THE RELATIONSHIPS BETWEEN INTERNATIONALISATION AND INNOVATION— INTERNATIONALISATION STRATEGIES, FOREIGN FIRMS' PATENTING BEHAVIOUR, AND FDI INNOVATION SPILLOVERS

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Thesis Summary

This thesis aims to contribute to the understanding of the relationships between internationalisation and innovation. Based on large comprehensive firm level data from China, this thesis comprises of three empirical chapters examining internationalisation from different aspects.

Specifically, the first empirical work studies how firms internationalise. It links the choice of firms' internationalisation strategies with firm characteristics. Additionally, it re-examines the stepwise internationalisation theory by distinguishing different foreign direct investment (FDI) motives. It proposes two pecking orders of firm performance in internationalisation strategies.

The second empirical study investigates what kind of innovation activities internationalised firms do. It analyses the factors that drive foreign firms to patent in an emerging host country context. It stresses the importance of the intellectual property rights protection aspect of business environment at regional level in promoting patents, the role of industry dependence on external finance in shaping foreign firms' patenting behaviour, as well as links foreign firms' patent production with FDI motivation.

The third empirical research examines the effect of internationalisation by examining the links between inward FDI and domestic innovation in a host country. It specifically examines technology spillovers from inward FDI through the direct lens of innovation (captured by grant patents), instead of adopting the indirect productivity approach widely employed by the literature. Distinguishing different types of innovation, it provides direct evidence of heterogeneous innovation spillovers from FDI.

Key words: internationalisation, FDI motivation, technology spillovers, subsidiaries' patent, China

DEDICATION

I dedicate this work to my PhD supervisors and my parents.

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CHAPTER 1: INTRODUCTION

1.1 Background

This thesis contributes to the understanding of the relationships between internationalisation and innovation. It examines the factors driving firms to internationalise, as well as the effects of internationalisation. Specifically the thesis investigates the internationalisation strategies (exporting and conducting foreign direct investment, ie. FDI) of emerging market-based firms, the innovation activities of foreign owned firms, and the spillover effect from inward FDI on innovation in a host country.

China is of particular interest in the context of internationalisation, as it has become integrated with the world economy since its "Open Door" reform in the late 1970s and hastened such integration after joining the World Trade Organisation in 2001 (Buckley et al., 2007). China was the largest exporter in the world in 2009, with a large proportion of exports generated from domestic sectors (WTO, 2010). Meanwhile, another notable feature of China's internationalisation is that its outward FDI is no longer only constrained to be conducted or influenced by large state-owned enterprises (SOEs) as traditionally viewed (Schuler-Zhou and Schuller, 2009). Faced with intense domestic market competition and motivated by strong entrepreneurship, domestic sectors have become more participative in conducting outward FDI since 2005 (Gu, 2009).

Although the significant increase of outward FDI from China has drawn great attention, the current discussion appears to be based on macro level evidence (Cheung and Qian, 2009), conceptual frameworks (Cui and Jiang, 2009) and case studies (Deng, 2007), which may not be representative of the whole picture of internationalisation. Given that firm characteristics and ownership advantages are crucial for internationalisation (Hollenstein, 2005), there is a paucity of micro level evidence about how emerging market-based firms internationalise. This topic not only offers important insights into the internationalisation behaviour of emerging market

multinational enterprises (EMNEs), but also has obtained great importance in the world trading system. Therefore, it is important to understand the internationalisation of Chinese firms from both a policy and academic perspective.

Moreover, a new pattern of MNEs' internationalisation is that emerging economies appear to have gained importance in the R&D internationalisation process. R&D offshore investment by MNEs into emerging economies is no longer only restricted to imitation and product adaption, but also is to create new knowledge and launch innovation (Liu and Chen, 2012). For example, in China, according to the data used for this thesis, the patents owned by foreign firms have increased dramatically in the last decade, due to the growth of the proportion of foreign firms obtaining patents and the increase in the number of patents granted to foreign firms. Since the existing literature calls attention to foreign firms' innovation activities which has important implications for technology transfer (Driffield and Love, 2007; Marin and Bell, 2006), the question of what drives foreign firms to innovate and patent in host countries is profoundly important but stays largely unanswered.

Furthermore, as a high-profile host country of inward FDI, China was ranked the second largest FDI recipient in the world in 2012 (UNCTAD, 2013). Given that a crucial reason for the Chinese government to attract inward FDI is to improve technology competence, it is important to understand how FDI contributes to the technology development in China. This leads to another motivation for this thesis, which is to investigate the relationships between inward FDI and innovation of domestic sectors. Especially during the global economic downturn, innovation can play a pivotal role in long-term economic growth. A thorough understanding of the effect from FDI on innovation has important policy and practical implications.

Therefore, three research questions are explored in this thesis to provide a systematic investigation into the relationships between internationalisation and innovation: (1) how emerging market-based firms choose between different internationalisation strategies (ie. exporting only, conducting FDI only, and engaging in both exporting and FDI simultaneously),

and how these strategies are related?; (2) what factors drive foreign firms to patent in an emerging host country?; (3) to what extent can domestic firms receive innovation spillovers from inward FDI?.

These questions are inter-related and aim to study distinctive aspects of internationalisation. The first research question investigates how firms internationalise. It specifically examines why firms export, conduct FDI or engage in exporting and FDI simultaneously. Additionally, this empirical work elucidates the links between firms' characteristics and FDI motivation. The second research question is related to what internationalised firms do in a host country. It investigates what factors drive foreign firms to patent and explains the links between patenting activities and FDI motivation. The third research question is to explore how internationalised firms can affect a host country. It examines the technology spillovers from inward FDI by adopting a grant patent approach. Existing spillovers studies typically employs a productivity approach to infer technology spillovers from inward FDI. However, the improved productivity performance could be pecuniary externalities rather than technological benefits. Hence, grant patent is used to capture a direct output of technology spillovers from FDI.

The thesis makes several contributions. Chapter 2 provides micro level evidence of how firm characteristics influence their choices of internationalisation strategies, and re-states the traditional stepwise internationalisation framework. Chapter 3 contributes to the understanding of foreign firms' innovation and patenting behaviour in host countries. Chapter 4 proposes an innovative approach to directly capture technology spillovers from inward FDI from an innovation spillovers perspective. It also generates a high quality linked dataset with information on patents and firm characteristics in China for future research.

1.2 Research Aims and Objectives

The aim of this thesis is to contribute to the understanding of the relationships between innovation and internationalisation. Three empirical works have been conducted. This section

individually explains the motivation for each chapter, the research objectives, the data employed and contributions.

1.2.1 What factors drive firms to choose different internationalisation strategies?

Chapter 2 links firms' internationalisation strategies with firm characteristics. It is motivated by the fact that the new patterns of internationalisation cannot be fully explained by the traditional internationalisation theory (Johanson and Wiedersheim-Paul, 1975). Data from various countries display deviations from the theory. Some firms engage in exporting and FDI simultaneously, while others only adopt either exporting or FDI strategy. There are also "born global" firms which conduct FDI soon after their establishment without exporting (Freeman et al., 2010). These new patterns challenge the prediction of the stepwise internationalisation theory.

Another motivation for chapter 2 is the paucity of work which identifies firm level ex-ante motives to conduct FDI. Although there is voluminous international economics literature explaining firms' export and FDI decisions by productivity heterogeneity (Helpman, Melitz and Yeaple, 2004), or examining internationalisation strategies based on resource-based view (Hu and Cui, 2014) or an institutional perspective (Stoian, 2013), it is unclear if the exporting leading to conducting FDI relationship stands for different FDI motivation.

Moreover, the literature suggests that exporting experience is important for conducting FDI (Gao, Liu and Zou, 2013). Exporting experience is heterogeneous depending on the learning opportunities of exporting destinations (Love and Ganotakis, 2013). Nevertheless, formal analysis of why heterogeneous exporting experience may affect firms' FDI decision is quite scant.

Chapter 2 has three objectives. The first objective is to study how firms choose between internationalisation strategies of exporting, FDI, or a combination of the two strategies. The internationalisation strategies will be linked to firms' economic performance, technology

endowment and government perspectives, extending the literature that focuses mainly on the productivity differences between exporters and non-exporters, or between MNEs and non-MNEs (Greenaway and Kneller, 2007). The second objective is to examine whether or not the predicted relationship of exporting leading to conducting FDI holds when FDI has different motives. This extends the stepwise internationalisation theory and empirical works which may reach contradictory findings because they generally treat FDI motivation as equivalent. The third objective is to explain what makes exporters to conduct FDI in the future. This will shed some light on the mechanism of how exporting experience could affect firms' FDI decision.

Chapter 2 draws on panel data from the National Survey of Above-scale Private Firms in China, collected and maintained by the All-China Federation of Industry and Commerce (ACFIC). Only firms which reach over 300 million Renminbi yuan (about 45 million US dollars) annual revenue are included in the survey. The sample contains approximately 3,000 observations over the period 2005, 2006 and 2009, covering 11 manufacturing industries and 10 service industries in all the 31 provinces in China. The panel data structure allows me to investigate the dynamic choice of internationalisation strategies. The survey is conducted among private firms, which mitigate the potential political factors that may shape firms' internationalisation strategies.

