacturers in a specialised industry structure can allocate resources efficiently and coordinate cluster members to make joint efforts for collaborative innovations.

The Chinese government encourages regional authorities to establish economic zones and science parks which attract numerous manufacturers and suppliers in the same or related sectors (Lai and Shyu, 2005). A total number of 132 National Economic Cooperation Zones and 14 Cross Border Economic Cooperation Zones at the end of the year 2013,[24] indicates that specialised industry structure is common in China and it is welcomed by both policy makers and practitioners. For instance, Tan (2006) studied the Beijing Zhongguancun Science Park, which is the largest cluster of semiconductor, computer, and telecommunication firms in China, highlighting the positive role of the cluster in facilitating technology transfer and economic growth. Therefore, the following hypothesis is proposed.

> **Hypothesis 2:** Regional industrial specialisation is positively related to domestic firms' IC.

Jacobs externalities suggest that a diversified IS is beneficial for local firms to conduct innovative activities as they can obtain knowledge from multi-disciplinary knowledge bases (Jacobs, 1969). Successful innovation requires not only expertise in a single technology field, but also knowledge from other subjects. Innovation is a process of knowledge recombination and recreation (Cohen and Levinthal, 1990b). Multiple knowledge bases at regional level provide convenient platforms for innovators to communicate and share their ideas, findings, breakthroughs, and applications (Beaudry and Schiffauerova, 2009). All of these knowledge spillovers from a diversified IS

[24] For specific names and details of these zones, please refer to the website of the Ministry of Commerce of the People's Republic of China at: http://www.mofcom.gov.cn/xglj/kaifaqu.shtml.

enable firms in such a context to conduct effective R&D and earn successful innovations.

Studies have emphasised that in-house R&D is full of uncertainties and resource restrictions. Firms are encouraged to conduct open innovation, which means they can benefit from collaboration with external partners (Chesbrough, 2003). This idea has been proved to be a useful way for both process innovation and product innovation (Chesbrough and Crowther, 2006). Technology purchase or licensing is found to be useful for firms' technology upgrades and innovation, especially in developing countries (Wang and Zhou, 2013). Cross disciplinary knowledge flows and diffusion are therefore conducive for local firms to conduct both incremental and radical innovations. Therefore the following hypothesis is established.

> **Hypothesis 3:** Regional industrial diversity is positively related to domestic firms' IC.

6.2.4 Interactive effect between foreign presence and IS

Although foreign presence can bring spillovers to domestic firms, the amount of FDI is not a sole determinant for the spillover effect. An increasing number of studies have realised that FDI itself is highly heterogeneous and complex (Chen and Moore, 2010; Chung, 2001). Both the source and destination of foreign investment have close relationships with the effect of FDI spillovers. For instance, investment originating from OECD countries is found to be more productive than that from the Hong Kong, Macao, and Taiwan regions; and FDI targets in the high technology sectors bring more advanced knowledge for domestic players than that targeting the labour intensive or low technology sectors (Buckley et al., 2002). In general, the specific effect of foreign presence not only depends on the amount of FDI itself, but is also related to other factors such as idiosyncratic features of FDI and characteristics of domestic firms, e.g. absorptive capacity (Ferragina and Mazzotta, 2013), and regional features, e.g. infrastructure (Fu, 2008). A missing aspect in the literature is the linkage between foreign presence and the IS in which FDI is embedded. The reason why this missing aspect is essential is due to the majority of FDI being attracted to industrial sectors, but little is known about whether and how the industrial setting may affect the association between foreign presence and indigenous firms' innovative capability.

Although a highly specialised structure is beneficial for cluster members, it may set barriers for foreign presence. A highly centralised IS in a region means that vertical linkages of the firms in supply chain are strong and stable. External actors face fewer opportunities to take leadership in a specialised sector if they invest in that sector. This problem prohibits potential foreign presence as one of the objectives of foreign investment is to search and occupy markets in host countries. Moreover, specialised clusters are more likely to be '*locked*' into some specific technologies, which impedes cluster members from absorbing and utilising new ideas and knowledge from outside for their R&D activities (Beaudry and Schiffauerova, 2009). New knowledge, for example knowledge spillover from foreign presence, may not be compatible with the knowledge base of a specialised IS, which in turn limits the scope of the benefits of foreign knowledge spillovers. Chinese PLCs in a specialised IS at regional level often play the role of key innovators or key producers, which means they have incentives to protect their influences on other cluster members in the region. For instance, CSR Zhuzhou Electric Locomotive Co., Ltd. is the main production base of electric locomotives in China and the nationally designated enterprise of mass transit vehicles localisation: its increasing R&D investment not only promotes their technological IC, but also reinforces its leading status in regional and national markets. Thus, indigenous firms may facilitate the diffusion of their R&D outputs as a way to compete with foreign companies rather than imitate or learn the spillover technologies from regional foreign counterparts. Therefore, I argue that a region with highly specialised IS will impede the positive effect of FDI spillovers, as stated in the following hypothesis.

> **Hypothesis 4:** Regional industrial specialisation negatively moderates the association between regional foreign presence and domestic firms' IC, i.e. the positive effect of foreign presence on domestic firms' IC will be mitigated with the increase of regional industrial specialisation.

In contrast, a diversified regional IS is more likely to attract foreign investment as the more active industrial sectors available, the bigger market potential at regional level. It is not surprising to find that foreign investors are interested in those host regions with great market potential, especially in emerging markets (Luo, 2003). Overseas MNEs have stronger financial and R&D capabilities which are extremely helpful for integration of their technical advantages with regional science bases (Dunning, 2000). A region with high degree of industrial diversity provides a feasible platform for the application of foreign expertise, and it is helpful for foreign firms to explore regional advantages that can be used as new elements for product and service innovation. Meanwhile, the frequent communication between knowledge workers in different business organisations can facilitate knowledge diffusion and integration, which in turn provides excellent opportunities for domestic firms to gain positive knowledge spillovers from foreign presence. Moreover, foreign firms in a diversified region are able to utilise the local knowledge base to complement their understanding of host markets; foreign firms are more likely to collaborate with domestic firms (Liu et al., 2009), which offers domestic firms valuable opportunities to learn from foreign collaborators and in turn improve domestic firms' R&D capability. Therefore, I argue that a region with a highly diversified IS will reinforce the positive role of foreign knowledge spillovers.

> **Hypothesis 5:** Regional industrial diversity positively moderates the association between regional foreign presence and domestic firms' IC, i.e. the positive effect of foreign presence on domestic firms' IC will be enhanced with the increase of regional industrial diversity.

6.3 Results

6.3.1 Descriptive analysis

Table 6.1 shows the mean, standard deviation, and correlations of all variables. Most correlation coefficients of independent variables are smaller than 0.10, indicating that specific effects of explanatory variables will not be seriously affected by other control variables.

Table 6.1 Descriptive statistics and correlation matrix of variables for the firm level study

	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11	12	13
1.Firm patent	12.47	123.50	1.00												
2.R&D intensity	0.16	1.17	-0.01	1.00											
3.Firm age	10.64	4.48	0.02	0.03	1.00										
4.Firm size	21.46	1.31	0.15	-0.08	0.10	1.00									
5.Firm leverage (%)	1.39	6.67	0.00	0.00	0.05	0.13	1.00								
6.ROA	0.04	0.10	0.02	0.12	-0.09	0.06	-0.06	1.00							
7.Tobin's *Q*	1.72	1.52	-0.01	0.03	0.16	-0.27	-0.03	0.10	1.00						
8.Foreign presence (%)	39.95	26.97	0.06	0.01	0.17	0.12	0.02	0.05	0.04	1.00					
9.Specialization	0.96	0.34	-0.01	0.00	0.04	-0.01	0.00	-0.00	0.08	-0.20	1.00				
10.Diversity	0.90	0.04	-0.01	-0.01	0.04	-0.04	-0.01	0.04	0.06	-0.11	0.29	1.00			
11.Human capital	8.82	6.69	0.03	-0.01	0.09	0.24	0.04	0.05	0.07	0.47	-0.15	-0.12	1.00		
12.GDP growth (%)	12.30	2.22	0.00	0.01	0.17	0.05	0.02	0.01	0.00	0.09	-0.15	0.02	-0.04	1.00	
13.Employment	2932.83	1626.70	0.04	-0.02	0.07	-0.07	-0.03	0.05	0.07	-0.03	-0.02	0.38	-0.47	0.03	1.00
VIF (Variance Inflation Factors)				1.03	1.15	1.24	1.01	1.08	1.24	1.44	1.26	1.38	2.02	1.09	1.77

Note: The unbalanced panel from 2000 to 2010. Correlation (absolute) value that bigger than 0.029 is at 0.05 significance.

Given that the greatest correlation value is -0.47, between regional human capital and employment, I further computed the VIF to ensure the results were not affected by multicollinearity. VIF values for each independent variable are shown in the bottom line of Table 6.1. The mean of all VIF values is 1.31 which is much smaller than the threshold of 10 (Belsley, 1980). Moreover, the average value of VIF for each estimation is provided in Table 6.2, Table 6.3, and Table 6.4 below, all of which are smaller than 2.0. Therefore, the multicollinearity problem is not a serious concern for the estimations.

6.3.2 Estimating results

To further examine the hypotheses developed in Section 6.2, the negative binomial model for panel regression has been adopted. Following prior studies, I used negative binomial panel regressions with fixed effects, and reported several fitness values of each model, e.g., log-likelihood, Wald chi2, and VIF, to present the effectiveness of the estimates (see Chapter 3 for details about data and methods). Following Schilling and Phelps (2007), I also report estimates using negative binomial panel regressions with random effects in the appendices as robustness tests for the findings (see Appendix 2). To decrease the potential for multicollinearity, I standardised both the predictor (foreign presence) and moderator variables (specialisation and diversity) before creating the interaction terms (Aiken and West, 1991). Moreover, as I expected a moderating effect in the empirical framework, I mainly use estimates in the full model, as shown in Equation (12) in Chapter 3, to testify the hypotheses, i.e. whether the interaction term is significant (Dawson, 2013).

Table 6.2 Negative binomial panel regressions (fixed effects) using patent number in t+1, 2, 3 as dependent variable (all PLCs)

	$Patents_{it+1}$				$Patents_{it+2}$				$Patents_{it+3}$			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Firm features												
R&D	0.463***	0.451***	0.463***	0.493***	0.198	0.199	0.208	0.241*	0.270**	0.264**	0.269**	0.293**
intensity	(0.118)	(0.115)	(0.114)	(0.114)	(0.135)	(0.132)	(0.131)	(0.131)	(0.136)	(0.133)	(0.133)	(0.131)
age	0.086***	0.079***	0.075***	0.068***	0.100***	0.087***	0.085***	0.078***	0.103***	0.086***	0.085***	0.078***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.008)	(0.008)	(0.008)	(0.010)	(0.010)	(0.010)	(0.010)
size	0.078***	0.098***	0.094***	0.086***	0.058**	0.078***	0.072**	0.067**	0.039	0.056	0.049	0.045
	(0.026)	(0.027)	(0.027)	(0.027)	(0.029)	(0.029)	(0.029)	(0.030)	(0.037)	(0.038)	(0.038)	(0.038)
leverage	-0.017***	-0.017***	-0.017***	-0.017***	0.004	0.004	0.003	0.003	-0.014	-0.014	-0.015	-0.013
	(0.006)	(0.006)	(0.006)	(0.006)	(0.005)	(0.005)	(0.005)	(0.005)	(0.014)	(0.013)	(0.013)	(0.012)
ROA	1.003***	1.021***	1.029***	0.986***	0.624*	0.706*	0.711*	0.721**	0.668*	0.721*	0.736*	0.727*
	(0.342)	(0.343)	(0.343)	(0.341)	(0.360)	(0.365)	(0.366)	(0.362)	(0.399)	(0.406)	(0.409)	(0.404)
Tobin's Q	0.043**	0.053***	0.044**	0.037**	0.040*	0.042*	0.033	0.024	0.012	0.009	-0.001	-0.007
	(0.017)	(0.017)	(0.018)	(0.017)	(0.023)	(0.023)	(0.023)	(0.023)	(0.031)	(0.031)	(0.032)	(0.032)
Regional features												
human	0.061***	0.045***	0.047***	0.051***	0.049***	0.028***	0.031***	0.035***	0.040***	0.018**	0.022**	0.025***
capital	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.007)	(0.007)	(0.007)	(0.008)	(0.009)	(0.009)	(0.010)
GDP growth	0.020**	0.013	0.021**	0.028***	0.034***	0.027***	0.032***	0.039***	0.076***	0.071***	0.076***	0.079***
	(0.009)	(0.009)	(.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.011)	(0.011)	(0.011)	(0.011)
Employment	0.585***	0.558***	0.548***	0.577***	0.447***	0.407***	0.414***	0.450***	0.308***	0.282***	0.307***	0.339***
	(0.054)	(0.054)	(0.058)	(0.056)	(0.057)	(0.057)	(0.062)	(0.062)	(0.065)	(0.065)	(0.070)	(0.071)
Explanatory variables												
fdi		0.008***	0.008***	0.227***		0.009***	0.008***	0.256***		0.009***	0.008***	0.252***
		(0.001)	(0.001)	(0.034)		(0.001)	(0.001)	(0.037)		(0.002)	(0.002)	(0.045)
specializatio			0.181**	-0.030			0.135**	-0.053*			0.117*	-0.021
n			(0.071)	(0.032)			(0.068)	(0.030)			(0.071)	(0.033)
diversity			1.372	0.175***			0.797	0.142***			-0.141	0.085**

			(0.914)	(0.037)			(0.920)	(0.038)			(1.000)	(0.043)
fdi×spe				-0.139***				-0.154***				-0.091***
				(0.034)				(0.032)				(0.033)
fdi×div				0.232***				0.202***				0.155***
				(0.035)				(0.035)				(0.039)
Constant	-8.732***	-8.957***	-10.27***	-8.664***	-7.224***	-7.295***	-8.120***	-7.151***	-5.969***	-6.032***	-6.124***	-5.967***
	(0.696)	(0.702)	(0.954)	(0.720)	(0.751)	(0.754)	(0.991)	(0.780)	(0.946)	(0.945)	(1.166)	(0.970)
Log Likelihood	-10072.71	-10053.47	-10046.16	-10022.06	-8930.82	-8909.07	-8905.24	-8884.04	-6495.01	-6480.26	-6478.66	-6469.72
Wald chi2	941.66***	964.32***	973.91***	1029.81***	633.62***	679.99***	687.24***	731.74***	435.07***	473.65***	478.28***	498.99***
VIF	1.18	1.25	1.32	1.52	1.19	1.27	1.33	1.55	1.21	1.29	1.34	1.58
Firms	894	894	894	894	770	770	770	770	609	609	609	609
Obs.	5452	5452	5452	5452	4773	4773	4773	4773	3385	3385	3385	3385

Note: The panel includes Chinese PLCs in the period of 2000 to 2010. Standard errors are reported in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

To further investigate whether the effect of foreign presence and IS on firms' IC is contingent on firms' ownership, I separately report the estimates for all PLCs, state-owned PLCs, and non-state-owned PLCs in Table 6.2, Table 6.3, and Table 6.4, respectively, where the hierarchical regression approach is employed to assess the explanatory power of each set of variables (Aiken and West, 1991).