Chapter 2 contributes to the literature in several ways. Firstly, it confirms the importance of productivity for firms to conduct FDI. More importantly, it extends the literature by finding that while strategic asset-seeking FDI can enhance parent firms' ownership advantages, it is not without costs. Firms have to possess some key elements to engage in strategic asset-seeking FDI. Only the firms that are productive and profitable enough are capable to do so. Secondly, chapter 2 distinguishes FDI motivation and suggests that the predicted relationship of exporting leading to conducting FDI only stands for market-seeking FDI, but not for other FDI motives. It expands the traditional stepwise internationalisation theory which pools heterogeneous FDI motives together. Thirdly, this chapter explains the mechanism of the relationship between exporting and conducting FDI, emphasising the importance of heterogeneous exporting

experience.

1.2.2 What drives foreign firms to patent in an emerging host country?

Chapter 3 is concerned with patenting activities of foreign firms (MNEs' foreign subsidiaries) in emerging host countries. It stresses the important roles of local intellectual property rights (IPR) protection at regional level, FDI motivation, and industry dependence on external finance.

The motivation for chapter 3 is based on the fact that MNEs are increasing their innovation internationalisation activities in emerging countries, such as Eastern European countries, India and China (Demirbag and Glaister, 2010). Not only do MNEs invest in R&D activities, but also they produce a large number of patents (Hu, 2010). Such phenomenon challenges the traditional view that the FDI in R&D in an emerging economy context mainly involves product adaptation in lieu of creating new knowledge (Athukorala and Kohpaiboon, 2010). In addition, there is sparse literature specifically investigating foreign firms' patenting behaviour (Park, 2008b). Despite the broad literature investigating MNEs' R&D internationalisation (Nieto and Rodriguez, 2011), the enquiry of what makes foreign firms to produce innovation output such as patents in an emerging economy becomes paramount but is largely unanswered.

Additionally, FDI motivation plays a crucial role in determining foreign firms' innovation in terms of the extent to which technologies are transferred from parent firms to foreign subsidiaries, and subsequently the potential of foreign subsidiaries producing innovation (Driffield and Love, 2007). However, there is even less work on this, and hence it is pivotal to take FDI motivation into consideration.

Finally, in an emerging economy where capital markets tend to be inefficient and financial systems are likely to be against private firms, industries that are more dependent on external finance could be more penetrated by foreign firms which are capital endowed. It is interesting to explore foreign firms' patenting behaviour according to industry dependence on external finance.

Chapter 3 investigates three questions: (1) how does local intellectual property rights protection affect foreign firms' patenting?; (3) whether or not foreign firms' patenting activities are shaped by industry dependence on external finance?; (2) how can different FDI motives influence foreign firms' patenting behaviour?.

The empirical analysis of chapter 3 is based on linked data generated from linking two large firm level datasets from China. Since there are no existing firm level patent data covering a large population of firms in China, I match two datasets over the period of 2000 to 2008 based on the identifications of firm and legal person, as well as location and time of observation. The first dataset is the Annual Report of Industrial Enterprise Statistics maintained by the National Bureau of Statistics (NBS) of China. The NBS data cover the population of state-owned enterprises and all non-state firms with an annual turnover of over five million Renminbi yuan (about 600,000 US dollars). The firms in the dataset account for about 85-90% of total output in most industries reported in the national aggregate annual statistics. The second dataset is the population of grant patents registered by the State Intellectual Property Office (SIPO) of China. It provides detailed information on both applied patents and granted patents.

The econometric analysis in this chapter is restricted to foreign invested firms operating in China. There are 297,254 observations for 82,624 firms identified over the period 2001-2008 that have the necessary information for estimations. Panel Probit random effect model is employed for all the estimations. I also distinguish different types of patents in addition to analysing patenting behaviour in general.

Chapter 3 completes the internationalisation literature by specifically studying foreign firms' patenting activities. This chapter proposes a new approach to capture IPR protection at provincial level and discovers that the effects of IPR protection on different types of patents are heterogeneous. It provides empirical support for the IPR system reform in China to enhance innovation. Second, chapter 3 links FDI motivation with foreign firms' innovation, which is rarely investigated by the literature. Domestic market-seeking foreign firms are more likely to

patent. This finding stresses the importance to have a thorough understanding of foreign firms in terms of their innovation activities and potential for technology spillovers. Third, chapter 3 expands the literature on R&D internationalisation by suggesting that foreign firms are likely to innovate and patent in industries that are more dependent on external finance. These industries are more likely to be penetrated by foreign firms, as a result of the inefficient and biased financial system against private firms. Also, for industries which are more dependent on external finance, foreign firms likely have less severe financial constraints than domestic Chinese firms when it comes to innovation.

1.2.3 To what extent can domestic firms receive innovation spillovers from inward FDI?

Chapter 4 contributes to the studies on technology spillovers from inward FDI in host countries. Specifically it explores the extent to which domestic firms can benefit from innovation spillovers by adopting a grant patent approach. It is motivated by the fact that typically FDI spillovers studies employ a productivity approach and infer technology transfer from MNEs to domestic firms from productivity performance. However, productivity improvement could come from pecuniary externalities rather than technological improvement (Driffield and Jindra, 2012). In addition, the situation is more complex given the variety of influencing factors of productivity and the way productivity is estimated, which could lead to contradictory findings (MacGarvie, 2006). The mixed findings reported in meta-analysis such as Havranek and Irsova (2011) and Irsova and Havranek (2013) could be result of the indirect methodologies adopted by the literature linking economic performance with FDI.

Another reason to examine the innovation spillovers is that inward FDI is an important external knowledge source, especially for emerging host countries, it is perhaps surprising to observe that the empirical studies linking FDI with host country innovation are scant.

Moreover, innovation is crucial for sustainable economic development (Grossman and Helpman, 1994). For an emerging economy, it is particularly important for policymakers to

evaluate the cost and benefit of attracting inward FDI and to understand the role of FDI in influencing innovation.

I therefore seek to further the understanding of technology spillovers from inward FDI to domestic firms in host countries through the direct lens of innovation measured by grant patents rather than productivity. Chapter 4 has three particular interests: (1) to examine the extent to which horizontal and vertical FDI is related to innovation of domestic firms; (2) to test if innovation spillovers from FDI are stronger from backward linkages with FDI than forward linkages; (3) to explore how FDI can affect domestic innovation that have different levels of technological contents.

Chapter 4 employs the linked data described in Chapter 3. The empirical analysis of chapter 4 is restricted to domestic firms in the linked data. There are 995,757 observations for 320,688 domestic Chinese firms during 2001-2008 have been used for the econometric analysis.

Chapter 4 makes several contributions to the literature. First, it uses grant patents to capture a more direct output of technology spillovers from FDI than productivity. I linked two large comprehensive datasets to create a new high quality dataset, which has not been done before by firm level FDI studies. This linked dataset is valuable for future research as well. Second, since the existing literature underlines the importance of spillovers from vertical linkages with MNEs (Javorcik, 2004), chapter 4 examines innovation spillovers from horizontal as well as vertical FDI. It expands the nascent literature which only focuses on the effect from horizontal FDI on innovation (Hu and Jefferson, 2009). Third, the findings confirm positive innovation spillovers from both horizontal and vertical FDI, particularly via forward linkages with MNEs which the literature using productivity approach has often failed to find (Smeets, 2008). Finally, this empirical chapter distinguishes innovation by level of technology contents, which is rarely distinguished by the literature. Technology contents embedded in innovation reflect different levels of knowledge and technologies. For instance, China has three types of patents, with the most innovative and novel type being invention patent, followed by utility

model patent which are more related to improve products' practicality. I explain the diversified innovation spillover effects from an absorptive capacity perspective.

CHAPTER 2: CHOICE OF INTERNATIONALISATION STRATEGIES: A RE-EXAMINATION OF THE STEPWISE APPROACH

2.1 Introduction

This chapter examines the role of firm characteristics in explaining internationalisation strategies. The standard approach to this in the international business literature is to apply the stepwise internationalisation theory based on the Uppsala model proposed by Johanson and Wiedersheim-Paul (1975). It predicts that firms initially explore exporting via foreign agencies, then proceed by setting up their own sales agencies abroad and finally establishing overseas production facilities.

However, more recent approaches, such as the born global literature, suggest that observed patterns of internationalisation challenge the established theory (Cavusgil and Knight, 2009). Indeed, data from many countries suggest that some firms export and conduct FDI simultaneously, while others either export or conduct FDI, but not necessarily sequentially (Hollenstein, 2005). Further, some firms adopt a combination of exporting and different types of FDI activities including manufacturing, distribution and R&D centres (Castellani and Zanfei, 2007). Despite the growing literature in this area, there is still little consensus of: (1) how firms choose between the internationalisation strategies of exporting, FDI, or a combination of the two strategies; (2) whether or not the predicted relationship of exporting leading to conducting FDI still holds for FDI with different motives; and (3) what makes exporters to engage in FDI in the future. Typically the literature divides into three approaches: the international economics literature which focuses on firm level heterogeneity, usually based on productivity (Helpman, Melitz and Yeaple, 2004); the strategy literature based on resource-based view (Hu and Cui, 2014; Wei et al., 2013), or institutional theory (Stoian 2013; Yi, Wang and Kafouros, 2013). Typically however, empirical work in this area is unable to apply and test these approaches adequately, for example by identifying the ex-ante motives of firms undertaking FDI, while at the same time linking these empirically to firm level characteristics. For example,

market-seeking and strategic asset-seeking FDI are observationally equivalent in most datasets, leading to contradictory results. This chapter seeks to address this.

The empirical analysis is based on a unique large scale survey of internationalising firms from China. This offers several unique insights, not merely into the increasingly important questions surrounding EMNEs and the internationalisation of emerging countries more generally, but because of the importance of China's internationalisation in the world trading system. China became the largest exporter in the world in 2009, with an increasing proportion of exports generated by indigenous firms rather than by foreign firms (Du and Girma, 2009). Equally it is becoming an increasingly important source of outward investment, with Chinese investment being courted by all western governments, as a solution to the slow growth in the West. Although some studies argue that the outward FDI from China is mainly driven by the Chinese government, private sector firms are increasing their outward investment since 2005 (Gu, 2009). A better understanding of this process is required from both a policy and academic perspective. The data employed in this chapter show that the internationalisation strategies of privately owned Chinese firms cannot be fully explained by the traditional stepwise international expansion theory. The purpose of chapter 2 is to close this knowledge gap by providing new evidence on the determinants of different types of internationalisation strategies.

Chapter 2 employs panel data of private firms compiled by the All-China Federation of Industry and Commerce in 2005, 2006 and 2009. The panel structure of the data allow the investigation of the dynamic choice of internationalisation strategies, which to the best of my knowledge is among the first to be employed to study outward FDI from the private sector of China. Importantly, the data distinguish five types of FDI activities including manufacturing, sales agency, R&D centre, natural resources exploitation and project contracting for construction.

The reminder of chapter 2 is structured as follows. Section 2.2 reviews the literature on internationalisation theories and empirical studies. Section 2.3 describes the dataset and offers

summary statistics. Section 2.4 presents the empirical model and discusses variables. Main findings are discussed in section 2.5 and section 2.6 concludes.

2.2 Literature Review and Hypotheses Development

While the economics and international strategy literature on firm performance and internationalisation is abundant, studies that directly compare performance effects of different modes of foreign market entry are less common. The Uppsala model proposed by Johanson and Wiedersheim-Paul (1975) posits that the process of foreign market entry is based on accumulated knowledge of overseas markets. Initially a firm exports via external sales agents, subsequently establishing sales agencies abroad, and finally production facilities through FDI. However, this theory has proved difficult to operationalise, with data displaying deviations from this. Some firms engage in exporting and FDI simultaneously, while others appear to have been "born global" establishing FDI presence very early without having engaged in exporting (Freeman et al., 2010). In addition, the internationalisation process is dependent on the nature and characteristics of firms. Firms engaging in mass production may internationalise stepwise, while project-based firms are likely to internationalise quickly (Malhotra and Hinings, 2010). Overall the empirical and theoretical literature has proved deficient in explaining this apparent deviation between theory and data.

Chapter 2 therefore seeks to examine this issue through the lens of firm level heterogeneity and performance, explaining the different internationalisation strategies as potentially a non-sequential, mutually inclusive process, as a function of firm level and industry level characteristics.

This section reviews the literature on firm performance and internationalisation, discusses relevant theories and main findings on the choices of different internationalisation strategies, identifies the gaps, and develops hypotheses.

2.2.1 Export vs FDI: pecking order I (Hypothesis 1)

There is voluminous literature that links firm productivity and internationalisation. The theoretical framework is based on the prediction that serving foreign markets incurs sunk costs such as acquiring information of foreign markets and establishing networks with local business partners. Only firms with low marginal production costs can receive enough profits after entering foreign markets (Clerides, Lach and Tybout, 1998; Helpman, Melitz and Yeaple, 2004).

The empirical works linking productivity and internationalisation strategies tend to examine exporting and FDI behaviour, respectively. As for exporting behaviour, Wagner (2007) summarises that the literature generally tests two hypotheses: whether better firms self-select into exporting market and whether exporters learn from exporting and improve performance after exporting. The majority empirical evidence suggests that better firms self-select to export, but learning-by-exporting effect is more controversial. Using data on US manufacturing firms, Bernard and Jensen (1999) find that good firms become exporters, while the learning-be-exporting effect is evidence in terms of the probability to survive and employment growth. Baldwin and Gu (2003) find that there is self-selection effect and more productive firms are more likely to be able to stay in export market. In a study of German firms, Arnold and Hussinger (2005a) find that high-productive firms self-select into export market, but exporting experience does not improve productivity. Serti and Tomasi (2008) study Italian manufacturing firms during 1989-1997. They find both self-selection and learning-by-exporting effect with respect to labour productivity and total factor productivity.

Compared with studies on exporting behaviour, there is less research on FDI decision. Micro level evidence tends to be based on resource-based view. It argues that the decision to conduct FDI is dependent on firms' competitive advantages. Hollenstein (2005) finds that productivity is a key driver for Swiss firms to conduct FDI. Several other studies have reported that firm performance is one of the most important ownership advantages to conduct FDI (Claver and Quer, 2005; De Maeseneire and Claeys, 2012; Kling and Weitzel, 2011; Lien, Piesse, Strange and Filatotchev, 2005; Trevino and Grosse, 2002).

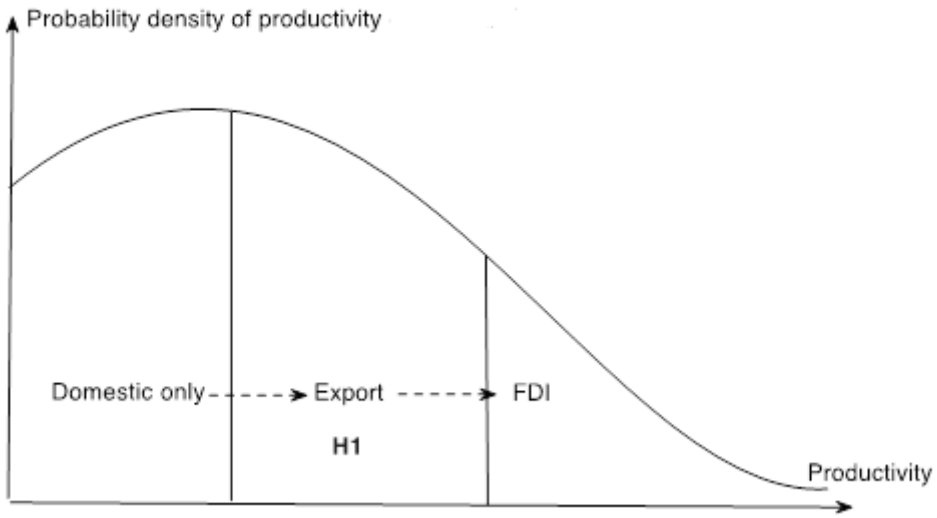
The above studies compare the performance differences between exporters and non-exporters, or MNEs with non-MNEs. Another strand of literature has compared the performance differences between exporting firms and firms engaging in FDI (Greenaway and Kneller, 2007). Based on the assumption that sunk costs of exporting are lower than that of conducting FDI (Buckley and Casson, 1981), Helpman, Melitz and Yeaple (2004) suggest that only the most productive firms find it profitable do conduct FDI. Less productive firms serve foreign markets via exporting, while the least productive firms can only serve domestic markets. Using data on exports and FDI of US firms, they find support for this prediction. Similar results have also been observed in Germany (Arnold and Hussinger 2005b; Wagner, 2005), Ireland (Girma, Gorg and Strobl, 2004), Italy (Castellani and Zanfei, 2007), Spain (Delgado, Farinas and Ruano, 2002), and the UK (Girma, Kneller and Pisu 2005). For European countries, Oberhofer and Pfaffermayr (2012) report that increased productivity will decrease the probability of exporting and increase the probability of conducting FDI.

As for emerging countries, Yang and Mallick (2010) study Chinese firms' exporting behaviour. They find support for both self-selection and learning-by-exporting effect. MNEs based in emerging countries appear to be different from those based in developed countries, especially when firms' ownership is considered. For privately owned Chinese firms, Lu, Liu and Wang (2010) study what factors drive them to conduct FDI, and further distinguish between strategic asset-seeking and market-seeking FDI. They do not observe that firms with better performance captured by return on sales are more likely to conduct FDI. Using a mixture of state-owned enterprises (SOEs) and private firms, Wei, Zheng, Liu and Lu (2013) observe that more productive Chinese firms are less likely to invest in FDI. In terms of outward FDI volume, firms with higher productivity tend to invest less. Therefore, they argue that Chinese firms lack ownership advantages and aim to seek strategic assets via FDI. Wang, Hong, Kafouros and Boateng (2012) also report that Chinese firms investing in FDI tend to have lower profitability. However, the findings of these studies may be influenced by pooling state and privately owned firms together. Given that SOEs can receive abundant support from the government to promote

internationalisation, while private firms usually do not obtain such support, the internationalisation behaviour of these firms could differ. It is possible that SOEs which have poor performance can internationalise and survive as a result of government support, whereas private firms need to possess some ownership advantages to go abroad (Lin, 2010). However, it is not clear in the existing literature about how privately owned firms from emerging countries internationalise.