6.3.2.1 Estimating results for all PLCs

Table 6.2 above shows estimated results for the three dependent variables ($Patents_{it+1}$; $Patents_{it+2}$; $Patents_{it+3}$) using the full sample of all PLCs. The results of negative binomial regressions are reported separately for the three dependent variables. Models 1, 2, 3 and 4 report the results using a one-year lag between all independent variables and firm patenting ($Patents_{it+1}$). Models 5, 6, 7 and 8 report the results using a two-year lag between all independent variables and firm patenting ($Patents_{it+2}$). Models 9, 10, 11 and 12 report the results using a three-year lag between all independent variables and firm patenting ($Patents_{it+3}$). For each dependent variable, the first models (models 1, 5, 9) include firm and regional characteristics only; the second models (models 2, 6, 10) and third models (models 3, 7, 11) add the direct effects of foreign presence (*fdi*), industrial specialisation (*specialisation*), and industrial diversity (*diversity*); and the fourth models adds the interaction terms, $fdi \times spe$ and $fdi \times div$ (models 4, 8, 12).

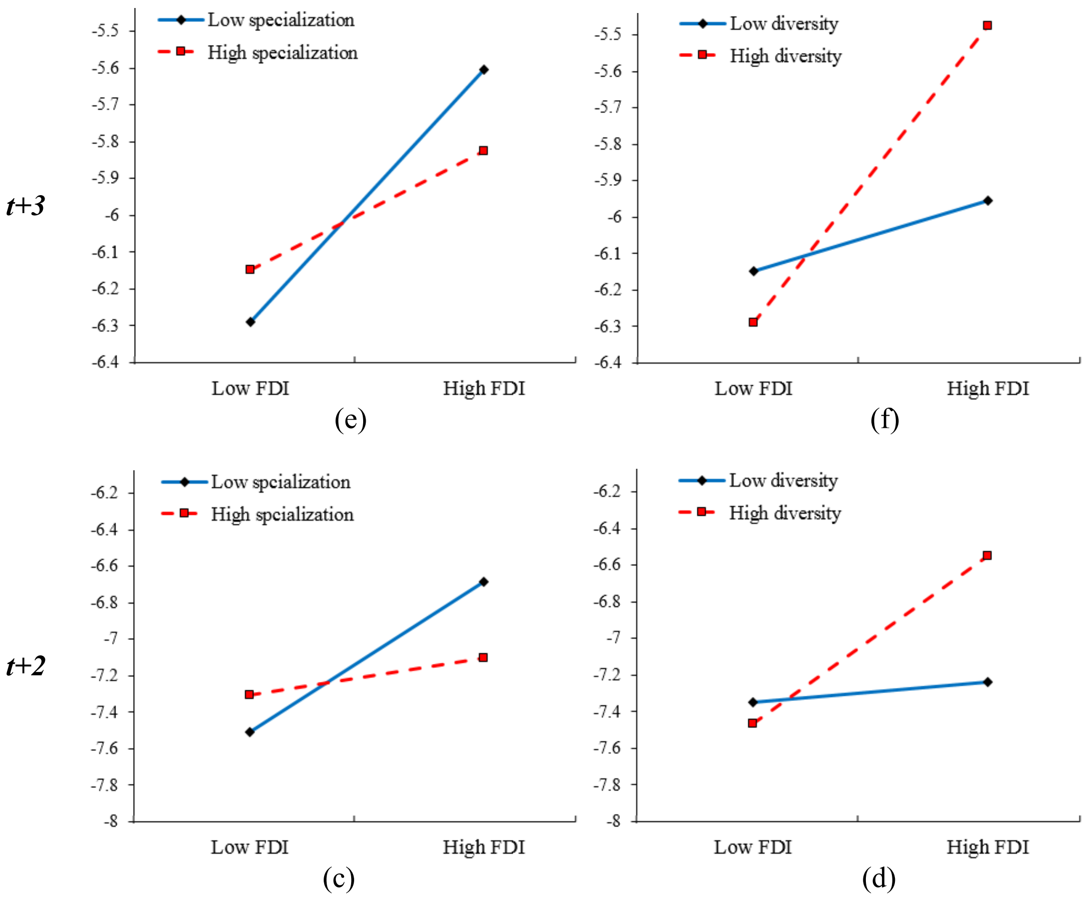
In Hypothesis 1, I predicted foreign presence has a positive effect on PLCs' IC in terms of patenting. Table 6.2 shows that the main effect of foreign presence (*fdi*) is positive with a significance at 0.01 level (β=0.227, p<0.01, Model 4 [$Patents_{it+1}$]). This positive influence on firms' patenting can also be found in longer year lagged settings (β=0.256, p<0.01, Model 8 [$Patents_{it+2}$]; β=0.252, p<0.01, Model 12 [$Patents_{it+3}$]), indicating that knowledge spillovers of FDI are beneficial for domestic firms' IC and this argument is robust in various year lagged settings. Therefore, Hypothesis 1 is supported.

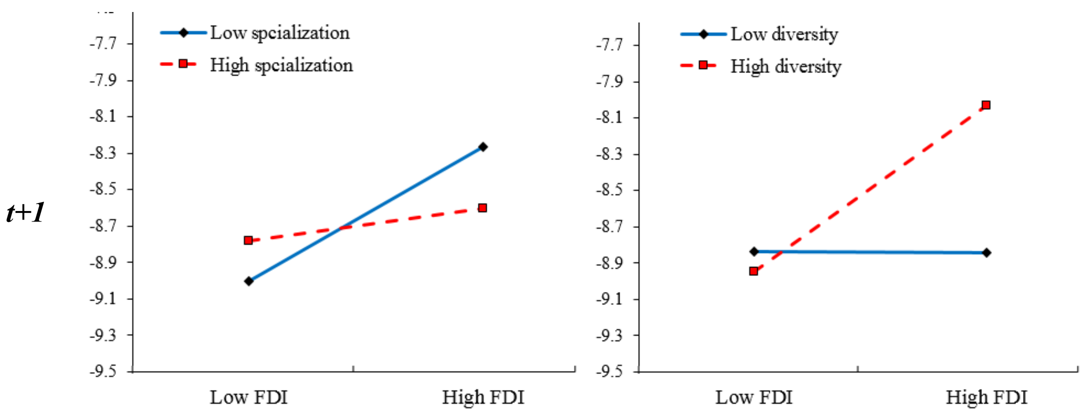
In Hypothesis 2, I predicted that regional industrial specialisation has a positive effect on PLCs' IC. Table 6.2 shows that the main effect of industrial specialisation (*specialisation*) is insignificantly negative (β=-0.030, p>0.1, Model 4 [$Patents_{it+1}$]). Similar effect on firms' patenting can also be found in longer year lagged settings (β=-0.053, p<0.1, Model 8 [$Patents_{it+2}$]; β= -0.021, p>0.1, Model 12 [$Patents_{it+3}$]), indicating that a specialised industry structure at regional level may bring negative externalities on indigenous firms' innovative activities. Therefore, Hypothesis 2 cannot be supported.

In Hypothesis 3, I predicted that regional industrial diversity has a positive effect on PLCs' IC. Table 6.2 illustrates that the main effect of industrial diversity (*diversity*) is statistically positive for all PLCs' IC (β=0.175, p<0.01, Model 4 [$Patents_{it+1}$]). Moreover, I find the main effect of diversity becomes smaller albeit significant in longer year lagged settings. Therefore, Hypothesis 3 is supported.

In Hypothesis 4, I predicted a negative effect of the interaction between foreign presence and specialisation on firm patenting. In the one-year lagged model, the interaction term, $fdi \times spe$, is negative and obtains great significance (β=-0.139, p<0.01, Model 4 [$Patents_{it+1}$]). Moreover, the coefficient for $fdi \times spe$ is negative and statistically significant in models using both two- and three-year lags (β=-0.154, p<0.01, Model 8 [$Patents_{it+2}$]; β=-0.091, p<0.01, Model 12 [$Patents_{it+3}$]). Therefore, Hypothesis 4 received strong support in models using different year lags.

In Hypothesis 5, I predicted a positive effect of the interaction of foreign presence and diversity on firm patenting. In the one-year lagged model, the interaction term, $fdi \times div$, is positive and obtains great significance (β=0.232, p<0.01, Model 4 [$Patents_{it+1}$]). Moreover, the coefficient for $fdi \times div$ is positive and statistically significant in models using both two- and three-year lags (β=0.202, p<0.01, Model 8 [$Patents_{it+2}$]; β=0.155, p<0.01, Model 12 [$Patents_{it+3}$]). Therefore, Hypothesis 5 received strong support in models using different year lags.





(a) (b)

Figure 6.1 Moderating plots of specialization and diversity on the association between regional foreign presence and $\boldsymbol{Paten}_{t+1,\ t+2,\ t+3}$ (all PLCs)

To illustrate the patterns of the significant moderating effects that support hypotheses 4 and 5 in Table 6.2, I plotted the effect of the interactions using $Patents_{it+1}$, $Patents_{it+2}$, and $Patents_{it+3}$ as dependent variables, which is shown in Figure 6.1. For the ease of illustration and interpretation, the log-linear form of the negative binomial models in Table 6.2 was adopted to calculate interactive effects. Figure 6.1 shows the interaction plot of foreign presence and specialisation (plot a) and foreign presence and diversity, respectively (plot b), in $Patents_{it+1}$. I use one standard deviation below and above the mean to denote the high and low levels of moderating variables, respectively. The coefficients are taken from Table 6.2 for Figure 6.1; for instance plot (a) and plot (b) are based on the results reported in model 4 ($Patents_{it+1}$). In plot (a) of Figure 6.1, the slope of '*low specialisation*' (blue and solid line) is steeper than the slope of '*high specialisation*' (red and dashed line). This is consistent with Hypothesis 4, indicating that firms in a region with a lower level of specialisation can gain more benefits from the foreign presence to improve their innovation capabilities. Similarly, in plot (b) of Figure 6.1 the slope of '*high diversity*' (red and dashed line) is greater than the slope of '*low diversity*' (blue and solid line), implying that industrial diversity enhances the positive relationship between foreign presence and local firms' IC, consistent with the Hypothesis 5. In addition, the pair of plot (c) and (d) in Figure 6.1 shows the moderating effect of specialisation and diversity on two-year lag of independent variables (*Patents*$_{it+2}$) while the pair of plot (e) and (f) in Figure 6.1 shows the moderating effect of specialisation and diversity on the three-year lag of the independent variable (*Patents*$_{it+3}$). Both of these pairs indicate similar patterns of slopes as shown in the pair of plot (a) and (b) in Figure 6.1. Therefore, the moderating roles of specialisation and diversity in affecting the association between foreign presence and domestic firms' IC are verified in various configurations.

6.3.2.2 Estimating results for state-owned PLCs

I further take the ownership of PLCs into consideration and divide the whole sample of PLCs into SOEs and non-SOEs according to whether the largest shareholder (with at least 10% shares) is the state (Ning et al., 2014). Table 6.3 below shows estimated results for the three dependent variables (*Patents*$_{it+1}$; *Patents*$_{it+2}$; *Patents*$_{it+3}$) using the data of state-owned PLCs. The results of negative binomial regressions are reported separately for the three dependent variables. Similarly, model 1, 2, 3 and 4 in Table 6.3 report the results using a one-year lag between all independent variables and firm patenting (*Patents*$_{it+1}$). Models 5, 6, 7 and 8 report the results using a two-year lag between all independent variables and firm patenting (*Patents*$_{it+2}$). Models 9, 10, 11 and 12 report the results using a three-year lag between all independent variables and firm patenting (*Patents*$_{it+3}$). For each dependent variable, the first models (models 1, 5, 9) include firm and regional characteristics only; the second models (models 2, 6, 10) and third models (models 3, 7, 11) add the direct effects of foreign presence (*fdi*), industrial specialisation (*specialisation*), and industrial diversity (*diversity*); and the fourth models add the interaction terms, $fdi \times spe$ and $fdi \times div$ (models 4, 8, 12).