In short, the dominant paradigm in the literature is that productivity determines whether or not firms will go international. This is established alongside the empirical literature that compares productivity performance between exporters and non-exporters, or between MNEs and non-MNEs, and provides strong and consistent evidence that international firms have higher productivity than domestic ones. Combining the above literature on productivity heterogeneity and different internationalisation strategy choices, I recognise that the additional costs and the tacit knowledge owned by firms investing abroad should be no less than exporters. Hence I posit a "pecking order" of firm performance in the internationalisation strategy, that is the most productive firms engage in FDI, the next most productive ones engage in exporting, and the least productive ones only serve domestic markets. Allocating firms in a distribution of firm performance, a large proportion of firms locate in the lower side of performance density and only sell domestically, and a less proportion of better performing firms manage to enter foreign markets by exporting, while an even smaller share of best performers conduct FDI, as shown in Figure 2.1.

Figure 2.1: Distribution of firm performance across internationalisation dimension



The first hypothesis is:

Hypothesis 1 (H1): The firms engaged in FDI are on average more productive than those only export or stay in the domestic market.

2.2.2 Motives of FDI: pecking order II (Hypothesis 2)

The second hypothesis focuses on the motives behind conducting FDI. I examine the factors that give rise to conducting FDI with different motivation, and in particular I focus on the distinctions between strategic asset-seeking and market-seeking FDI.

Firms engage in strategic asset-seeking FDI in order to acquire physical assets or human resources to enhance their ownership advantages (Dunning and Lundan, 2008). Belderbos (2003) finds support for this view with Japanese firms in the early 90's. Firms source knowledge from FDI because it provides a faster way of learning and building R&D capability than solely relying on internal learning. Also, seeking assets via FDI is an efficient and quick way for developing and emerging economies to close technology gaps to industry leaders (Mathews, 2006; Li, 2007). FDI into the US and the UK from less developed countries are found to be motivated by obtaining technological advantages to develop new products for parent firms,

seeking complementary assets, acquiring high talent R&D personnel and technical experts (Florida, 1997; Shan and Song, 1997; Serapio and Dalton, 1999; Driffield and Love, 2007). Buckley et al. (2008) suggest that Chinese MNEs investing in R&D activities in advanced countries are technology sourcing. Peng and Wang (2000) also find that strategic asset-seeking FDI by emerging market-based MNEs aim to access innovations in host countries and to improve organisational learning of parent firms.

The motivation of strategic asset-seeking FDI is seldom linked to firm characteristics in a general sense. While the empirical evidence often uses country level data to infer FDI motivation (Buckley et al., 2007; Ramasamy, Yeung and Laforet, 2012), there is much less evidence on how firm specific attributes may influence strategic asset-seeking FDI. One exception is the study by Hollenstein (2005) who finds that there is a hierarchical order of ownership advantages. Firms with the highest level of ownership advantages of productivity and R&D efforts tend to conduct FDI in R&D, followed by firms that conduct FDI in distribution and production, and firms with the lowest ownership advantages remain in domestic markets.

What is clear in the literature is that while technological laggards are able to engage in technology sourcing and that indeed both theoretical and empirical models provide evidence of this (Fosfuri and Motta, 1999; Siotis, 1999). What is also clear is that it is not without costs for firms to engage in FDI in order to access technology abroad which requires significant internal resources. Typically EMNEs are derived from their success in home country markets, and their internationalisation is associated with firm performance rather than technological intensity (Bhaumik and Driffield, 2011). Therefore, I propose:

Hypothesis 2a: Firms engaging in strategic asset-seeking FDI are more productive and profitable than firms that engage in other FDI activities.

Another important motivation for conducting FDI is to seek markets. These firms are in pursuit of main suppliers and customers or in need to adapt to local language and business practices. They may consider it necessary to have physical presence in major foreign markets,

especially when overseas markets are large and growing fast (Dunning and Lundan, 2008). In addition, firms that aim to explore new markets and expand existing market may use FDI to avoid anti-dumping tariffs (Blonigen, 2005). The model proposed by Belderbos, Vandenbussche and Veugelers (2004) suggests that tariff jumping FDI occurs when the EU employ anti-dumping policies in order to protect industry profitability and when foreign firms are able to transfer cost advantages abroad. Using data from the anti-dumping cases in the US during 1980-1990, Blonigen (2002) finds that anti-dumping duties increases inward FDI probability. Kogut and Chang (1991) find that voluntary export restraints have encouraged Japanese firms to conduct FDI in the US during 1976-1987. Moreover, home country competition also shapes firms' decision to conduct FDI. Child and Rodrigues (2005) suggest that Chinese firms tend to internationalise due to the competitive home market and low profit margins. Gu (2009) also points out that the outward FDI by Chinese private firms is driven by the intense competition in the home market. Since China's joining WTO and private sectors are allowed to conduct outward FDI in 2003, the previously protected industries in China are gradually opening up to foreign firms. Domestic firms are faced with intense competitive pressure and have become more participative in outward FDI in order to seek new markets (Buckley et al., 2008). It is well established that exporting experience is important for firms to conduct FDI. Firms collect information on foreign markets, build networks with local business partners and overcome foreignness (Lin, 2010; Wei et al., 2013). Nevertheless, it is not yet clear in the literature how the heterogeneous exporting experience relates to conducting FDI with different motives. I hypothesise that reaching out foreign markets through exporting leads to conducting FDI, but this prediction depends on FDI motives.

Hypothesis 2b: More export experienced firms are more likely to engage in market-seeking FDI, but exporting experience does not encourage firms to engage in FDI with other motives.

2.2.3 Heterogeneous export experience and FDI (Hypothesis 3)

While the literature highlights the importance of exporting experience in conducting FDI (Gao, Liu and Zou, 2013; Wei et al., 2013), chapter 2 examines what drives exporters to conduct FDI

simultaneously, which is hardly addressed by the literature. I propose that exporters are heterogeneous in terms of the types and numbers of destinations they manage to reach. The accumulated exporting experience is heterogeneous. Therefore, exporters may not equally adopt FDI strategy in the future. For example, high-income countries could provide better knowledge and wider learning opportunities for exporters than poor and less demanding countries (Love and Ganotakis, 2013).

More specifically, exporting allows firms to access valuable information about product preferences, technological expertise and competition in foreign markets (Clerides, Lach and Tybout, 1998). Firms also collect information on market preferences, government policies and institution systems (Pradhan, 2004), and establish networks in foreign markets that are important for conducting FDI later on (Mathews, 2006). Hence, the sophistication level of export destinations determines how much exporters may learn from international markets. Exporters are more likely to benefit from serving more demanding advanced markets. De Loecker (2007) finds that the productivity gains are higher for Slovenian manufacturers that export to high income regions than to low income regions. For Portugal, Silva, Afonso and Africano (2010) report that knowledge sourced from exporting depends on the learning opportunities of the export destinations. Exporting only to non-developed does not provide much useful knowledge for exporters, whereas intensive exporting to advanced economies provides exporters with new knowledge. Yashiro and Hirano (2009) find that the Japanese firms exporting to a variety of destinations are rewarded by considerable productivity growth. However, exporting to one destination does not contribute to higher productivity. Using cross-sectional data for private firms in China, Wei et al. (2013) find that more export intensive firms tend to conduct FDI and they invest more intensively.

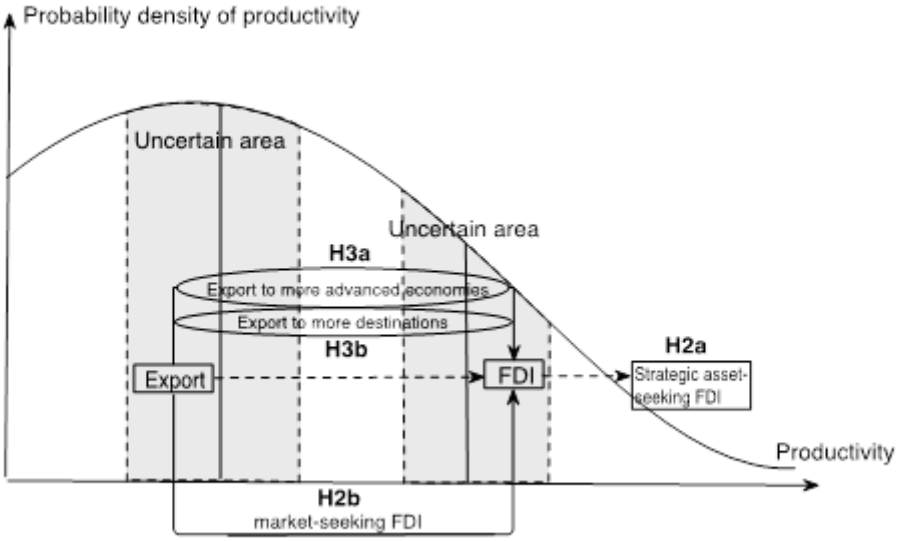
Overall, the existing evidence suggests that exporting to more advanced markets can enhance exporters' knowledge, innovation and productivity, encouraging them to engage in FDI. Also, exporting to a variety of destinations helps exporters acquire complementary knowledge of foreign markets. Therefore, I propose:

Hypothesis 3a: Exporting to more advanced economies is positively associated with the probability of conducting FDI in the future.

Hypothesis 3b: Exporting to more destinations is positively associated with the probability of conducting FDI in the future.

The ideas of Hypotheses 2 and Hypothesis 3 are demonstrated in Figure 2.2. It demonstrates that only a small proportion of firms that have high productivity are able to conduct strategic asset-seeking FDI. In addition, not all exporters will conduct FDI. Instead, exporting experience helps firms to conduct market-seeking type of FDI. In general, exporters that are able to export to the most advanced economies or export to a variety of destinations are more likely to conduct FDI.

Figure 2.2: Interactions between export and FDI



2.3 Data

Chapter 2 employs panel data compiled based on the National Survey of Above-scale Private Firms in China, collected and maintained by the All-China Federation of Industry and Commerce (ACFIC). This is a unique and an appropriate dataset for the purpose of this study due to the following reasons. Firstly, the survey collects comprehensive information about firm

characteristics, operation, performance, innovation, and internationalisation behaviour, much of which is not often available at firm level. Secondly, only private firms are included in the survey, which is important to mitigate the political factors that may shape firms' internationalisation strategies.[1] It is reasonable to assume that compared with large state-owned enterprises (SOEs), private firms tend to operate and allocate resources according to market principles. Thirdly, the data are of high quality, since the survey is regularly conducted by the ACFIC, the supervisory agency of the private sector firms. The survey aims to understand the development of the private sector in China that plays a pivotal role in the economy. In recent years, there has been an increasing amount of outward FDI conducted by the private sector of China in various industries (Gu, 2009; Lin, 2010). Hence, the available information on firms' outward investment activities is highly valuable to study the internationalisation behaviour of the private sector. It is worthy of notice that the information is collected from above-scale firms that reach over 300 million Renminbi yuan (about 45 million US dollars) annual revenue; hence the firms surveyed in the data are not small and medium enterprises. The survey covers 11 manufacturing industries and 10 service industries in all the 31 provinces in China, and chapter 2 employs the data for the years 2005, 2006 and 2009.[2]

Subject to the standard data cleaning process, the final data matrix contains 2,829 observations. Table 2.1 presents the variables and their definitions, as well as the summary statistics. These firms on average are 16 years old and have nearly 1,300 employees.[3] About 53% of firms report to have patents and there is large variation in government technology subsidies intensity (measured technology development subsidies granted by the government per employee). Among these private firms, about 37% were reformed from state-owned, urban collectively owned or township-owned firms, and the rest were originally launched as private firms. As for the export destinations, about 39.7% of the firms in the sample are able to export

[1] Many recent studies that document on outward FDI from China note that a large proportion of the firms investing overseas have close links to the Chinese government, and frequently owned by the State (among others, see Luo, Xue and Han, 2010).

[2] This is due to the availability of the data and completeness of the relevant variables.

[3] Calculated from Table 2.1 (log of the number of employees=7.158): $e^{7.158} - 1$.

to the richest countries in the world, and on average firms export to two countries. With regard to the various FDI activities, 17.5% of the firms in the sample have sales agencies abroad, and 4% of the firms have manufacturing facilities in foreign countries. About 3.7% and 1.9% of the firms conduct FDI in R&D centres and natural resources exploitation activities.

Table 2.1: Variables definitions and summary statistics

Variable	Definition	Mean	Std. Dev.
Performance			
Labour productivity	Revenue per employee in logarithm form	4.371	1.146
ROA	Return on total assets: net profit/total assets	0.067	0.063
Resources			
Has patents	1 if has patents, 0 otherwise	0.535	0.499
Gov subsidy	Government subsidies for firm technology development per employee	0.070	0.204
Reformed	1 if a firm was reformed from state-owned, urban collectively owned firms or township enterprises firms to a private firm, 0 if a firm was launched as a private firm originally	0.375	0.484
Technology level			
Int'l leading	1 if the key technologies employed by a firm are internationally leading, 0 otherwise	0.045	0.207
Domestic advanced	1 if the key technologies employed by a firm are domestically advanced, 0 otherwise	0.534	0.499
Export destinations			
Export to the richest countries[4]	1 if export to the richest countries, 0 otherwise	0.397	0.489
Number of destinations	Number of export destinations	2.064	2.243
Types of FDI activities			
Manufacturing	1 if has FDI in manufacturing facilities, 0 otherwise	0.044	0.206
Sales agency	1 if has FDI in sales agency, 0 otherwise	0.175	0.380
R&D centre	1 if has FDI in R&D centre, 0 otherwise	0.037	0.189
Natural resources exploitation	1 if has FDI in natural resources exploitation, 0 otherwise	0.019	0.136
Contracting for construction	1 if has FDI in international project contracting for construction, 0 otherwise	0.026	0.161
Control variables			

[4] Note: I use a dummy variable to indicate whether or not a firm manages to export to one of the riches countries in the world. The richest countries are defined as countries which have real GDP per capita within the top 10 percentile real GDP distribution of all the countries. The richest countries include Australia, Austria, Belgium, Canada, Denmark, Finland, Ireland, Japan, Kuwait, the Netherlands, New Zealand, Norway, Sweden, Switzerland, United Kingdom, the United States. The data are available from the United States Department of Agriculture: http://www.ers.usda.gov/data-products/international-macroeconomic-data-set.aspx.

Log emp	Number of employees in logarithm form	7.158	1.362
Age	Firm age	16.478	11.397
Coastal province	1 if a firm is located in coastal region, 0 otherwise	0.815	0.388
Midland province	1 if a firm is located in midland region, 0 otherwise	0.125	0.331
Western province	1 if a firm is located in western region, 0 otherwise	0.059	0.236
Observations	2,829		

Table 2.2: Correlation matrix

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
(1) Labour productivity	1															
(2) ROA	-0.017	1														
(3) Has patents	-0.143	0.107	1													
(4) Gov subsidy	0.075	0.093	0.256	1												
(5) Reformed	-0.082	-0.007	0.002	0.017	1											
(6) Int'l leading	-0.015	0.034	0.082	0.062	-0.044	1										
(7) Domestic advanced	-0.076	0.037	0.206	0.073	0.021	-0.169	1									
(8) Export to richest countries	-0.198	0.033	0.307	0.075	0.020	0.083	0.132	1								
(9) Number of destinations	-0.169	0.038	0.354	0.111	0.008	0.089	0.154	0.715	1							
(10) Manufacturing	-0.054	0.031	0.139	0.037	-0.055	0.083	-0.005	0.089	0.120	1						
(11) Sales agency	-0.067	0.047	0.218	0.111	-0.081	0.059	0.054	0.309	0.324	0.236	1					
(12) R&D centre	-0.020	0.058	0.107	0.022	-0.030	0.120	0.024	0.128	0.138	0.170	0.220	1				
(13) Natural resources	0.023	0.030	0.039	-0.001	-0.044	0.051	-0.033	0.046	0.008	0.140	0.050	0.084	1			
(14) Project construction	-0.074	-0.034	0.067	-0.022	0.034	-0.023	-0.001	-0.006	0.003	0.036	0.023	0.009	-0.016	1		
(15) Log emp	-0.671	0.051	0.194	-0.065	0.069	0.070	0.068	0.202	0.215	0.187	0.172	0.112	0.021	0.172	1	
(16) Age	-0.171	0.026	0.109	0.052	0.322	-0.023	0.067	0.077	0.060	0.034	0.030	-0.017	-0.013	0.133	0.245	1

Table 2.3 shows the summary statistics by dividing firms by their choice of internationalisation strategy. It can be seen from the bottom row that more than half of the firms in the survey have international activities in the whole sample. About 36.37% of firms only export, and 21.56% export and conduct FDI simultaneously. On average, the productivity of firms that remain in the domestic market are the highest, suggesting that these private firms have achieved high efficiency at home market. In addition, firms that conduct FDI are on average more productive than exporting only firms. With regard to profitability (measured by return on total assets), firms that engage in FDI are more profitable than firms that only serve the domestic market or the exporting only firms. Firms that have international activities via export and/or FDI are more innovative than firms only serve the domestic market.