Table 6.3 Negative binomial panel regressions (fixed effects) using patent number in t+1, 2, 3 as dependent variable (State-owned PLCs)

	$Patents_{it+1}$				$Patents_{it+2}$				$Patents_{it+3}$			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Firm features												
R&D	0.418***	0.412***	0.418***	0.475***	0.270	0.279	0.283	0.327*	0.074	0.085	0.087	0.145
intensity	(0.125)	(0.124)	(0.124)	(0.124)	(0.194)	(0.193)	(0.193)	(0.195)	(0.180)	(0.182)	(0.182)	(0.183)
age	0.102***	0.096***	0.092***	0.081***	0.125***	0.114***	0.112***	0.105***	0.114***	0.103***	0.102***	0.093***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.011)	(0.012)	(0.012)	(0.012)	(0.013)
size	0.117***	0.125***	0.121***	0.116***	0.042	0.053	0.048	0.051	-0.034	-0.028	-0.032	-0.027
	(0.037)	(0.037)	(0.037)	(0.037)	(0.038)	(0.038)	(0.038)	(0.039)	(0.046)	(0.046)	(0.046)	(0.046)
leverage	-0.006	-0.006	-0.006	-0.007	-0.027	-0.030	-0.031	-0.035	0.010	0.006	0.007	0.002
	(0.009)	(0.009)	(0.009)	(0.009)	(0.025)	(0.025)	(0.025)	(0.025)	(0.027)	(0.028)	(0.028)	(0.028)
ROA	0.719	0.790	0.867	0.880	0.301	0.436	0.467	0.431	1.259**	1.335**	1.367**	1.291**
	(0.537)	(0.539)	(0.541)	(0.542)	(0.559)	(0.561)	(0.564)	(0.562)	(0.618)	(0.621)	(0.624)	(0.620)
Tobin's Q	0.050	0.052	0.030	0.011	-0.014	-0.012	-0.024	-0.031	-0.010	-0.014	-0.022	-0.029
	(0.038)	(0.038)	(0.040)	(0.040)	(0.041)	(0.042)	(0.043)	(0.043)	(0.046)	(0.046)	(0.048)	(0.048)
Regional features												
human	0.056***	0.047***	0.051***	0.060***	0.047***	0.031***	0.035***	0.038***	0.054***	0.041***	0.043***	0.048***
capital	(0.008)	(0.009)	(0.009)	(0.009)	(0.008)	(0.009)	(0.009)	(0.009)	(0.009)	(0.010)	(0.010)	(0.011)
GDP growth	0.022*	0.020	0.030**	0.038***	0.017	0.015	0.020	0.026**	0.069***	0.066***	0.070***	0.074***
	(0.012)	(0.012)	(0.013)	(0.012)	(0.012)	(0.012)	(0.013)	(0.013)	(0.014)	(0.014)	(0.015)	(0.015)
Employment	0.477***	0.482***	0.470***	0.536***	0.314***	0.315***	0.334***	0.377***	0.282***	0.282***	0.309***	0.360***
	(0.074)	(0.074)	(0.079)	(0.081)	(0.071)	(0.071)	(0.077)	(0.078)	(0.078)	(0.078)	(0.084)	(0.085)
Explanatory variables												
fdi		0.004**	0.004**	0.139**		0.007***	0.006***	0.218***		0.006**	0.005**	0.198***
		(0.002)	(0.002)	(0.054)		(0.002)	(0.002)	(0.056)		(0.002)	(0.002)	(0.063)
specializatio			0.180**	-0.024			0.116	-0.047			0.091	-0.036
n			(0.087)	(0.041)			(0.083)	(0.038)			(0.083)	(0.039)

diversity			1.616	0.228***			-0.050	0.121**			-0.642	0.122**
			(1.186)	(0.056)			(1.133)	(0.054)			(1.174)	(0.058)
fdi×spe				-0.122***				-0.125***				-0.093**
				(0.043)				(0.039)				(0.040)
fdi×div				0.245***				0.179***				0.203***
				(0.053)				(0.049)				(0.053)
Constant	-8.808***	-9.015***	-10.53***	-9.202***	-5.718***	-5.945***	-6.073***	-6.163***	-4.285***	-4.369***	-4.049***	-4.800***
	(0.959)	(0.968)	(1.279)	(0.988)	(0.950)	(0.956)	(1.234)	(0.989)	(1.135)	(1.139)	(1.392)	(1.177)
Log Likelihood	-4909.54	-4907.32	-4902.34	-4890.65	-5035.94	-5030.39	-5029.20	-5020.53	-4154.40	-4151.09	-4150.48	-4142.57
Wald chi2	453.52***	453.21***	464.50***	488.93***	392.41***	405.04***	407.71***	424.29***	322.63***	331.40***	333.57***	351.20***
VIF	1.22	1.31	1.36	1.65	1.22	1.31	1.36	1.67	1.26	1.35	1.39	1.71
Firms	415	415	415	415	430	430	430	430	376	376	376	376
Obs.	2763	2763	2763	2763	2764	2764	2764	2764	2207	2207	2207	2207

Note: The panel includes Chinese state-owned PLCs in the period of 2000 to 2010. Standard errors are reported in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

Table 6.3 above illustrates that the main effect of foreign presence (*fdi*) is statistically positive in the short term (β=0.139, p<0.05, Model 4 [$Patents_{it+1}$]). This positive influence on state-owned PLCs' patenting can also be found in medium and long terms (β=0.218, p<0.01, Model 8 [$Patents_{it+2}$]; β=0.198, p<0.01, Model 12 [$Patents_{it+3}$]), indicating that knowledge spillover of FDI is beneficial for local state-owned PLCs' IC in terms of patenting and that this prediction is robust in various year lag settings.

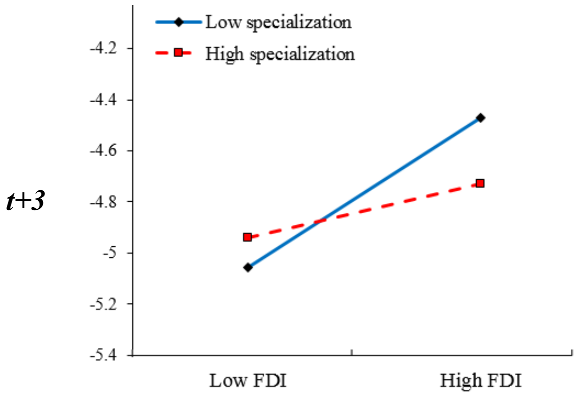
Similarly, with Hypothesis 2, I expected that regional industrial specialisation has a positive effect on state-owned PLCs' IC. Table 6.3 demonstrates that the main effect of industrial specialisation (*specialisation*) is negative and insignificant (β=-0.024, p>0.1, Model 4 [$Patents_{it+1}$]). And this effect of specialisation on firms' patenting is similar in longer year lag settings (β=-0.047, p>0.1, Model 8 [$Patents_{it+2}$]; β=-0.036, p>0.1, Model 12 [$Patents_{it+3}$]), indicating that regional industrial specialisation may exert negative externalities on local state-owned PLCs' innovative activities although this effect is insignificant.

Similarly, with Hypothesis 3, I predicted that regional industrial diversity has positive effects on state-owned PLCs' IC. Table 6.3 shows that the main effect of industrial diversity (*diversity*) is significantly positive on regional state-owned PLCs (β=0.228, p<0.01, Model 4 [$Patents_{it+1}$]). Moreover, I find that the main effect of diversity is also significant in both medium and long terms.

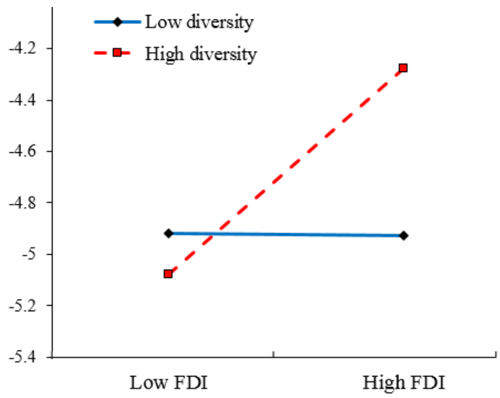
I also expected a negative effect of the interaction of regional foreign presence and specialisation on local state-owned PLCs' patenting. In the one-year lag model, the interaction term, $fdi \times spe$, is statistically negative (β=-0.122, p<0.01, Model 4

[$Patents_{it+1}$]). Moreover, the coefficient for *fdi*×*spe* is negative and statistically significant in models using both two- and three-year lags (β=-0.125, p<0.01, Model 8 [$Patents_{it+2}$]; β=-0.093, p<0.01, Model 12 [$Patents_{it+3}$]).

Similarly, with hypothesis 5, I expected a positive effect of the interaction of regional foreign presence and diversity on regional state-owned PLCs' patenting. As shown in Table 6.3, in the one-year lagged model, the interaction term, *fdi*×*div*, is positive and obtains great significance (β=0.245, p<0.01, Model 4 [$Patents_{it+1}$]). Moreover, the coefficient for *fdi*×*div* is positive and statistically significant in models using both two- and three-year lags (β=0.179, p<0.01, Model 8 [$Patents_{it+2}$]; β=0.203, p<0.01, Model 12 [$Patents_{it+3}$]).



(e)



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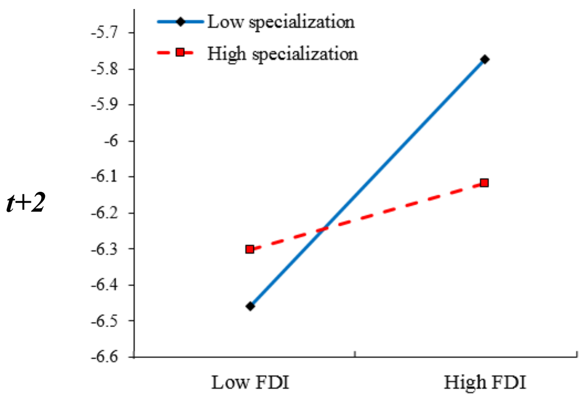

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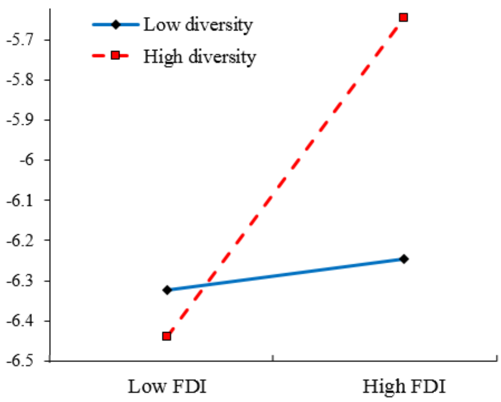

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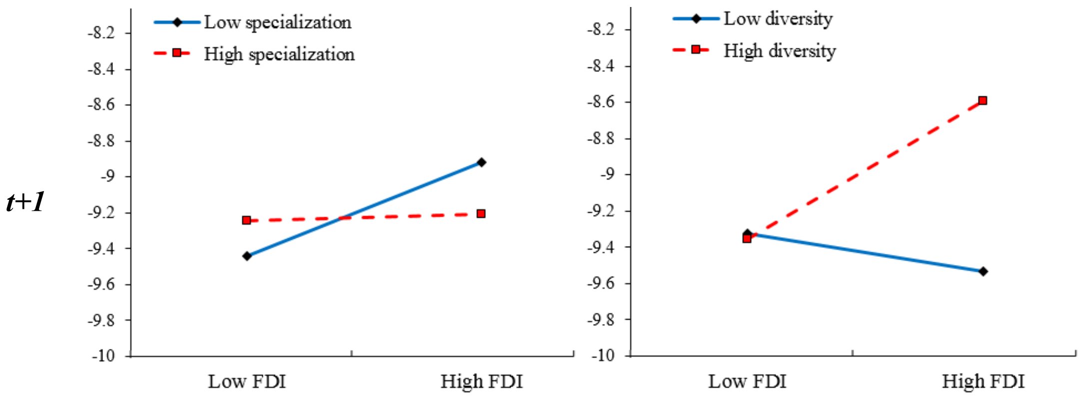

(a) (b)

Figure 6.2 Moderating plots of specialization and diversity on the association between foreign presence and ***Patent***$_{t+1,\ t+2,\ t+3}$ (State-owned PLCs)

To present the patterns of the significant moderating effects of foreign presence and IS on state-owned PLCs' IC, I plotted the effect of the interactions using $Patents_{it+1}$, $Patents_{it+2}$, and $Patents_{it+3}$ as dependent variables, which is shown in Figure 6.2. For the ease of illustration and interpretation, the log-linear form of the negative binomial models in Table 6.3 was adopted to calculate interactive effects. Figure 6.2 shows the interaction plot of foreign presence and specialisation (plot a) and foreign presence and diversity, respectively (plot b), in $Patents_{it+1}$. In line with the literature, I use one standard deviation below and above the mean to denote the high and low levels of moderating variables respectively. The coefficients are taken from Table 6.3 for Figure 6.2, for instance plot (a) and plot (b) are based on the results reported in Model 4 ($Patents_{it+1}$). In plot (a) of Figure 6.2, the slope of '*low specialisation*' (blue and solid line) is steeper than the slope of '*high specialisation*' (red and dashed line). This result indicates that state-owned PLCs in a region with a lower level of specialisation can gain more advanced knowledge or technical opportunities from the foreign presence to improve their innovation capabilities. Similarly, in plot (b) of Figure 6.2 the slope of '*high diversity*' (red and dashed line) is greater than the slope of '*low diversity*' (blue and solid line), implying that industrial diversity enhances the positive relationship between foreign presence and regional state-owned PLCs' IC. In addition, the pair of plot (c) and (d) of Figure 6.2 show the moderating effect of specialisation and diversity on two-year lag of independent variables ($Patents_{it+2}$) while the pair of plot (e) and (f) in Figure 6.2 show the moderating effect of specialisation and diversity on three-year lag of the independent variable ($Patents_{it+3}$). Both of these pairs indicate similar patterns of slopes as shown in the pair of plot (a) and (b) in Figure 6.2. Therefore, the moderating roles of specialisation and diversity in affecting the association between foreign presence and regional state-owned PLCs' IC are verified in various settings.

6.3.2.3 Estimating results for non-state-owned PLCs

Table 6.4 below shows estimates for the three dependent variables ($Patents_{it+1}$; $Patents_{it+2}$; $Patents_{it+3}$) using the data of non-state-owned PLCs. The results of negative binomial regressions are reported separately for the three dependent variables. Similar to Table 6.3, models 1, 2, 3 and 4 in Table 6.4 report the results using a one-year lag between all independent variables and firm patenting ($Patents_{it+1}$). Models 5, 6, 7 and 8 report the results using a two-year lag between all independent variables and firm patenting ($Patents_{it+2}$). Models 9, 10, 11 and 12 report the results using a three-year lag between all independent variables and firm patenting ($Patents_{it+3}$). For each dependent variable, the first models (models 1, 5, 9) include firm and regional characteristics only; the second models (models 2, 6, 10) and third models (models 3, 7, 11) add the direct effects of foreign presence (*fdi*), industrial specialisation (*specialisation*), and industrial diversity (*diversity*); and the fourth models add the interaction terms, $fdi \times spe$ and $fdi \times div$ (models 4, 8, 12).

With Hypothesis 1, I predicted that foreign presence has a positive effect on non-state-owned PLCs' IC in terms of patenting. Table 6.4 illustrates that the direct effect of foreign presence (*fdi*) is statistically positive in the short term (β=0.198, p<0.01, Model 4 [$Patents_{it+1}$]). This positive impact on non-state-owned PLCs' IC can also be found in medium and long terms (β=0.250, p<0.01, Model 8 [$Patents_{it+2}$]; β=0.325, p<0.01, Model 12 [$Patents_{it+3}$]) with an increasing trend of magnitude, indicating that knowledge spillover of FDI is beneficial for regional non-state-owned PLCs' IC in terms of patenting and that this prediction is robust in various year lag settings.

Similarly, with Hypothesis 2, I predicted that regional industrial specialisation has a positive effect on non-state-owned PLCs' IC. Table 6.4 shows that the main effect of industrial specialisation (*specialisation*) is statistically negative (β=-0.011, p>0.1, Model 4 [$Patents_{it+1}$]). This negative influence on firms' patenting is similar in the medium and long terms (β=-0.063, p>0.1, Model 8 ($Patents_{it+2}$); β=-0.01, p>0.1, Model 12 [$Patents_{it+3}$]), indicating that regional industrial specialisation may bring negative externalities on regional non-state-owned PLCs' innovative activities.

Table 6.4 Negative binomial panel regressions (fixed effects) using patent number in t+1, 2, 3 as dependent variable (Nonstate-owned PLCs)

	$Patents_{it+1}$				$Patents_{it+2}$				$Patents_{it+3}$			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Firm features												
R&D	0.393	0.386	0.432	0.446	0.325	0.346	0.425	0.480	1.527***	1.626***	1.626***	1.667***
intensity	(0.297)	(0.296)	(0.294)	(0.295)	(0.330)	(0.328)	(0.326)	(0.327)	(0.465)	(0.465)	(0.453)	(0.456)
age	0.052***	0.050***	0.045***	0.041***	0.051***	0.046***	0.043***	0.038***	0.052***	0.036**	0.033**	0.032*
	(0.011)	(0.011)	(0.011)	(0.011)	(0.013)	(0.013)	(0.013)	(0.013)	(0.017)	(0.017)	(0.017)	(0.017)
size	0.091*	0.094*	0.094*	0.080	0.129**	0.110*	0.109*	0.091	0.366***	0.344***	0.329***	0.318***
	(0.047)	(0.048)	(0.048)	(0.049)	(0.061)	(0.061)	(0.061)	(0.061)	(0.080)	(0.079)	(0.079)	(0.080)
leverage	-0.020***	-0.019***	-0.019***	-0.018***	0.001	0.005	0.000	0.000	-0.013	-0.010	-0.009	-0.008
	(0.006)	(0.006)	(0.006)	(0.007)	(0.005)	(0.005)	(0.005)	(0.005)	(0.018)	(0.015)	(0.015)	(0.015)
ROA	1.278**	1.349**	1.319**	1.324**	0.918*	1.082*	1.048**	1.151**	0.023	0.116	0.100	0.132
	(0.529)	(0.528)	(0.527)	(0.525)	(0.518)	(0.530)	(0.529)	(0.526)	(0.531)	(0.550)	(0.551)	(0.549)
Tobin's Q	0.061**	0.069***	0.062**	0.058**	0.064**	0.057*	0.041	0.036	0.066	0.059	0.046	0.044
	(0.025)	(0.025)	(0.025)	(0.025)	(0.033)	(0.032)	(0.033)	(0.033)	(0.045)	(0.044)	(0.045)	(0.045)
Regional features												
human	0.046***	0.032***	0.034***	0.036***	0.044***	0.020	0.021	0.022	-0.010	-0.041**	-0.037**	-0.038**
capital	(0.010)	(0.010)	(0.011)	(0.011)	(0.013)	(0.014)	(0.015)	(0.015)	(0.016)	(0.018)	(0.018)	(0.018)
GDP growth	-0.011	-0.015	-0.008	-0.005	0.035**	0.028**	0.035**	0.037**	0.057***	0.051***	0.058***	0.060***
	(0.013)	(0.013)	(0.014)	(0.014)	(0.014)	(0.014)	(0.015)	(0.015)	(0.018)	(0.018)	(0.019)	(0.019)
Employment	0.642***	0.586***	0.561***	0.566***	0.641***	0.554***	0.519***	0.531***	0.345***	0.291**	0.288**	0.284**
	(0.094)	(0.094)	(0.101)	(0.103)	(0.107)	(0.108)	(0.116)	(0.119)	(0.124)	(0.123)	(0.131)	(0.133)
Explanatory variables												
fdi		0.007***	0.007***	0.198***		0.009***	0.009***	0.250***		0.012***	0.012***	0.325***
		(0.002)	(0.002)	(0.053)		(0.002)	(0.002)	(0.062)		(0.003)	(0.003)	(0.076)
specializatio			0.222*	-0.011			0.120	-0.063			0.084	-0.011

n			(0.131)	(0.055)			(0.129)	(0.053)			(0.140)	(0.060)
diversity			2.901*	0.156**			4.317**	0.214***			2.296	0.108
			(1.711)	(0.065)			(1.870)	(0.071)			(2.206)	(0.085)
fdi×spe				-0.170***				-0.205***				-0.071
				(0.063)				(0.059)				(0.062)
fdi×div				0.190***				0.189***				0.059
				(0.059)				(0.063)				(0.069)
Constant	-8.470***	-8.253***	-10.95***	-7.574***	-9.755***	-8.742***	-12.51***	-7.843***	-12.19***	-11.36***	-13.24***	-10.35***
	(1.202)	(1.219)	(1.769)	(1.257)	(1.505)	(1.511)	(2.025)	(1.586)	(1.852)	(1.835)	(0.131)	(1.894)
Log Likelihood	-4126.15	-4118.58	-4113.16	-4106.29	-3144.55	-3135.64	-3130.01	-3121.73	-2083.48	-2073.14	-2071.70	-2070.88
Wald chi2	245.91***	259.06***	263.94***	275.47***	138.37***	158.72***	167.44***	184.17***	105.20***	130.45***	132.94***	134.46***
VIF	1.17	1.21	1.30	1.44	1.17	1.23	1.32	1.46	1.17	1.23	1.32	1.46
Firms	479	479	479	479	340	340	340	340	233	233	233	233
Obs.	2226	2226	2226	2226	1664	1664	1664	1664	1076	1076	1076	1076

Note: The panel includes Chinese nonstate-owned PLCs in the period of 2000 to 2010. Standard errors are reported in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

Table 6.4 also reports that the main effect of industrial diversity (*diversity*) is statistically positive (β=0.156, p<0.05, Model 4 [$Patents_{it+1}$]). This positive influence on non-state-owned PLCs' IC can be found in the medium term (β=0.214, p<0.01, Model 8 [$Patents_{it+2}$]) as well, but it becomes insignificant in the long term (β=0.108, p>0.1, Model 12 [$Patents_{it+3}$]). This result indicates that regionally diversified economies produce positive externalities on non-state-owned PLCs' innovative activities, but that this positive impact is only significant in a short and medium term.

I further examined whether a negative effect of the interaction of foreign presence and specialisation on non-state-owned PLCs' patenting existed. In the one-year lagged model, the interaction term, $fdi \times spe$, is statistically negative (β=-0.170, p<0.01, Model 4 [$Patents_{it+1}$]). This negative interactive effect on regional non-state-owned PLCs' innovative activities can also be found in the medium term (β=-0.205, p<0.01, Model 8 [$Patents_{it+2}$]), but it becomes insignificant in the long term (β=-0.071, p>0.1, Model 12 [$Patents_{it+3}$]). Meanwhile, the positive effect of the interaction of foreign presence and diversity on non-state-owned PLCs' patenting is reported in Table 6.4. In the one-year lagged model, the interaction term, $fdi \times div$, is positive and obtains great significance (β=0.190, p<0.01, Model 4 [$Patents_{it+1}$]). This positive interactive effect on regional non-state-owned PLCs' innovative activities can also be found in the medium term (β=0.189, p<0.01, Model 8 [$Patents_{it+2}$]), but it becomes insignificant in the long term (β=0.059, p>0.1, Model 12 [$Patents_{it+3}$]).

t+3 **N.A.** **N.A.**

(e) (f)

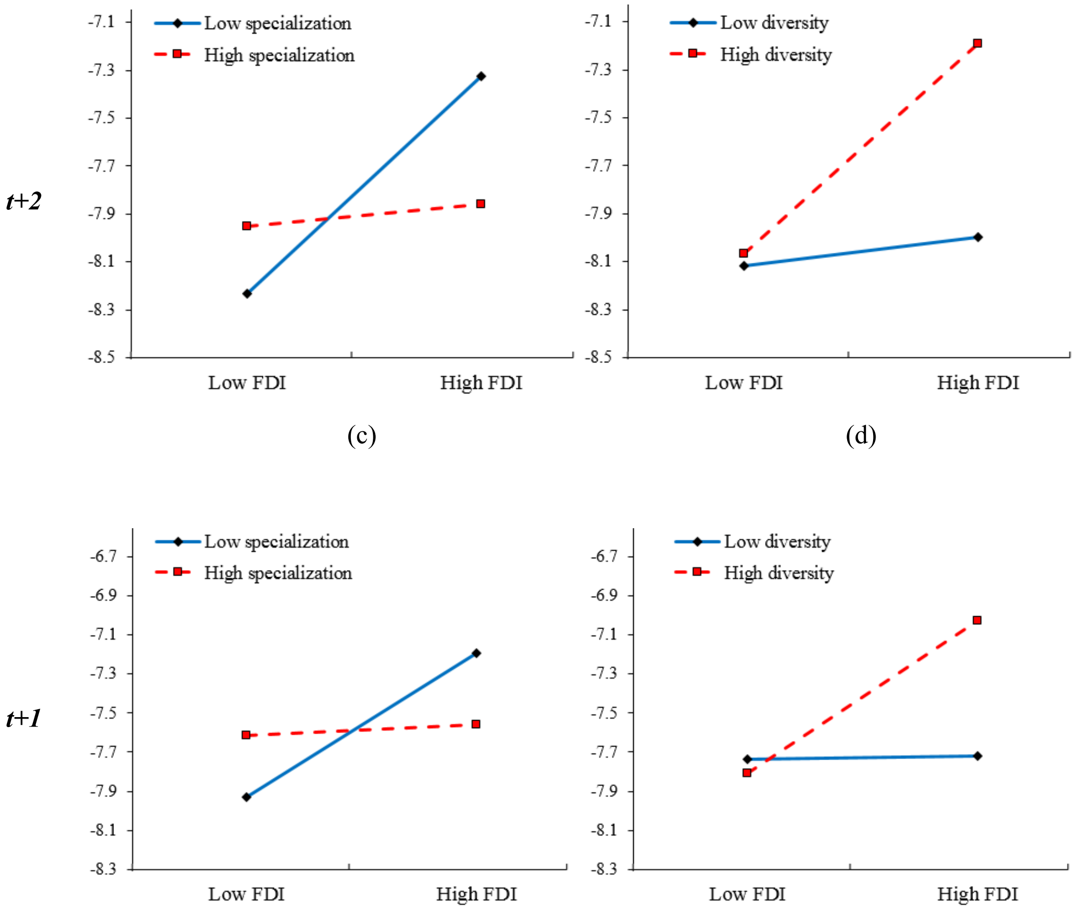

Figure 6.3 Moderating plots of specialization and diversity on the association between foreign presence and $\boldsymbol{Patent}_{t+1,\ t+2,\ t+3}$ (Nonstate-owned PLCs)

To present the patterns of the significant moderating effects of foreign presence and IS on non-state-owned PLCs' IC, I plotted the effect of the interactions using $Patents_{it+1}$, $Patents_{it+2}$, and $Patents_{it+3}$ as dependent variables, which is shown in Figure 6.3. For the ease of illustration and interpretation, the log-linear form of the negative binomial models in Table 6.4 was adopted to calculate interactive effects. Figure 6.3 shows the interaction plot of foreign presence and specialisation (plot a) and foreign presence and diversity, respectively (plot b), in $Patents_{it+1}$. In line with the literature, I use one standard deviation below and above the mean to denote the high and low levels of moderating variables, respectively. The coefficients are taken from Table 6.4 for Figure 6.3, for instance plot (a) and plot (b) are based on the result reported in Model 4 ($Patents_{it+1}$). In plot (a) of Figure 6.3, the slope of '*low specialisation*' (blue and solid line) is steeper than the slope of '*high specialisation*' (red and dashed line). This result indicates that non-state-owned PLCs in a region with a lower level of specialisation can gain more from the foreign presence to improve their innovation capabilities. Similarly, in plot (b) of Figure 6.3 the slope of '*high diversity*' (red and dashed line) is greater than the slope of '*low diversity*' (blue and solid line), implying that industrial diversity enhances the positive relationship between foreign presence and non-state-owned PLCs' IC. In addition, the pair of plot (c) and (d) in Figure 6.3 shows the moderating effect of specialisation and diversity on two-year lag of independent variables ($Patents_{it+2}$). This pair indicates a similar pattern of slopes as shown in the pair of plot (a) and (b) in Figure 6.3. The moderating roles of specialisation and diversity in affecting the association between foreign presence and non-state-owned PLCs' IC are verified in the short and medium term settings.

6.4 Concluding remarks

The knowledge spillover effect of foreign presence and industrial externalities in terms of industrial specialisation and diversity are adopted as key explanatory variables for domestic firms' IC in this study. Both the main and interactive effects of foreign presence and industrial externalities have been taken into account in the research framework.

Table 6.5 Summary of hypothesis and corresponding estimates at firm level study

Hypothesis	Estimated effect		
	$Patents_{it+1}$	$Patents_{it+2}$	$Patents_{it+3}$
Firm level (Chapter 6)			
H1: Regional foreign presence is positively related to domestic firms' innovation capability	All: Pos*** SOE: Pos*** NSOE: Pos***	All: Pos*** SOE: Pos*** NSOE: Pos***	All: Pos*** SOE: Pos*** NSOE: Pos***
H2: Regional industrial specialization is positively related to domestic firms' innovation capability	All: Neg SOE: Neg NSOE: Neg	All: Neg* SOE: Neg NSOE: Neg	All: Neg SOE: Neg NSOE: Neg
H3: Regional industrial diversity is positively related to domestic firms' innovation capability	All: Pos*** SOE: Pos*** NSOE: Pos**	All: Pos*** SOE: Pos** NSOE: Pos***	All: Pos** SOE: Pos** NSOE: Pos
H4: Regional industrial specialization is negatively moderated the association between regional foreign presence and domestic firms' innovation capability	All: Neg*** SOE: Neg*** NSOE: Neg***	All: Neg*** SOE: Neg*** NSOE: Neg***	All: Neg*** SOE: Neg** NSOE: Neg
H5: Regional industrial diversity is positively moderated the association between regional foreign presence and domestic firms' innovation capability	All: Pos*** SOE: Pos*** NSOE: Pos***	All: Pos*** SOE: Pos*** NSOE: Pos***	All: Pos*** SOE: Pos*** NSOE: Pos

Note: Pos represents positive, Neg represents negative, SOE represents state-owned PLCs, NSOE represents nonstate-owned PLCs.

As shown in Table 6.5, after controlling possible impacts of firm and regional level characteristics on firms' patenting, I find that the positive effect of foreign presence is significant and robust in different year lags, indicating that knowledge spillovers of FDI provide both advanced knowledge and technical opportunities for domestic firms' innovative activities, and that this positive influence is effective in different year lag settings. Moreover, the expectation that indigenous firms can benefit from regional specialisation cannot be supported when examining the main effect of specialisation in different year lag settings. This result indicates that a highly specialised context may not exert positive externalities on local companies' IC, which is inconsistent with the findings in developed countries, for instance Usai's (2011) empirical studies of innovative activities in OECD countries finds that inventive performance is concentrated in some regions in Continental Europe, North America and Japan.