With regard to export destinations, there is a higher proportion (78.9%) of firms exporting to the richest countries among firms engaging in exporting and FDI simultaneously than those only export (65.3%). Therefore, it is interesting to examine whether or not the accumulated knowledge from exporting to different destinations may shape exporters' decision to adopt FDI strategy simultaneously. Moreover, FDI activities include investment in manufacturing, sales agency, R&D centre, natural resources exploitation and project contracting for construction. Interestingly, firms that simultaneously export and conduct FDI tend to concentrate FDI on sales agency (80.2%) and manufacturing (20%).

Table 2.3: Summary statistics by type of firms

	Domestic	Exporiting only	FDI only	Exporting & FDI
Variable	Mean	Mean	Mean	Mean
Performance				
Labour productivity	4.644	4.201	4.280	4.186
ROA	0.063	0.067	0.078	0.073
Resources				
Has patents	0.270	0.672	0.558	0.770
Gov subsidy	0.032	0.091	0.074	0.103
Reformed	0.368	0.404	0.327	0.349
Technology level				
Int'l leading	0.021	0.038	0.022	0.097
Domestic advanced	0.462	0.604	0.548	0.525
Export destinations				
Export to richest countries	-	0.653	-	0.789
Number of destinations	-	3.473	-	3.966
Types of FDI activities				
Manufacturing	-	-	0.120	0.200
Sales agency	-	-	0.398	0.802
R&D centre	-	-	0.169	0.157
Natural resources	-	-	0.120	0.075
Project construction	-	-	0.301	0.086
Control variables				
Log emp	6.705	7.185	7.673	7.831
Age	15.123	16.658	18.288	18.279
Coastal province	0.706	0.890	0.779	0.890
Midland province	0.198	0.079	0.125	0.074
Western province	0.096	0.031	0.096	0.036
Observations	1086	1029	104	610
%	38.39	36.37	3.68	21.56

2.4 Model

Chapter 2 is to extend the existing attempts to apply theoretical constructs empirically, see for example Wang et al. (2012) and Wei et al. (2013). The approach is to conduct the analysis in a number of stages, outlined below. I first link firm characteristics to explain the choice of distinctive internationalisation strategy, ie. exporting only, conducting FDI only, and exporting and conducting FDI simultaneously.

Next, I examine why firms conduct different types of FDI.[5] This allows me to examine the importance of accumulated export experience for adopting a given FDI strategy.

2.4.1 Step 1: pecking order I (Hypothesis 1)

To model the choices of internationalisation strategies, I set up a Multinomial Logit Model which can be expressed as a probability function:

$$\Pr(y_{it} = \mathrm{j} \mid X_{1it}) = \frac{\exp(X_{1it} * \alpha_j)}{\left[1 + \sum_{h=1}^{J} \exp(X_{1it} * \alpha_h)\right]} \quad (j = 1, 2, 3, 4) \quad (1)$$

where *y* indicates the choice of an internationalisation strategy of firm *i* at time *t*, with *j* being 1 if a firm only serves the domestic market, 2 if a firm's internationalisation strategy is only exporting, 3 if the strategy is only conducting FDI, and 4 if the strategy is exporting and conducting FDI simultaneously. X_1 is a vector of explanatory variables that are expected to affect firms' internationalisation strategies.

The model is estimated using maximum likelihood function, and all explanatory variables are lagged by one year to mitigate potential endogeneity problems. As the literature suggests, exporters can benefit from learning-by-exporting effect and therefore have better economic performance than non-exporting firms. The lagged firm performance variables are employed to control for this possible reverse causation. The key assumption of independence of irrelevant alternatives (IIA) that requires that the odds of choosing one internationalisation strategy do no depend on the other alternatives is tested using the Hausman-McFadden test (Hausman and McFadden, 1984).

Four sets of explanatory variables are employed to capture firm performance, resources, technological competence and other controlling variables. For performance, productivity is included because it plays an important role in starting internationalisation and increasing international commitment (Helpman, Melitz and Yeaple, 2004). Productivity is measured by labour productivity which is value added per employee. While firm value-added is not available in the data, total revenue

[5] The data distinguish five types of FDI activities including manufacturing, sales agencies, R&D centre, natural resources exploitation and project contracting for construction.

is used as the measure of output instead (Syverson, 2010).[6] Profitability is included because firms that are financially constrained often have difficulties in accessing external funding and are therefore discouraged to conduct FDI. It is measured by return on total assets (ROA) which is net profit divided by total assets (Fryges and Wagner, 2010).[7]

For firm resources, I control for innovation by a dummy variable indicating whether or not a firm owns any patents (Lachenmaier and Wo ßmann, 2006). Second, governments in emerging markets adopt favourable policies to encourage local firms to go global (Luo, Xue and Han, 2010). Government can play an important role in enhancing firm competitiveness such as providing access to finance in an underdeveloped financial market like China (Cai and Tylecote, 2008). I hence control for government subsidies intensity by government technology development subsidies grant to firms per employee. Third, a dummy variable is included which equals to 1 if a private firm was reformed from state-owned, urban collectively owned, or township enterprises, and equals to 0 if a firm was originally launched as a private firm. In the context of China, share issuing privatisation increases earning ability, sales and labour productivity of firms (Sun and Tong, 2003; Driffield and Du, 2007).

Two dummy variables are included to capture firms' technology competence. One dummy variable indicates whether or not the key technologies employed by a firm are internationally leading and the other dummy variable indicates whether or not the key technologies a firm employs are advanced in the domestic market. Firms that are more technologically competitive internationally or in the domestic market could be more capable of investing abroad, because they are expected to be more innovative than technology laggards and can compete with foreign competitors (Lee, 2009). Although using the variables that are based on firms' self-perception could be risky of potential bias, they do have the advantage of delivering what could not be measured by standard innovativeness variables employed by the literature.

[6] Total revenue values are deflated using ex-factory index at province level for manufacturing firms and consumer price index for service firms. The base year is 2005.

[7] Net revenue values are deflated using ex-factory index at province level for manufacturing firms and consumer price index for service firms. Total assets are deflated using investment index at province level for all firms. The base year is 2005.

In addition, I also control for firm age and firm size which is measured by the number of employees, as well as regional, industrial and year fixed effects.

2.4.2 Step 2: pecking order II (Hypothesis 2)

To model the relationships between firm characteristics and FDI engagement, a binary outcome model is employed. Latent variables *FDI** are created to capture the tendency of a firm engaging in FDI with a particular motive *k*, and *FDI* becomes observable when *FDI** is greater than zero:

$$FDI^{*}_{k_{it}} = X_{1it} * \beta + \upsilon_{it}, \qquad FDI_{it} = 1\ [FDI^{*}_{it} > 0] \quad (2)$$

where k = 1, 2,…5 for the motives of FDI of conducting manufacturing, sales agency, R&D centre, natural resources exploitation and project contracting for construction, respectively. Vector X_{1it} contains the same explanatory variables as described in the equation (1). The Logit models are estimated using maximum likelihood function and the odds ratios are calculated.

2.4.3 Step 3: exporting experience and FDI (Hypothesis 3)

To examine whether or not the heterogeneous exporting experience of exporters relates to their decision to conduct FDI simultaneously, I model the decision to simultaneously engage in exporting and FDI to be determined by a latent process *Exp_FDI**, and *Exp_FDI* becomes observable when *Exp_FDI** is greater than zero:

$$Exp\_FDI^{*}_{it} = (X_{1it} + X_{2it}) * \lambda + \epsilon_{it}, \qquad Exp\_FDI_{it} = 1\ [Exp\_FDI^{*}_{it} > 0] \quad (3)$$

where *Exp_FDI** is a binary variable which equals to 1 if a firm exports and conducts FDI simultaneously, and 0 if it only exports. In addition, the vector X_{1it} remains the same as that in the previous equation, and X_{2it} adds two variables to capture the heterogeneity of exporting experience. One is a dummy variable which equals to 1 if a firm exports to one of the richest countries in the world,[8] and the other is the number of export destinations. The export destination variables aim to

[8] The richest countries are defined as the countries which have real GDP per capita within the top 10 percentile real GDP per capita distribution of all the countries. The richest countries include Australia, Austria, Belgium, Canada, Denmark, Finland, Ireland, Japan, Kuwait, the Netherlands, New Zealand,

capture the heterogeneous exporting experience obtained from various foreign countries.

2.5 Results and Discussions

This section reports the estimation results and discusses the findings. The estimated odds ratios of the equation (1) are reported in Table 2.4, with the base category being firms that only serve domestic market and do not have any international activities. The Hausman-McFadden test supports the independence of irrelevant alternatives (IIA) so that the multinomial Logit model is validated.