Moreover, estimates using the sample of all Chinese PLCs provide support for the positive main effect of a diversified IS on the firms' innovation in different year lag settings. The moderating roles of industrial specialisation and diversity, which is a key argument in this study, are found to be significant in the estimating models in different year lag settings as well. Specifically, I find that the interactive terms of foreign presence and industrial specialisation are statistically negative in different year lag settings, whereas the interactive terms of foreign presence and industrial diversity are found to be statistically positive in different year lag settings. This result not only provides robust support for the prediction, but also indicates that regional IS is significantly contingent upon the association between foreign presence and domestic firms' IC. This result advances the understanding about the mechanism of FDI knowledge spillovers.

As discussed in a preceding section and in Chapter 2 of the literature review, state-owned enterprises and non-state-owned enterprises are different in terms of managerial structure, market status, and also social capital, etc. I further examined the predictions proposed in Section 2 by splitting the sample into two subsets with different ownership (state-owned PLCs and non-state-owned PLCs). Estimates using these two samples provided further support for the positive effect of foreign presence as the corresponding coefficient of *fdi* is statistically positive in models using dependent variables in various year lags. This finding indicates that both state-owned PLCs and non-state-owned PLCs are recipients of positive knowledge spillovers of foreign presence in China. The estimates of the main effects of regional IS on state-owned PLCs' and non-state-owned PLCs' IC in terms of patents are a bit more complicated. Specifically, state-owned and non-state-owned PLCs may gain negative externalities from regional specialisation even though the estimates are insignificant in most lagged settings. In contrast, state-owned PLCs are able to obtain innovation opportunities from a diversified IS in different year lag settings, whilst non-state-owned PLCs gain statistically positive effects from regional diversity in only short and medium terms. These results indicate that both state-owned PLCs and non-state-owned PLCs will benefit from the positive externalities of regional knowledge varieties and that companies' IC relies on the fertilisation of multidisciplinary technology bases.

Moreover, I note that the interactive effect between foreign presence and regional IS for both state-owned and non-state-owned PLCs' IC is consistent with the predictions developed in Section 2. However, the interactive effect on non-state-owned PLCs' IC becomes insignificant in the three-year lag configuration, indicating that the current effect of regional foreign presence on non-state-owned PLCs' IC is less likely to be affected by IS in the long term (i.e. three years after foreign presence).

Overall, the estimating results of state-owned and non-state-owned PLCs help me to learn more about the roles of foreign presence and industrial externalities in affecting firms' IC in terms of patenting from the perspective of firms' internal features, i.e. corporate ownership. And the inconsistent result between subsets of state-owned and non-state-owned PLCs advances the understanding about the difference between indigenous firms regarding the mechanisms of gaining knowledge spillovers from foreign presence. And, more essentially, the empirical evidence highlights the critical role of contextual factors that have been neglected or taken as simple dummy variables in prior studies.

I can draw some implications from these results for both policy makers and business practitioners. First of all, the series of stimuli launched by the Chinese government to attract FDI leads to positive knowledge spillovers for the innovative activities of PLCs. Such benefits are not only conducive to state-owned PLCs' IC but also provide technical opportunities for non-state-owned PLCs' R&D. The panel dataset particularly demonstrates the effect of foreign presence since China entered the WTO at the end of 2001, and proves that the positive effect of knowledge spillovers from FDI is robust in various year lag settings. Thus, regulations and policies aiming to provide a more comfortable environment for overseas investment will help domestic firms to develop their own technical capability through benefiting from regional foreign presence. Secondly, managers of local firms are recommended to obtain innovation opportunities in a region with multidisciplinary knowledge bases. Thirdly, for those regions with great foreign investment, a diversified IS is more conducive for regional domestic firms to gain positive knowledge spillovers from foreign presence. Firms that have close associations with foreign partners are able to gain more opportunities in a diversified region. Policy makers in regions with great openness, such as Chinese coastal regions, are able to facilitate positive knowledge spillovers from foreign presence using industrial diversity oriented regulations and policies to guide regional economic development.

Limitations of this study cannot be neglected. Firstly, I only adopted Chinese PLCs for the estimations following prior studies, e.g. Choi et al. (2011). Future studies are strongly recommended to dig deeper by examining the role of foreign presence with an enlarged dataset that encompasses both listed firms and unlisted firms. The comparison of the roles of regional foreign presence and IS in affecting different types of indigenous firms will extend the findings of this research. Secondly, I mainly used the number of patents as a proxy of IC as suggested by the literature; other indicators, such as new product sales and total factor productivity, etc., are recommended to be looked at when future research focussing on the effect of FDI and IS on local firms' IC. Finally, although I highlight the main and interactive effect of foreign presence and IS on patenting of firms with different ownership, I did not take other firms' internal features, e.g. absorptive capacity, ambidexterity of innovation, etc., into consideration. Future studies are strongly recommended to investigate whether and how the interactive effect between regional foreign presence and IS will be contingent on these firms' internal features. Overall, aforementioned points deserve further research.

Chapter 7 Conclusions

7.1 Introduction

The research conducted in this thesis was motivated by the fact that despite increasing R&D expenditure, better trained talent, and the more sophisticated equipment invested in China, the Chinese RISs are still underperforming (Cao et al., 2013); there is wide variation in regional innovativeness (Prevezer et al., 2013); and few prior studies made efforts to investigate the reasons behind this phenomenon. Inspired by these practical concerns, three years were spent investigating influential factors that determine regional innovativeness in China, especially those factors neglected within the literature in respect to RISs in emerging markets. As preceding chapters of this thesis indicate, foreign presence and IS – specialisation and diversity – are two critical determinants that impact on both regional innovativeness and indigenous companies' IC. Findings of this thesis are based on systematic investigation and examination .

In order to make sure this research focuses on the main theme of determinants of regional IC in China, the core research question and five specific research questions were identified at the very beginning of this thesis (see section 1.2 in Chapter 1). Both regional and firm level datasets were compiled and analysed using the methods of comparative analysis, descriptive studies and panel regression analysis. Although I have made concluding remarks for each chapter, it is reasonable to summarise the main findings and discuss what can be extracted from these findings. Therefore, in this chapter, in Section 7.2.1 I revisit and discuss the findings gained from preceding chapters. Theoretical contributions and practical implications of this thesis are highlighted in Section 7.2.2 and Section 7.2.3, respectively. The limitations and several avenues for future research are reported in Section 7.3.

7.2 Discussion and contributions of this research

7.2.1 Discussion of findings

In the first chapter of this thesis, I made clear that the research objective of this thesis is to investigate influential determinants of regional innovativeness in the Chinese context. In order to achieve this objective, I reviewed prior studies and concentrated on three themes, i.e. RISs, FDI spillovers and industrial externalities. The core research question of this thesis was derived from this literature as: "*Do regional foreign presence and IS affect IC and, if so, how?*" In order to answer this core research question, I divided it into five specific questions and allocate them to different chapters.

Specifically, Chapter 4 was designed to answer RQ1. To do so, I explored the developmental path of Chinese RISs, IS, and inward FDI, adopting the method of comparative analysis to further investigate the RISs of five Chinese regions (i.e. Beijing, Shanghai, Guangdong, Hubei, and Hunan). Findings of Chapter 4 indicate the process of the establishment of Chinese RISs and advances understanding of the important role of regional foreign presence and IS in Chinese RISs. However, the findings of Chapter 4 cannot show the precise role of regional foreign presence and IS in affecting regional IC.

In order to answer the specific research questions 2 in Chapter 5, I hypothesised specific relationships between regional foreign presence, IS, and regional IC, based on the theoretical arguments of prior studies, and then conducted estimations using a selfcompiled panel dataset with 30 Chinese regions over 11 years (2000–2010). Findings in Chapter 5 indicate that both inward FDI and industrial diversity exert significant effect on regional innovativeness in terms of patent applications per 10,000 inhabitants. And, more importantly, the positive role of inward FDI in affecting regional innovativeness is constrained by regional specialisation but promoted by regional diversity.

Given that enterprises have become the main player in Chinese RISs, only focussing on the role of inward FDI and IS on regional innovativeness may neglect some idiosyncratic features of local companies and thus I cannot conclude on the specific effect of foreign presence and IS on domestic companies' IC. In order to answer the fifth specific research question (RQ3) in Chapter 6, I transformed the research question into several hypotheses that assume associations between regional foreign presence and IS and domestic companies' IC and empirically examined these hypotheses using a firm level panel dataset of Chinese PLCs during 2000 to 2010. More importantly, by dividing the whole sample into two subsamples (state-owned PLCs versus non-state-owned PLCs), I further investigated whether the effects of regional FDI and IS on firms' innovativeness is varied according to the firms' ownership. A discussion of the findings from each chapter is presented below.

In Chapter 4, I aimed to answer the first specific research question: "*Why are FDI and IS two critical factors in a **regional** innovation system?*" The analysis of the developmental path of RISs shows that the development of Chinese RISs have close relationships with the dynamic changing processes of IS and the increasingly opened status of Chinese market, for example the increasing inward FDI. Firstly, the focus of

S&T development in China was directly related to promoting specific industrial sectors. For instance, in the early stage of the establishment of the innovation system (1949–1978), the majority of R&D resources were assigned to heavy industrial sectors and military technological fields because national security was the top priority in that period. Due to the strategy of shifting some national defence related industries into rural areas (*san xian jian she*, 1964–1980), many research institutes and universities were set up in inland regions, such as Jiuquan Satellite Launch Centre in Gansu province, and Xi'an Jiaotong University in Shannxi province, which serve as the science base for the development of the RIS of inland regions.

Secondly, the degree of openness of a region is closely related to its RIS. The developmental path of inward FDI attraction provides great opportunities for Chinese innovators, e.g. companies, research institutes, and universities, to absorb advanced knowledge embedded in inward FDI. The descriptive analysis of regional foreign presence in the last decade illustrates that the number of regional patent applications is positively correlated with regional foreign presence in terms of the number of regional FIEs' employees. Thirdly, the process of establishing the Chinese RIS is closely related to the economic transition of industrial companies which become the predominant actors in the S&T development framework.

The analysis of the developmental path of Chinese RISs reveals that, before the 1990s, the Chinese central government used to be the organiser of innovative activities because limited R&D resources needed to be allocated to significant R&D projects, for instance the research on the development of the atomic bomb and satellites. Regional innovative activities in this period were focussed on S&T tasks assigned by the central government instead of determined by regional inventors. In other words, regional innovative activities were part of the national S&T development plan, which neither fully considered market demands nor gave R&D incentives to regional innovators. The reform of the Chinese economic system in the 1990s, i.e. from a planned economy system to a market-driven economy system, reconfigured the S&T framework as the reform confirmed the central role of industrial companies in a decentralised innovation system (Huang et al., 2004). The regional innovation system in China was established in the 1990s which gave regional innovators and policy makers greater autonomy in organising innovative activities (Hong, 2008).

Fourth, the systematic descriptive studies of the five Chinese regions, i.e. Beijing, Shanghai, Guangdong, Hubei, and Hunan, indicate that regional industrial specialisation and diversity changed during the last decade, and apart from Hunan, four of these five regions favour the quadrant of LSHD (low specialization and high diversity). This result provided a preliminary insight, namely that perhaps RISs will be more prosperous with a relatively low level of industrial specialisation and a highly diversified IS. Fifth, the descriptive studies further suggest that FIEs are active players in the regional economy, for example FIEs play an even greater role than domestic companies in Shanghai and Guangdong as FIEs' industrial output exceeds the output of domestic companies. In contrast, inland regions are more likely to rely on the development of indigenous companies because the output of regional FIEs in these regions is comparatively smaller than indigenous companies. The reason for this phenomenon is that coastal regions have better business environments while inland regions lack access to overseas investment. Another interesting finding is derived from the comparison between Hubei and Hunan, indicating that although regional features and conditions are similar for these two inland regions, Hubei went ahead of Hunan in terms of attracting foreign investment. Overall, findings in Chapter 4 confirm that both regional foreign presence and IS are two essential aspects in Chinese RISs. Moreover, results of descriptive studies conducted in Chapter 4 provides some preliminary clues on the relationship between foreign presence, IS and regional innovativeness.

Considering that the descriptive analysis cannot tell me the precise effects of foreign presence and IS on regional innovativeness, I conducted panel regressions using a dataset of 30 Chinese regions over 11 years (2000–2010). Specifically, in the research framework of this thesis, Chapter 5 aimed to answer the second specific research question ("*Can foreign presence affect **regional** IC and, if so, how?*"), the third specific research question ("*Can IS, i.e. specialisation and diversity, affect **regional** IC and, if so, how?*"), and the fourth specific research question ("*Is the association between foreign presence and **regional** innovation contingent on the degree of industrial specialisation and diversity?*"). As Chapter 5 and Chapter 6 show, the panel regression estimates at regional level support most of the hypotheses except the positive effect of specialisation on regional innovativeness in terms of patent applications. As reported in both Chapter 5 and Chapter 6, the independent variables were standardised before entering the full model to reduce the potential problem of multicollinearity (Aiken and West, 1991), allowing direct comparison of the estimates and guaranteeing that the coefficients of interactive effects between foreign presence and specialisation and diversity are meaningful (Dawson, 2013).

Several findings can be extracted from the results of panel regressions from Chapter 5. Firstly, the positive effect of regional foreign presence is even stronger in longer terms (*t+3*) as the increase of regional inward FDI brings more patent applications. Similarly, the moderating roles of specialisation and diversity in affecting the association between foreign presence and regional innovativeness is strongest in the long term (*t+3*), indicating that knowledge spillovers of FDI need some time to be fully exploited by regional innovators. This result is consistent with the argument of prior studies that R&D activities are uncertain and time consuming; that knowledge spillovers from foreign presence cannot be absorbed unless innovators have accumulated a certain level of absorptive capacity; and that this process cannot be completed in a short time (Cohen and Levinthal, 1990a; Jaffe et al., 1993).

Secondly, the overall effect of industrial specialisation on regional innovativeness is insignificant although the coefficients are negative whilst diversity exerts positive effects on regional innovativeness and the effect is greater in the long term (*t+3*) rather than in the short (*t+1*) and medium terms (*t+2*). A possible reason for the insignificant effect of industrial specialisation is that a Chinese region usually has more than 20 industrial sectors and different regions have different portfolios of industrial sectors. As the comparative analysis of the five regions in Chapter 4 illustrates, coastal regions, i.e. Beijing, Shanghai, and Guangdong, were more likely to be specialised in high technology sectors, e.g. '*Electronic and Telecommunications Equipment*' and '*Instrument and Meter*', etc., while inland regions, such as Hunan, was specialised in labour intensive industries, e.g. '*Tobacco Processing*' and '*Nonferrous Metal*', etc. Regional specialisation at an aggregate level may ignore these differences as well as the possibility of the existence of the diversified specialisation regions where both industrial diversity and specialisation and diversity are comparatively higher than other regions. Though I find that there is no linear relationship between specialisation and diversity in the sample, these issues could be the reason for not finding significant effects of specialisation on regional innovation.

Thirdly, I found that regional specialisation negatively moderated the role of foreign presence in affecting regional innovativeness while diversity exerted a positive moderating effect. This result is consistent with the prediction, indicating that the actual effect of inward FDI is affected by regional IS, i.e. that a multi-disciplinary context is better for a region to absorb knowledge spillovers from foreign presence while a higher specialised IS will hinder a region to gain benefit from inward FDI. However, only looking at the roles of foreign presence and IS at regional level might neglect some idiosyncratic features of local companies, which cannot help in further understanding the effect of contextual factors on firm innovation. Therefore, based on the findings of Chapter 5, Chapter 6 further examined the effect of regional foreign presence and IS on regional domestic companies' IC and whether these associations are affected by domestic companies' internal features such as ownership (RQ 3).

Chapter 6 summarised the panel regression results and the hypotheses focussing on the effects of foreign presence and IS on domestic firms' IC as measured by the number of patent applications. As shown in Table 6.5 in Chapter 6, foreign presence and industrial diversity bring positive effects on regional domestic firms' IC but the effect of specialisation is insignificant. This result is consistent with what I find at the regional level, indicating that knowledge spillovers of regional inward FDI and IS are two influential factors of domestic firms' IC. As Chinese PLCs play an essential role in the Chinese economy, the majority of them are competitive in domestic or overseas market. This is because a Chinese company has to gain profit over three consecutive years before it can apply to be a PLC and Chinese PLCs face strict accounting regulations. All these features indicate that Chinese PLCs are more likely to be able to take advantage of foreign presence and to absorb FDI knowledge spillovers for in-house innovative activities. This is consistent with prior studies which suggested that not all host firms can gain benefits from foreign presence since a firm cannot exploit external knowledge unless it has a strong capability in absorbing knowledge from spillovers from foreign presence (Cohen and Levinthal, 1990b; Ferragina and Mazzotta, 2013).

Considering the insignificant role of regional specialisation, besides the aforementioned reason in the regional level study, another reason is that firms in a highly specialised environment are more likely to lock in some specific technologies, which may be detrimental for their innovative activities, for instance radical innovation efforts (Narula, 2002). Similarly, Frenken et al. (2007) contend that a specialised industrial environment is conducive to those incremental innovations while a diversified region is better for conducting radical innovations. Since PLCs are LMEs, once they lock in certain technologies, they may find it difficult to adopt other technologies or absorb new knowledge because of the high sunk costs they have invested in the specialised knowledge base. Moreover, both the expectations of negative moderating role of specialisation and positive role of diversity are supported by panel regression estimates at firm level, indicating that a specialised IS is an obstacle for domestic firms trying to learn from foreign presence while regional diversity is an impetus for domestic firms to gain benefit from FDI spillovers.

Considering that the ownership structure of companies is a critical determinant of their IC (Choi et al., 2011; Choi et al., 2012; Jiang et al., 2013; Love et al., 2009), and although the specific corporate governance structure of Chinese PLCs varies, I distinguished the whole sample as state-owned PLCs and non-state-owned PLCs. I thus examined the effect of regional foreign presence and IS on domestic firms' IC with different ownership (state-owned PLCs and non-state-owned PLCs) in Chapter 6. From a comparative perspective, I found several interesting points as follows.

First of all, although regional foreign presence leads to positive effects on the innovation capabilities of state-owned PLCs and non-state-owned PLCs, the latter can gain greater benefits from inward FDI than state-owned PLCs as the coefficient of FDI is greater in the subsample of non-state-owned PLCs than state-owned PLCs (compare estimates in Table 6.3 and Table 6.4 in Chapter 6). This is mainly because, compared with state-owned PLCs, non-state-owned PLCs may be more promptly to the new products or services launched by local foreign counterparts and non-state-owned PLCs may more efficient in decision making which helps them to absorb foreign spillovers. In fact, prior studies contend that Chinese state-owned enterprises are less innovative as they either have heavy labour burden or have relatively low productivity (Lin et al., 1998). For instance, Gao (2004) examined Chinese state-owned enterprises' presence at provincial level and found a negative association between state-owned enterprise presence and regional economic growth. However, Chinese state-owned PLCs usually show sound financial performance and act as key players in each regional IS. State-owned PLCs are active innovators since they are responsible for a series of national S&T projects and are also the main contributors to Chinese outbound investment (Buckley et al., 2008; Deng, 2004). Therefore, state-owned PLCs have a strong knowledge base and incentives to gain benefits from foreign spillovers.

Secondly, the positive role of industrial diversity significantly affects both state-owned PLCs' and non-state-owned PLCs' IC in short and medium terms, but in the long term, its positive effect is only significant on state-owned PLCs. One possible reason for this result is that, compared with state-owned PLCs, non-state-owned PLCs may be eager to obtain external knowledge to promote their competitiveness because of the disadvantages of in-house R&D capability or of networking with government (Guo et al., 2014). In addition, as Cohen and Levinthal (1990b) suggested, firms need to accumulate sufficient knowledge before gaining knowledge opportunities from external knowledge sources. This concept of knowledge absorptive capacity is especially relevant in a diversified industrial context as firms cannot successfully exploit outside technology opportunities unless they have strong absorptive capacity. Chinese PLCs are believed to be powerful players in regional markets. Both their financial and technical accumulations are stronger than other non-listed companies. Although the state-owned PLCs and non-state-owned PLCs have different characteristics, both of them are giant players in their corresponding sectors and play essential roles in the development of each regional economy. In other words, Chinese PLCs have strong knowledge absorptive capacity to gain benefits ofknowledge spillovers from foreign counterparts. This is helpful for PLCs to absorb knowledge spillovers through communication, local labour mobilisation, and collaborations with foreign companies (Tian, 2006). A diversified industry structure provides multiple knowledge sources to regional PLCs, which is conducive to PLCs' innovative activities. Another potential reason is that non-state-owned PLCs are believed to be more sensitive to the possibilities of combining external knowledge with internal R&D efforts. Non-state-owned PLCs, such as private or legal person owned PLCs, are thought to be more flexible in decision making than state-owned companies (Fu et al., 2006). Chinese non-state-owned PLCs are those first-tier private or legal person owned firms in specific industries which have financial strength that helps them to learn from foreign counterparts in regional markets.

Thirdly, the negative moderating role of specialisation and positive moderating role of diversity in affecting the association between foreign presence and state-owned PLCs' innovativeness are significant in all lagged settings, indicating that state-owned PLCs can gain more benefits from regional inward FDI in a diversified IS rather than in a specialised structure. Although the expectations of the moderating roles of specialisation and diversity in affecting the association between foreign presence and non-state-owned PLCs' IC are only significant in the short and medium term, I believe that the moderating roles of industrial structure exist. Moreover, as introduced in an earlier section, Chinese PLCs are usually giant companies in their corresponding sectors. PLCs have stronger power and capability to gain benefits from industrial externalities and as well to manage their horizontal linkages in a cluster. Specifically, state-owned PLCs are the core manufacturers in key industries, such as China National Petroleum Corporation (CNPC) [25] in the petrochemical industry, China Datang Corporation[26] in the electronics industry, and Aviation Industry Corporation of China[27] in the aerospace industry, etc., indicating that they are able to gain extra support or resources from the Chinese government (Ramasamy et al., 2012b). In other words, state-owned PLCs have sufficient resources to exploit knowledge and opportunities in local industry structure. Non-state-owned PLCs, on the other hand, are essential players

[25] For detailed information on CNPC, please refer to the website of the corporation: http://www.cnpc.com.cn/en/aboutcnpc.
[26] For detailed information on China Datang Corporation, please refer to the website of the corporation: http://www.china-cdt.com/en/index.html
[27] For detailed information on Aviation Industry Corporation of China, please refer to the website of the corporation: http://www.avic.com.cn/cn/EnglishVersion/FromthePresident/index.shtml

in both traditional and high technology sectors, such as the retail industry and ICT industry (Gao, 2014). R&D activities are highlighted in non-state-owned firms as they do not have advantages of close relationships (known as '*guanxi*' in the Chinese context) with regional government and banks (Park and Luo, 2001); non-state-owned PLCs are therefore likely to gain market competitiveness through technology innovation. Non-state-owned PLCs have more autonomy in operations and decision making, which enables them to gain opportunities from foreign presence in diversified sectors. Overall, the findings gained from the firm level study advance the understanding about the effects of foreign presence and IS on domestic PLCs' IC.

7.2.2 Contribution and implications

I hope this thesis can address the five research gaps identified in Chapter 1 and provide some insightful evidence for these theoretical concerns. Contribution and implications of this research are summarised as follows.

Contribution 1: regional IS and RISs

One aim of this thesis is to examine the role of IS in affaecting IC. The literature on regional innovativeness mainly focuses on the roles of internal innovators (and interactive relationships between these innovators), which overlook the effect of industrial externalities. Specialisation and diversity as two dimensions of IS are topics of debate in agglomeration economies. However, very few attempts have been made to incorporate the role of specialisation and diversity into the framework of RISs. The findings of this thesis indicate that industrial diversity is an impetus for both regional and local companies' IC, although the effect of specialisation is unclear in the research. This result may spark an argument that industrial context is actually an important aspect for RISs. Although the findings are mainly based on the Chinese context, the theoretical meaning of the role of IS could be the same when future research incorporates findings in other contexts. And the findings related to the effect of industrial externalities on regions' and firms' IC provide some evidence for the first research gap.

Contribution 2: the role of FDI in the RISs of emerging markets

The second research gap identified at the beginning of this thesis is "*few studies focussed on RISs in the context of emerging markets which may provide different findings for complementing RIS theory*". Indeed, RISs have become a critical part of national innovation competitiveness in emerging markets. Inward FDI as a main driver for regional economic activities in host countries is believed to be a potential factor affecting regional innovative activities as well. The literature has mainly focussed on the experiences of RISs in developed countries and has shifted the theoretical framework to emerging markets directly without comprehensively considering the contribution of regional foreign presence to regional innovativeness. In this thesis, I systematically reviewed two streams of prior literature – RIS and FDI spillovers – and developed several hypotheses based on them. The findings of this research emphasise the positive role of inward FDI in affecting regional innovativeness and domestic firms' IC, which supports the argument that inward FDI is a critical factor which impacts the RISs in emerging countries. Both regional and firm level empirical evidence confirms the idea that studies focussing on RISs in emerging markets cannot neglect the critical role of inward FDI.

Contribution 3: integration of FDI spillovers and industrial externalities

The third and fourth research gaps identified in this thesis were "*few studies* *investigated the regional contingent factors that moderate the association between foreign presence and IC, particularly in recent periods*" and "*the debate of MAR versus Jacobs externalities is inconclusive and few studies focus on the role of IS in affecting the association between foreign presence and IC*". This thesis extends the debate on IS in the context of a developing economy through studying the impacts of FDI spillovers. It addresses a gap in the literature, namely that although most prior studies focussed on the impact of IS and domestic knowledge sources in developed countries, very few empirical studies explored the effects of the MAR and Jacobs models in emerging economies (Beaudry and Schiffauerova, 2009). The debate on MAR and Jacobs externalities for developed countries has been focussed on internal sources of knowledge transfer, whereas this thesis on a leading developing country highlights the essential role of FDI as a potential carrier of new technology and knowledge. This emphasis on IS is particularly relevant in the Chinese context. China has been endeavouring to restructure its industrial composition in building its NIS since the end of 1990s (Ning, 2009b; Sun and Liu, 2010). This thesis provides both regional and firm level evidence illustrating the positive role of industrial diversity and the insignificant role of specialisation in affecting regional innovativeness, which advances the understanding of the debate of MAR versus Jacobs externalities. This thesis links up the two aforementioned strands of debate (see Chapter 2 for details) relating to the effect of FDI spillovers on host innovative activity and the effect of regional industrial externalities within regions. More importantly, as this thesis focuses on regional innovation and FDI, it thus extends the IS debates by examining the impact of an external knowledge source on regional innovation activities, as well as the debate on the determinants of FDI spillovers in a host country's regions by considering the effect of IS. The interesting findings at both regional and firm level indicate the opposite role of industrial specialisation and diversity in affecting external knowledge from FDI spillovers, suggesting that IS is actually a contingent factor impacting on the effect of FDI spillovers. Therefore, this research provides some recent evidence for the debate relating to the effect of FDI spillovers on host innovative activity.

Contribution 4: Contextual factors impacting on companies' innovation

The fifth research gap identified in this thesis is "*few studies examined the role of contextual factors at the regional level in affecting firms' IC*". This thesis advances the understanding of the relationship between contextual features and companies' IC. As regional features in most firm level studies are treated as dummy variables, potential effects of idiosyncratic characteristics of different regions (e.g., industrial structure, technological capability, institutional context, etc) on local companies' innovative activities were neglected in prior studies. In this thesis, I empirically examined the role of inward FDI and IS in affecting local companies' IC, which integrates the findings at regional and firm levels and highlights that it is unreasonable to set regional features as simple dummy variables because the specific effects of regional features are complex and interactively related. The finding also offers a response to the contention addressed in some recent studies that contextual factors cannot be ignored when investigating companies' innovative and entrepreneurial activities (Wang and Lin, 2013; Zahra et al., 2014). Moreover, the findings further indicate that both the magnitude and persistence of the effects of regional foreign presence, industrial specialisation, and diversity are not the same on local firms with different ownership. This connects the roles of inward FDI and IS with the ownership of local companies, which extends the understanding of how local companies with different ownership manifest different reactions to the same regional features.

7.3 Limitations and recommendations for future research

The limitations and shortcomings of this research, I conclude, are as follows. First and foremost, in order to proxy the regional industrial specialisation an aggregated indicator was adopted to measure the overall degree of specialisation. Although this indicator reports the overall degree of specialisation of a region, it does not indicate which specific industrial sectors the region specialised in and may neglect the technology level of regional industries. In other words, it is possible that two regions with similar levels of regional specialisation are concentrating on different industrial sectors. For example, as shown in Chapter 4, although the aggregated specialisation of Guangdong and Hubei in 2008 is 0.97 and 0.99, respectively, the most specialised industrial sector in Guangdong is '*Electronic and Telecommunications Equipment*' (specialisation=3.07) while the most specialised sector in Hubei is '*Transportation Equipment*' (specialisation=2.64). This is a potential reason for the insignificant estimating results for industrial specialisation in both regional and firm level studies as well. Future studies are strongly recommended to devise an appraisal system which enables researchers to identify the most specialised sector or sectors in a region and advance the understanding of the real effect of specialisation on regional IC.