Table 2.4: Multinomial logit estimation

	Export	FDI	Export & FDI
Performance			
Labour productivity	0.931	1.262*	1.227**
	(0.0660)	(0.165)	(0.0982)
ROA	0.531	13.35	2.335
	(0.455)	(21.51)	(2.288)
Resources			
Has patents	3.182***	3.513***	4.633***
	(0.400)	(0.888)	(0.675)
Gov subsidy	1.006	2.295*	1.764*
	(0.306)	(1.152)	(0.572)
Reformed	1.000	0.451***	0.663***
	(0.118)	(0.120)	(0.0932)
Technology level			
Int'l leading	2.320**	4.423***	2.850***
	(0.792)	(2.340)	(1.035)
Domestic advanced	1.292**	1.167	0.974
	(0.143)	(0.275)	(0.126)
Control variables			
Log emp	1.429***	1.729***	2.405***
	(0.0897)	(0.194)	(0.167)
Age	1.002	1.005	1.008
	(0.00534)	(0.0102)	(0.00601)
Midland province	0.271***	0.548*	0.259***
	(0.0455)	(0.187)	(0.0539)
Western province	0.306***	1.101	0.336***
	(0.0740)	(0.437)	(0.0994)
Industry dummies	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes
Log likelihood	-2615.558		
Hausman Test of IIA : Chi_squared(df)	0.000(5)	-0.000(3)	0.000(6)
Observations	2,829		

Norway, Sweden, Switzerland, United Kingdom, the United States.

Notes: (1) The Multinomial Logit model is estimated using maximum likelihood function. All explanatory variables are lagged by one year to mitigate potential endogeneity problems. The estimation is based on all the firms in the sample. The base group consists of firms that only serve the domestic market and do not have any international activities. (2) Industry and year dummies are included. (3) Odds ratios are reported. Standard errors are in brackets. (4) Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

2.5.1 Pecking order I (Hypothesis 1)

The most notable result in Table 2.4 is that firms conducting FDI are on average more productive than domestic firms or exporting only firms, supporting Hypothesis 1. It is consistent with the prediction of Helpman, Melitz and Yeaple (2004) that only the most productive firms can bear the incurred high fixed costs of conducting FDI. Productivity appears to be one of the most important ownership advantages for firms to internationalise with high commitment to foreign markets, in line with Hollenstein (2005).

One interesting result is that exporting firms do not appear to be more productive than domestic firms, supporting the findings of Girma, Gorg and Strobl (2004). However, this is not fully consistent with the literature finding that exporters are more productive than those only serving domestic market (Alvarez and Lopez, 2005; Serti and Tomasi, 2008). The most likely explanation is that the private firms in this chapter are above-scale firms which have achieved large sales in the domestic market already. The productivity differences between exporters and those stay in the domestic market might not be drastic.

In addition, firm resources are important sources of competitive advantages to internationalise. Having patents significantly increases the probability of internationalisation, consistent with Lachenmaier and Wo ßmann (2006) and Yi, Wang and Kafouros (2013). Having patents may allow firms to compete internationally such as launching innovative products for niche markets (Rui and Yip, 2008; Harris and Li, 2009). Moreover, compared with a firm that has originally been launched as private one, if a firm has been reformed from SOEs, urban collectively-owned, or township enterprise, it is less likely to engage in FDI. It indicates that the reformed firms may not be as entrepreneurial as those originally launched by private investors who seek presence in host countries aggressively and

strategically (Mtigwe, 2006; Rui and Yip, 2008). Strong entrepreneurship is important to establish an international goal and initiate internationalisation from early on. These firms may pursue the strategy of international expansion to enjoy faster learning and development in the future (Autio, Sapienza and Almeida, 2000; Lin, 2010).

Another notable result is the importance of technology competence for internationalisation. Having internationally leading technologies is positively related to the probability of exporting and conducting FDI. This means that technology know-how could have enabled firms to grab international opportunities (Lu, Liu and Wang, 2010). Note that firms whose technology level is domestically advanced will be more likely to export, but they are not more likely to conduct FDI. This reveals that firms need to be technologically competitive enough to engage in high level of internationalisation via FDI.

Last but not least, firms serving international markets are larger than those only stay in the domestic market. Larger firms may receive economies of scale domestically and are endowed with more resources to pursue international goals, consistent with Hollenstein (2005).

2.5.2 Pecking order II (Hypothesis 2)

The Uppsala model predicts that exporting will lead to conducting FDI. This section tests whether or not this relationship stands for different FDI motives. It also tests what firms are able to seek strategic assets via FDI. Based on the equation (2), Hypothesis 2a and Hypothesis 2b are tested using Logit estimation based on a sample of FDI firms that may or may not export. Odds ratios are reported in Table 2.5. Based on the literature review, FDI in R&D and FDI in natural resources exploitation are regarded as mainly driven by strategic asset-seeking,[9] and FDI in sales agency as primarily driven by market-seeking.

[9] The most frequent locations for FDI in R&D centres are European Union, North America, Japan and South Korea which I consider to be technology advanced host countries. The locations of natural resources are widely spread all over the world rather than concentrating in a particular region, different from the state-owed MNEs that tend to exploit natural resources in Africa and East and Central Asia (Buckley et al., 2008).

Table 2.5: Logit estimations

	Model 1	Model 2	Model 3	Model 4	Model 5
	FDI in manufacturing	FDI in sales agency	FDI in R&D centre	FDI in natural resources exploitation	FDI in project contracting for construction
Export status (0/1)	1.102	4.814***	0.411**	0.421**	0.190***
	(0.385)	(1.354)	(0.145)	(0.167)	(0.0947)
Performance					
Labour productivity	1.488***	0.783*	1.032	1.474**	1.228
	(0.210)	(0.107)	(0.163)	(0.287)	(0.294)
ROA	6.500	0.0727	59.77**	0.235	0.496
	(11.51)	(0.131)	(115.1)	(0.692)	(1.820)
Resources					
Has patents	1.720**	1.108	2.478***	0.630	1.182
	(0.474)	(0.301)	(0.784)	(0.242)	(0.642)
Gov subsidy	0.373	1.895	1.268	0.725	0.242
	(0.235)	(1.152)	(0.752)	(0.643)	(0.392)
Reformed	0.967	0.950	0.693	0.817	0.705
	(0.261)	(0.250)	(0.205)	(0.331)	(0.358)
Technology level					
Int'l leading	2.385**	0.747	1.572	1.510	0.299
	(0.951)	(0.311)	(0.668)	(0.894)	(0.332)
Domestic advanced	0.731	1.085	1.391	0.756	0.812
	(0.173)	(0.256)	(0.353)	(0.262)	(0.330)
Control variables					
Log emp	1.630***	0.841	1.646***	1.024	1.395
	(0.186)	(0.0951)	(0.218)	(0.164)	(0.287)
Age	1.001	0.994	0.974*	1.001	1.006
	(0.0101)	(0.00960)	(0.0135)	(0.0148)	(0.0158)
Midland province	1.564	0.904	1.411	0.783	0.489
	(0.610)	(0.358)	(0.606)	(0.446)	(0.376)
Western province	1.675	0.335**	0.974	3.252*	0.135
	(0.894)	(0.162)	(0.634)	(2.005)	(0.198)
Industry dummies	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes
Log likelihood	-272.189	-275.526	-238.900	-147.743	-99.277
Observations	634	638	613	606	382

Note: (1) The Logit models are estimated using maximum likelihood function. All the estimations are based on all firms that conduct FDI. They may or may not export. For each model, the dependent variable equals to 1 if a firm is engaged in a particular type of FDI, and 0 if it is engaged in other types of FDI activities. (2) All explanatory variables are lagged one-year. Industry and year dummies are included in all the five Logit models. (3) Odds ratios are reported. Standard errors are in brackets. (4) Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

The first important result is that strategic asset-seeking FDI firms are on average more productive and profitable than other types of FDI firms, supporting Hypothesis 2a. The implication is that, as firms can seek strategic assets via FDI to enhance their ownership advantages and access advanced technologies abroad, but not every firm can do so. I extend the literature by finding that

strategic asset seekers should have strong ownership advantages such as efficiency and profitability in order to acquire human resources or physical assets by establishing R&D centres and secure natural resources supplies abroad. Although FDI from China to exploit natural resources is perceived to be conducted by the government which enjoys strong financial support (Buckley et al., 2008), I find that private firms do not behave in the same way as SOEs. The micro level evidence indicates that the most productive and profitable private firms are best placed to absorb technologies from international leaders and seek strategic assets via FDI. This result contrasts the findings of Wang et al. (2012) which argues that Chinese firms which lack ownership advantages can seek knowledge via outward FDI.

More specifically, higher profitability (measured by return on total assets) is significantly and positively associated with higher probability of FDI in R&D centres, and labour productivity significantly increases the probability of engaging in FDI in natural resources exploitation, keeping other variables the same.

Another key result is that while exporting experience is crucial for conducting market-seeking FDI in the form of sales agency, it does not lead to higher probability of engaging in other forms of FDI, supporting Hypothesis 2b. Chapter 2 thus extends the stepwise internationalisation theory by proposing that the predicted path of exporting leading to FDI relationship still exists for market seekers, but not for FDI with other motives.