Secondly, the definition and description of specialisation and diversity of this thesis is consistent with Glaeser et al. (1992), Gao (2004) and Ge (2009); some other indicators and measures have also been suggested in some recent studies. For instance, the effect of "*related variety*" and "*unrelated variety*" on employment and productivity has been examined in different countries (Boschma and Iammarino, 2009; Boschma et al., 2012; Essletzbichler, 2013; Frenken et al., 2007; Frenken et al., 2004; Quatraro, 2010). This strand of studies extend the debate of industrial externalities, but the empirical evidence is still inconclusive due to the adoption of a range of mixed methods and different industry classifications (Eriksson, 2011; Essletzbichler, 2013; Neffke and Henning, 2013). I did not incorporate the idea of "*related variety*" into this thesis because the dataset of the IS is mainly focused on the manufacturing industry which cannot support further distinctions of either related or unrelated varieties. Future studies are strongly recommended to examine whether the effect of this related and unrelated diversity is different for local firms' innovativeness.

Thirdly, although the research findings confirm that regional inward FDI is an impetus for both regional innovativeness and domestic companies' IC, the regional inward FDI was not disaggregated into the specific sector in which FIEs engaged. It is reasonable to assume that foreign presence in different sectors may exert different impact on regional innovativeness (Buckley et al., 2007a), but the focus in this thesis was to investigate regional level features that affect regional and local companies' IC. This shortcoming could be a promising avenue for future studies as dividing inward FDI to reflect a regional-sector level will enable researchers to unravel the idiosyncratic features of foreign presence with a more specific perspective and advance the understanding of their impact on firms' IC.

Fourth, the roles of foreign presence and IS were examined at both regional and local firm levels, but I did not try to investigate the roles of these determinants in affecting regional industries' IC. Lack of available data in respect to the patent number and key features (such us R&D intensity) of industries in each region are two practical concerns limiting the investigation in this thesis. Future studies could fill this gap by using regional-industry level datasets of other emerging markets or developed countries; the findings at the regional-industry level will extend the argument in the present research.

Fifth, though I examined the roles of inward FDI spillovers and industrial structure in the innovation capabilities of domestic SOEs and non-SOEs in China, further investigation into the effects of FDI spillovers and industrial structure on the innovativeness of minority state-owned enterprises (MISOEs) and majority state-owned enterprises (MASOEs) is very important (Cai & Tylecote, 2008; Jing & Tylecote, 2005). While the idiosyncratic features of various types of FIEs, such as wholly owned subsidiaries and joint ventures, have a close relationship with innovation, future studies are strongly recommended to examine the findings of my thesis from a more detailed perspective by incorporating these heterogeneous features of firms.

Sixth, though I used a lagged structure of independent variables in econometric configurations (see Chapter 3 for details) to reduce the risks of the endogeneity problem, future studies are strongly recommended to enlarge the data set and find appropriate instrumental variables for FDI spillovers and industrial externalities to avoid the influence of two-way causalities on the estimation results. In addition, as I highlight in subsection 3.4.2 of Chapter 3 on page 119, it is a promising avenue for future research to account for the possible effect of independent variables with varied time lengths on innovative activities.

Seventh, although I compared different indicators of IC, e.g. number of patent applications, number of patent grants, number of patent citations, new product sales, in this thesis, I only adopted the number of patent applications to proxy regional and firm IC, which might neglect other types of innovation output. As prior studies pointed out, the main deficiencies of using patents as the indicator of innovativeness is that not all innovative output, for instance core technologies and tacit knowledge, will be registered as a patent (Jaffe et al., 1993). Due to data constraints, I could only use the number of patent applications to proxy IC for both regional and firm level studies in this thesis. I thus suggest that future studies collect first-hand data through questionnaire surveys which can provide much more specific data for innovation indicators. As the firm level study was conducted based mainly on domestic PLCs, future studies are also strongly recommended to test the findings of this thesis using the dataset of non-listed companies in both the Chinese context as well as in developed countries.

Last but not least, the research is mainly focussed on the Chinese context; thus, the findings of this thesis, i.e. from a single country, can be generalised only with great caution. Although the underlying mechanisms of how inward FDI and IS impact on regional innovativeness appear to be applicable in other countries, China may have some particularities with respect to policy framework, science bases, innovation culture, organisational structure, or institutional setting. For instance, the average size of Chinese regions is much larger than regions in European countries and the industrial portfolio of Chinese regional industries nearly covers all sectors, although the emphasis is varied in different regions, leading to a variation of industrial specialisation and diversity more complex than in regions in other nations. Therefore the findings of this research need to be replicated using data from regions and firms in other countries to obtain greater generalisability.

Appendix 1 Definition of Chinese industrial enterprises with different ownership

Table A1 Definition of Chinese industrial enterprises with different forms of ownership

Type of industrial enterprises	Definition
State-Owned Enterprises	Enterprises in which all the properties belong to the state and that are registered as non-corporation economic organizations. State solely funded corporations are not included in this category.
Collectively Owned Enterprises	Enterprises in which all the properties belong to a collective and that are registered as economic organizations.
Joint Equity Cooperative Enterprises	Enterprises that build upon a cooperation mechanism, are invested in by employees together and absorb a proportion of the social fund. Joint equity cooperative enterprises operate independently, assume sole responsibility for their profits or losses, have democratic management and implement a combination of distribution according to their work and according to the stock dividends.
Joint Venture Enterprises	Economic organizations that are constituted upon the investment of at least two legal persons with the same or different ownership(s). The formats of JVEs include state joint ownership enterprises, collective joint ownership enterprises, joint state–collective enterprises and other joint ownership enterprises.
Limited Liability Corporations (LLCs)	Economic organizations that are invested in by two to fifty shareholders. Each shareholder bears limited liability according to the shareholder's investment, and the corporation uses its total assets to bear liability.
State Solely Funded Corporations (SSFC)	LLCs that are invested in solely by institutions or departments that are authorized by the state.
Other Limited Liability Corporations	LLCs that exclude SSFCs.
Shareholding Limited Corporations	Economic organizations and their registered capital are constituted by equal shares and the capital is raised through issuing shares. Shareholders bear limited liability via share subscription, and the corporation uses its total assets to bear liability.
Privately Owned	Economic organizations that are sponsored or held by an

Enterprises	individual person and employ a labour force to seek profits. The format of POEs includes private-funded enterprises, private partnership enterprises, private limited liability corporations and private shareholding limited corporations.
Other Enterprises	Domestic economic organizations excluding the above-listed enterprises.
Foreign-Invested Enterprises	
Joint Venture Enterprises	Economic organizations that are co-invested in by Hong Kong, Macao and Taiwan (HMT) or overseas investors and domestic enterprises according to a contracted proportion, and the HMT and domestic investors share the profit and operation risk.
Cooperative Enterprises	Economic organizations that are co-invested in or cooperated by HMT or overseas investors and domestic enterprises according to a contract, and the investors share the profit and bear the liability together.
Solely Invested Enterprises	Economic organizations that are located in domestic regions of China and solely invested in by HMT or overseas investors.
Shareholding Corporations Ltd.	Economic organizations that are approved by the Ministry of Commerce of the PRC, in which the proportion of HMT's or overseas investment should exceed 25%. Corporations in which HMT's or overseas investment is less than 25% belong to domestic share-holding limited corporations.

Source: Compiled by the author based on relevant definitions provided by the NBS (available at: http://www.stats.gov.cn/tjsj/tjbz/200610/t20061018_8657.html).

Appendix 2 Historical development of Chinese innovation system

I further illustrate the key S&T regulations or events in Chinese regional innovation system since the implementation of "*Reform and Opening Up*" policy in 1978. The first group of key S&T policies or events is following.

- 1977: The regime of national college entrance examination had been reestablished which signaled that Chinese higher education system became effective from then on;
- 1978: Deng Xiaoping, a famous Chinese leader, put forward that science is a crucial element of social productivity, which confirmed that the development of science and technology is one of the national strategic objectives; a lot of regional research institutes that were originally subordinated to the Chinese Academy of Sciences (CAS) were reshaped as new research organizations; the "*Invention Award Rules*" was promulgated;
- 1979: the "*Natural Science Award Rules*" was promulgated;
- 1982: Chinese Academy of Sciences (CAS) set up the Natural Science Foundation which can be applied by various innovators; the first national S&T development plan – "*Science and Technology Breakthrough Program*" – was implemented by the National Planning Committee and the National Science Committee;
- 1984: the "*Science and Technology Progression Award Rules*" and the "*Patent Law*" were promulgated
- 1985: the "*Central Committee of the Communist Party of China's (CCCPC) Decision on the Reform of Science and Technology Regime*" was promulgated, indicating that competition and market become main themes in S&T regime.

Specifically, market demands become an important determinant for R&D activities rather than the government's solely arrangement; the post-doctorate regime was introduced by the Ministry of Education, Chinese Academy of Sciences and National Planning Committee; the Spark Program has been implemented;

- 1986: the State Council began to reform the mechanism of R&D resources allocation; the '863 Program' has been implemented; the National Natural Science Foundation of China has been established;
- 1987: the "*State Council's Proposal to Further Facilitate the Reform of Science and Technology Regime*" was promulgated, which put forward several suggestions of the reform; National People's Congress examined and approved the "*Law of Technology Contract*";
- 1988: the "*State Council's Decision on Some Questions about Deep Reform of Science and Technology Regime*" was promulgated, which highlighted that universities and research institutes need to fulfill market demand when they conduct R&D activities; Beijing established New Technology Development Zone (NTDZ) in Haidian district; Torch Plan has been implemented;
- 1990: the National People's Congress issued "*The Copyright Law of the People's Republic of China*";
- 1991: National Science Committee launched the "*Policies of National High Technology Industry Development Zone*" and the "*Tax Policies of National High Technology Industry Development Zone*";
- 1992: the Climb Program has been implemented; National Science Committee and Institutional Reform Committee jointly launched the "*Some Recommendations Regarding to Talent Distribution, Organization Adjustment*

and Deep Reform of S&T Institution";

The first group of policies, which were launched during 1977 to 1992, focused on how to generate the Chinese innovation system combining with national reform and social development process. As I can see from the above policies, on the one hand, Chinese government made great efforts to establish national and regional S&T framework through setting up various research institutes, e.g., CAS, and issuing various S&T development programs, e.g., '863 Program' and 'Climb Program'. On the other hand, policy makers focused on the building of legal system of IPR in this period. Although the legal system of IPR was not perfect, it provided some preliminary guidance and supports for private inventive activities in this period. Additionally, the development of high technology industries was highlighted by policy makers as relevant regulations and policies were lunched to support the establishment of National High Technology Industry Development Zone. Overall, the policies and regulations that lunched in this group provided guidance and support to accumulate technology base for the Chinese regional innovation system.

The second group of key S&T policies or events is following.

- 1993: the '211 project' has been implemented, which means that the Ministry of Education would support the development of 100 universities before 2000, universities that on the list of '211 project' would receive no less than 100 million RMB; the National People's Congress approved the "*The progress of science and technology law of the People's Republic of China*";
- 1994: the State Council proposed the "*China's Agenda in 21st Century*", confirming the sustainable development strategy for the next century;
- 1995: the CPC Central Committee and the State Council jointly issued the

"*Decision on Facilitating the Science and Technology Progress*", highlighting the strategy of national development through science and education;

- 1996: the Technology Innovation Plan (TIP) was implemented, aiming to support R&D activities conducted by companies with great technological potential, such as Haier, Chang Hong, etc; the National People's Congress approved the "*Decisions on Promoting the Transfer of Scientific and Technological Achievements*";
- 1997: The '973 Program', aiming to support the development of basic science and technology, has been implemented;
- 1998: the Knowledge Innovation Program, focusing on the knowledge production role of universities and research institutes, has been implemented by the Chinese Academy of Sciences (CAS); in order to establish the first-tier university, the Ministry of Education selectively supports the development of ten universities, and Peking University and Tsinghua University especially received great amount of investment;
- 1999: the CPC Central Committee and the State Council jointly issued the "*Decisions on Technology Innovation Reinforcement, High Technology Development and Industrialization Realization*", putting forward to give financial and policy supports for industrial S&T projects;
- 2003: the Ministry of Science and Technology (MOST) launched "*Regulations about the Management of Intellectual Property Right within the National S&T Plan*";
- 2005: the State Council launched the "*Outlines of National S&T Development Plan in Medium and Long Term: 2006-2020*", which clearly points out the objective, method and key points of S&T development in the next fifteen years;

- 2006: the CPC Central Committee and the State Council jointly issued the "*Decisions on Implementation of the Outlines of S&T Development Plan and Reinforcement of Independent Innovation Capability*", highlighting the essential role of independent innovation capability;
- 2010: the CPC Central Committee and the State Council jointly issued the "*Outlines of the National Talents Training and Development Plan in Medium and Long Term: 2010-2020*", which systematically illustrates the importance and method of talent development;

The second group of policies, which were issued during the period of 1993 to 2010, mainly focused on three aspects of Chinese innovation system. Firstly, the fundamental role of higher education has been realized by government. Two significant programs, '211 project' and '985 program', have been launched by central government. These two programs not only allocate sufficient resources to support limited number of Chinese universities to develop and catch up with first tier universities in the world, but also promote the improvement of education system in China. The focus of promoting higher education sector is conducive to accumulate indigenous human capital and helpful to strengthen the University-Industry linkage (Hong, 2008). Second, the high technology sectors become a key focus within the group of policies during this period. Various policies and regulations have been issued to provide conveniences for the development of high technology industries. For instance, over 50 High Technology Development Zones have been established in major cities of China. The number of high technology enterprises (HTEs) in these High Technology Development Zones increased from 20,796 in 2000 to 51,764 in 2010 and the industrial output increased from 794.20 billion

RMB to 7,575.03 billion RMB during this period[28]. Thirdly, policy makers began to propose strategic plan for the development of region innovation system. As I analyzed in a preceding section, technological innovation has been confirmed as the engine for the economic development, and the sustainable development principle has been set as the core theme of future development (Fu and Mu, 2014; Liu and White, 2001). Overall, this group of S&T policies provides concrete and strategic guidance for the development of national and regional innovation system.

[28] Data source: National Statistical Bureau of P.R.China.

Appendix 3 Panel regressions using random effects model

Table A2 Negative binomial panel regressions (random effects) using patent number in t+1, 2, 3 as dependent variable (all PLCs)

	$Patents_{it+1}$				$Patents_{it+2}$				$Patents_{it+3}$			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Firm features												
R&D intensity	-0.035	-0.034	-0.031	-0.031	-0.101	-0.095	-0.087	-0.076	-0.040	-0.039	-0.039	-0.036
	(0.055)	(0.052)	(0.049)	(0.046)	(0.114)	(0.111)	(0.108)	(0.103)	(0.070)	(0.066)	(0.064)	(0.055)
age	0.056***	0.048***	0.044***	0.035***	0.072***	0.058***	0.055***	0.046***	0.067***	0.049***	0.047***	0.039***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.007)	(0.007)	(0.007)	(0.007)	(0.009)	(0.009)	(0.009)	(0.009)
size	0.083	0.106***	-0.101***	0.092***	0.074***	0.096***	0.089***	0.084***	0.071**	0.089***	0.080**	0.075**
	(0.024)	(0.024)	(0.025)	(0.025)	(0.027)	(0.027)	(0.027)	(0.027)	(0.034)	(0.034)	(0.034)	(0.034)
leverage	-0.016***	-0.016***	-0.016***	-0.015***	0.002	0.001	0.001	0.001	-0.012	-0.012	-0.012	-0.011
	(0.006)	(0.006)	(0.006)	(0.006)	(0.004)	(0.004)	(0.004)	(0.004)	(0.011)	(0.011)	(0.011)	(0.010)
ROA	1.305***	1.306***	1.309***	1.253***	0.962***	1.034***	1.040***	1.032***	1.080***	1.117***	1.142***	1.114***
	(0.305)	(0.305)	(0.304)	(0.303)	(0.333)	(0.334)	(0.335)	(0.331)	(0.381)	(0.383)	(0.385)	(0.380)
Tobin's Q	0.035**	0.044***	0.034**	0.024	0.030	0.032	0.020	0.008	-0.016	-0.019	-0.036	-0.045
	(0.016)	(0.016)	(0.016)	(0.017)	(0.022)	(0.022)	(0.022)	(0.022)	(0.030)	(0.030)	(0.031)	(0.031)
Regional features												
human capital	0.080***	0.062***	0.065***	0.070***	0.063***	0.038***	0.041***	0.047***	0.054***	0.027***	0.032***	0.037***
	(0.005)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.007)	(0.007)	(0.007)	(0.008)	(0.008)	(0.008)
GDP growth	0.028***	0.019**	0.029***	0.039***	0.038***	0.030***	0.038***	0.046***	0.093***	0.085***	0.093***	0.097***
	(0.008)	(0.008)	(0.009)	(0.009)	(0.008)	(0.008)	(0.009)	(0.009)	(0.011)	(0.011)	(0.011)	(0.011)
Employment	0.821***	0.785***	0.774***	0.813***	0.643***	0.587***	0.591***	0.644***	0.511***	0.470***	0.490***	0.540***
	(0.050)	(0.050)	(0.055)	(0.055)	(0.054)	(0.054)	(0.059)	(0.060)	(0.061)	(0.061)	(0.066)	(0.067)
Explanatory variables												
fdi		0.008***	0.008***	0.249***		0.010***	0.010***	0.299***		0.011***	0.010***	0.300***
		(0.001)	(0.001)	(0.031)		(0.001)	(0.001)	(0.034)		(0.001)	(0.001)	(0.041)

specializatio			0.269***	-0.003			0.189***	-0.042			0.168**	-0.011
n			(0.070)	(0.032)			(0.067)	(0.030)			(0.070)	(0.032)
diversity			1.449*	0.200***			1.034	0.179***			0.326	0.133***
			(0.870)	(0.036)			(0.882)	(0.036)			(0.956)	(0.041)
fdi×spe				-0.143***				-0.169***				-0.105***
				(0.034)				(0.032)				(0.033)
fdi×div				0.295***				0.268***				0.220***
				(0.033)				(0.033)				(0.037)
Constant	-10.57***	-10.77***	-12.24***	-10.52***	-8.915***	-8.826***	-9.982***	-8.826***	-8.127***	-8.089***	-8.570***	-7.997***
	(0.641)	(0.646)	(0.888)	(0.664)	(0.704)	(0.707)	(0.934)	(0.734)	(0.860)	(0.859)	(1.073)	(0.884)
Log Likelihood	-15993.08	-15965.61	-15951.61	-15909.57	-13998.61	-13963.65	-13956.18	-13919.55	-10751.13	-10725.32	-10721.12	-10702.43
Wald chi2	1029.9**	1064.6**	1084.0**	1186.3**	620.82**	695.47**	709.41**	792.32**	433.41**	497.41**	508.28**	552.57**
	*	*	*	*	*	*	*	*	*	*	*	*
Firms	1524	1524	1524	1524	1310	1310	1310	1310	1175	1175	1175	1175
Obs.	9291	9291	9291	9291	8065	8065	8065	8065	5965	5965	5965	5965

Note: The panel includes Chinese PLCs in the period of 2000 to 2010. Standard errors are reported in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

Table A3 Negative binomial panel regressions (random effects) using patent number in t+1, 2, 3 as dependent variable (state-owned PLCs)

	Patents$_{it+1}$				*Patents$_{it+2}$*				*Patents$_{it+3}$*			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Firm features												
R&D intensity	0.289*	0.287*	0.296*	0.361**	-0.001	0.004	0.006	0.034	-0.011	-0.010	-0.009	0.020
	(0.155)	(0.153)	(0.152)	(0.153)	(0.164)	(0.163)	(0.162)	(0.163)	(0.153)	(0.153)	(0.154)	(0.158)
age	0.083***	0.079***	0.074***	0.062***	0.104***	0.094***	0.092***	0.082***	0.087***	0.078***	0.076***	0.065***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.010)	(0.010)	(0.010)	(0.011)	(0.012)	(0.012)	(0.012)
size	0.140***	0.147***	0.141***	0.135***	0.065*	0.074**	0.065*	0.066	0.019	0.022	0.016	0.017
	(0.034)	(0.034)	(0.034)	(0.034)	(0.035)	(0.035)	(0.035)	(0.036)	(0.041)	(0.042)	(0.042)	(0.042)
leverage	-0.004	-0.004	-0.004	-0.005	-0.003	-0.005	-0.005	-0.006	-0.004	-0.005	-0.005	-0.003
	(0.034)	(0.008)	(0.008)	(0.008)	(0.012)	(0.012)	(0.012)	(0.013)	(0.013)	(0.013)	(0.013)	(0.014)
ROA	1.183**	1.242**	1.323**	1.322**	0.700	0.831	0.875*	0.844	-1.416**	1.504**	1.557***	1.492**
	(0.507)	(0.509)	(0.510)	(0.510)	(0.521)	(0.524)	(0.529)	(0.526)	(0.585)	(0.588)	(0.592)	(0.587)
Tobin's Q	0.037	0.039	0.014	-0.006	-0.015	-0.015	-0.032	-0.040	-0.019	-0.023	-0.039	-0.050
	(0.037)	(0.037)	(0.038)	(0.038)	(0.039)	(0.039)	(0.041)	(0.041)	(0.045)	(0.045)	(0.047)	(0.047)
Regional features												
human capital	0.066***	0.058***	0.062***	0.073***	0.053***	0.038***	0.043***	0.048***	0.059***	0.046***	0.050***	0.058***
	(0.007)	(0.008)	(0.008)	(0.009)	(0.007)	(0.008)	(0.009)	(0.009)	(0.008)	(0.009)	(0.010)	(0.010)
GDP growth	0.030**	0.028**	0.040***	0.051***	0.026**	0.024 **	0.031**	0.039***	0.083***	0.080***	0.087***	0.092***
	(0.012)	(0.012)	(0.013)	(0.013)	(0.012)	(0.012)	(0.013)	(0.013)	(0.014)	(0.014)	(0.014)	(0.014)
Employment	0.592***	0.595***	0.584***	0.663***	0.408***	0.407***	0.429***	0.485***	0.400***	0.397***	0.428***	0.500***
	(0.069)	(0.070)	(0.075)	(0.076)	(0.068)	(0.068)	(0.074)	(0.075)	(0.074)	(0.075)	(0.080)	(0.081)
Explanatory variables												
fdi		0.004**	0.003*	0.135***		0.006***	0.006***	0.207***		0.006***	0.005**	0.197***
		(0.002)	(0.002)	(0.050)		(0.002)	(0.002)	(0.052)		(0.002)	(0.002)	(0.058)
specialization			0.248***	-0.009			0.178**	-0.031			0.144*	-0.023
			(0.085)	(0.040)			(0.082)	(0.038)			(0.082)	(0.039)

diversity			1.599	0.257***			0.089	0.162***			-0.471	0.168***
			(1.131)	(0.053)			(1.087)	(0.052)			(1.128)	(0.055)
fdi×spe				-0.136***				-0.134***				-0.104***
				(0.042)				(0.039)				(0.040)
fdi×div				0.297***				0.234***				0.262***
				(0.051)				(0.048)				(0.051)
Constant	-10.17***	-10.33***	-11.89***	-10.60***	-6.896***	-7.045***	-7.337***	-7.340***	-6.274***	-6.268***	-6.146***	-6.789***
	(0.895)	(0.902)	(1.198)	(0.922)	(0.885)	(0.889)	(1.160)	(0.919)	(1.042)	(1.045)	(1.300)	(1.079)
Log Likelihood	-7774.01	-7771.74	-7763.66	-7745.47	-7901.85	-7896.05	-7893.05	-7879.22	-6803.86	-6799.83	-6798.18	-6784.53
Wald chi2	483.43**	482.36**	501.05**	538.56**	379.92**	392.16**	399.35**	426.91**	320.89**	330.57**	336.21**	365.03**
	*	*	*	*	*	*	*	*	*	*	*	*
Firms	899	899	899	899	859	859	859	859	801	801	801	801
Obs.	5310	5310	5310	5310	5010	5010	5010	5010	4023	4023	4023	4023

Note: The panel includes Chinese PLCs in the period of 2000 to 2010. Standard errors are reported in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

Table A4 Negative binomial panel regressions (random effects) using patent number in t+1, 2, 3 as dependent variable (nonstate-owned PLCs)

	Patents$_{it+1}$				*Patents$_{it+2}$*				*Patents$_{it+3}$*			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Firm features												
R&D	-0.331*	-0.332*	-0.312*	-0.312*	-0.354	-0.365*	-0.328	-0.315	-0.178	-0.172	-0.141	-0.145
intensity	(0.185)	(0.185)	(0.183)	(0.181)	(0.215)	(0.216)	(0.212)	(0.207)	(0.213)	(0.210)	(0.204)	(0.204)
age	-0.012	-0.015*	-0.022**	-0.027***	-0.026**	-0.032***	-0.036***	-0.042***	-0.025*	-0.040***	-0.042***	-0.045***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.011)	(0.011)	(0.212)	(0.011)	(0.014)	(0.014)	(0.014)	(0.014)
size	0.174***	0.186***	0.185***	0.172***	0.281***	0.269***	0.271***	0.252***	0.409***	0.386***	0.363***	0.343***
	(0.036)	(0.037)	(0.037)	(0.037)	(0.048)	(0.048)	(0.048)	(0.048)	(0.064)	(0.063)	(0.063)	(0.063)
leverage	-0.019***	-0.019***	-0.019***	-0.018***	-0.003	-0.004	-0.004	-0.004	-0.024	-0.019	-0.018	-0.016
	(0.006)	(0.007)	(0.006)	(0.007)	(0.006)	(0.006)	(0.006)	(0.006)	(0.015)	(0.013)	(0.012)	(0.012)
ROA	1.348***	1.342***	1.309***	1.320***	1.003**	1.082**	1.027**	1.108***	0.602	0.723	0.709	0.756
	(0.406)	(0.402)	(0.399)	(0.397)	(0.424)	(0.423)	(0.419)	(0.419)	(0.500)	(0.500)	(0.496)	(0.495)
Tobin's Q	0.056***	0.063***	0.052**	0.046**	0.057**	0.054**	0.040	0.030	0.024	0.018	-0.006	-0.010
	(0.021)	(0.021)	(0.021)	(0.021)	(0.027)	(0.027)	(0.027)	(0.027)	(0.042)	(0.041)	(0.043)	(0.043)
Regional features												
human	0.079***	0.066***	0.068***	0.071***	0.080***	0.053***	0.055***	0.059***	0.039***	-0.004	-0.001	-0.001
capital	(0.007)	(0.008)	(0.008)	(0.008)	(0.010)	(0.011)	(0.011)	(0.011)	(0.014)	(0.015)	(0.015)	(0.015)
GDP growth	-0.008	-0.011	-0.001	0.005	0.027**	0.020	0.029**	0.035**	0.071***	0.060***	0.072***	0.075***
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.014)	(0.018)	(0.017)	(0.018)	(0.018)
Employment	1.067***	1.011***	0.983***	1.012***	1.042***	0.933***	0.894***	0.934***	0.783***	0.669***	0.631***	0.645***
	(0.076)	(0.077)	(0.083)	(0.086)	(0.090)	(0.090)	(0.099)	(0.103)	(0.109)	(0.107)	(0.115)	(0.118)
Explanatory variables												
fdi		0.007***	0.008***	0.197***		0.010***	0.010***	0.258***		0.015***	0.015***	0.410***
		(0.002)	(0.002)	(0.043)		(0.002)	(0.002)	(0.051)		(0.002)	(0.002)	(0.063)
specializatio			0.428***	0.072			0.268**	-0.016			0.182	0.017
n			(0.123)	(0.054)			(0.119)	(0.050)			(0.130)	(0.057)

diversity			2.670*	0.144**			3.746**	0.200***			3.713**	0.160**
			(1.459)	(0.056)			(1.583)	(0.060)			(1.887)	(0.072)
fdi×spe				-0.138**				-0.206***				-0.089
				(0.061)				(0.057)				(0.061)
fdi×div				0.255***				0.280***				0.140**
				(0.051)				(0.054)				(0.063)
Constant	-13.20***	-13.17***	-15.83***	-12.70***	-15.50***	-14.48***	-17.92***	-13.84***	-16.16***	-14.80***	-17.70***	-13.25***
	(0.943)	(0.952)	(1.440)	(0.986)	(1.230)	(1.234)	(1.664)	(1.297)	(1.523)	(1.498)	(1.955)	(1.563)
Log Likelihood	-8294.64	-8284.24	-8271.03	-8257.85	-6189.69	-6174.87	-6164.85	-6148.82	-3968.36	-3945.29	-3939.89	-3936.97
Wald chi2	404.56***	421.69***	437.93***	463.03***	230.91***	269.98***	286.06***	322.80***	146.10***	206.70***	217.31***	227.53***
Firms	1186	1186	1186	1186	886	886	886	886	568	568	568	568
Obs.	3981	3981	3981	3981	3055	3055	3055	3055	1942	1942	1942	1942

Note: The panel includes Chinese PLCs in the period of 2000 to 2010. Standard errors are reported in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

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