Moreover, having patents increases the probability of investing in R&D centres abroad and these firms are larger and younger than other FDI firms, consistent with Lu, Liu and Wang (2010) that firms need technology-based competitive advantages to conduct strategic asset-seeking FDI. In addition, labour productivity is positively associated with the probability of having FDI in manufacturing. Possible reasons are as follows. In the sample, the most popular destinations for FDI in manufacturing are ASEAN,[10] the US and the EU. I argue that although factor prices are relatively cheap in China than foreign countries, these firms may seek to reduce transportation costs or avoid trade barriers by

[10] ASEAN is the abbreviation for Association of Southeast Asian Nations. Countries included are Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand and Vietnam.

investing in manufacturing facilities abroad. Manufacturing in the US and the EU is likely to be driven by protecting and expanding in these markets (Buckley et al., 2008). In addition, Chinese firms may seek opportunities in other developing countries in south-east Asia to exploit their cost-effective manufacturing capability. These firms may also look for ways to absorb the excess production capacity at home country (Luo and Tung, 2007).

2.5.3 Exporter heterogeneity and the probability of conducting FDI (Hypothesis 3)

Based on the equation (3), this section examines why some exporters adopt FDI strategy simultaneously, which is seldom addressed by the literature. The heterogeneity of exporters is captured by export destinations. Using a sample of exporters which may or may not conduct FDI, I report odds ratios from Logit estimations in Table 2.6.

Table 2.6: Logit estimations

	Model 1	Model 2
Export destinations		
Export to the richest countries	1.322**	
	(0.162)	
Number of export destinations		1.097***
		(0.0332)
Performance		
Labour productivity	1.234***	1.222***
	(0.0928)	(0.0916)
ROA	2.344	2.457
	(2.227)	(2.338)
Resources		
Has patents	1.417***	1.395**
	(0.189)	(0.187)
Gov subsidy	1.835**	1.771**
	(0.506)	(0.490)
Reformed	0.683***	0.686***
	(0.0863)	(0.0868)
Technology level		
Int'l leading	1.304	1.319
	(0.338)	(0.342)
Domestic advanced	0.766**	0.766**
	(0.0903)	(0.0905)
Control variables		
Log emp	1.637***	1.621***
	(0.102)	(0.101)
Age	1.005	1.005

	(0.00536)	(0.00536)
Midland province	0.975	0.994
	(0.215)	(0.221)
Western province	1.210	1.191
	(0.396)	(0.391)
Industry dummies	Yes	Yes
Year dummies	Yes	Yes
Log likelihood	-934.444	-932.347
Observations	1,550	1,550

Note: (1) The Logit models are estimated using maximum likelihood function. The estimations are based on exporting firms that may or may not conduct FDI. For both Model 1 and Model 2, the dependent variables equal to 1 if a firm does export and conducts FDI simultaneously and 0 if a firm only exports. (2) All explanatory variables are lagged one-year to mitigate potential endogeneity problems. Industry and year dummies are included. (3) Odds ratios are reported. Standard errors are in brackets. (4) Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

The key finding in Table 2.6 is that not all exporters will conduct FDI in the future. Export destinations capture the differences in the accumulated knowledge sourced from international markets. Exporters that can export to rich countries and to a variety of countries are more likely to adopt FDI strategy, supporting Hypothesis 3a and Hypothesis 3b. The implication is that firms could learn superior knowledge from rich and demanding exporting destinations to understand product preferences, technological expertise, competition and business partners in foreign markets (Clerides, Lach and Tybout, 1998). This finding is in line with Damijan, Polanec and Prasnikar (2004), Carlsson, Nordegren and Sjoholm (2005), Yashiro and Hirano (2009). While Wei et al. (2013) find that exporting experience is important for exporters to shift their internationalisation strategy, and Gao, Liu and Zou (2013) observe exports encourages outward FDI from China, I extend their findings by explaining how the exporting experience is different in determining whether or not to engage in FDI.

Another important result is that government support is important for exporters to conduct FDI. Government technology development subsidies may have helped exporters lever ownership disadvantages and encourage higher levels of internationalisation via FDI. This provides empirical support for the conceptual premise proposed by Luo, Xue and Han (2010). Interestingly, exporters that have undergone ownership restructure are less likely to conduct FDI compared with those launched as private firms originally. This again supports the previous finding that entrepreneurial ambitions are important shaping firms' internationalisation strategies, consistent with Rui and Yip (2008).

2.6 Conclusions

There have been new patterns of internationalisation that cannot be fully explained by the traditional theories. Some firms start internationalisation at an early stage and some adopt a combination of exporting and FDI strategies rather than completely stop exporting to conduct FDI. Some firms also change their internationalisation strategies after going abroad. Chapter 2 analyses (1) why firms choose different internationalisation strategies, (2) what factors drive firms to engage in different FDI activities, and (3) how the heterogeneous exporting experience relates to the FDI decision.

Chapter 2 offers several contributions to the literature. Firstly, it confirms the importance of productivity of engaging in FDI. Only the most productive firms can bear the high costs incurred by higher commitment to foreign markets via FDI, confirming pecking order I. More importantly, I propose pecking order II which posits that seeking strategic assets via FDI is not without costs. Firms need to have strong internal resources and be productive and profitable enough to source knowledge abroad in order to obtain strategic assets. In addition, chapter 2 extends the stepwise internationalisation theory by distinguishing between different FDI motives. The predicted relationship of exporting leading to conducting FDI only stands for market-seeking FDI, but not for engaging in FDI with other motives. To the best of my knowledge, it has not been done previously for China, and seldom at all.

In addition, not all exporting firms will equally conduct FDI in their internationalisation development. In line with the argument that exporting experience is important to conduct FDI (Wei et al., 2013), chapter 2 extends the argument by explaining how the heterogeneous exporting experience relates to engaging in FDI. More specifically, exporting to rich countries and to a variety of destinations encourage exporters to conduct FDI, because these markets are likely to be more demanding than developing markets and thus provide wider opportunities and better knowledge for exporters to learn to conduct FDI.

Moreover, chapter 2 integrates various firm resources and government support to explain

internationalisation strategies and strategies development, rather than adopting a single productivity approach or resource-based view. Intellectual properties (in the form of patents), technological competence and government technology development subsidies are important for international development.

The practical implication of chapter 2 is that productivity is important not only for internationalisation, but also to seek strategic assets to enhance ownership advantages of parent firms. This is important for firms from emerging markets which tend to lack intrinsic ownership advantages. Exporting experience is important for firms to collect information about foreign markets and expand markets via market-seeking FDI, especially for firms that face intense competition and local protection in home countries such as China (Child and Rodrigues, 2005). Government support also promotes private firms from emerging countries to overcome ownership disadvantages to achieve higher level of internationalisation. Therefore, more resources should be allocated from the government to private sectors to assist with international development.

It would be interesting for the future research to explore the strategies of how emerging countries-based MNEs can better seek strategic assets via FDI, and how the sourced knowledge can be adapted and implemented within organisations. In addition, it is interesting to study the communication and knowledge exchange between exporters and their business partners in foreign countries, and explore what kind of knowledge is acquired by exporters and how they can utilise such knowledge to conduct FDI later. Finally, future research may examine the extent to with the FDI can affect parent firms' ownership advantages, economic performance as a result of achieving high level of internationalisation.

CHAPTER 3: WHAT DRIVES FOREIGN FIRMS PATENTING IN AN EMERGING HOST COUNTRY? EVIDENCE FROM CHINA

3.1 Introduction

The purpose of chapter 3 is to understand what drives foreign firms (MNEs' foreign subsidiaries) to innovate and patent in emerging host countries. MNEs have been increasing their patenting activities in emerging host countries such as Eastern European countries, India and China (Demirbag and Glaister, 2010). Liu and Chen (2012) summarise that the international innovation activities of MNEs in emerging host countries seem to have passed the stage of adaptive R&D and start pursuing patenting activities. It indicates that while the main innovation activities could still be based in developed home countries (Minin and Bianchi, 2011), the innovation in emerging countries has become more important for MNEs (Hu, 2010). Therefore, the question of what drives foreign firms to patent in emerging countries becomes paramount.

Recent studies, as is also seen from the linked data employed by chapter 3, show that MNEs have become more participative in investing R&D, producing new products and patenting in emerging host countries (Giroud et al., 2011; Kampik and Dachs, 2011). It challenges the traditional view that MNEs' engaging in overseas R&D in emerging host countries mainly aim for product adaptation rather than creating new knowledge (Athukorala and Kohpaiboon, 2010). Although the existing literature does not specify the magnitude of this trend and demonstrates if it represents a global picture, it is an important phenomenon which may indicate the potential shifts under way in the global investment regime and MNEs' motives.

Relevant to this, several studies have examined the phenomenon of R&D internationalisation to explain how foreign subsidiaries absorb knowledge from parent firms to produce innovation (Phene and Almeida, 2008; Wang, 2010) and the improved economic performance effect of innovation (Zhang et al., 2007). Yet little is known about what factors drive foreign firms to produce innovative output (Nieto and Rodriguez, 2011). Given that the innovation literature explicitly articulates that the

determinants of innovation input and output do vary (Love, Roper and Bryson, 2011), it should not be assumed that the factors that drive MNEs' R&D investment are the same as those that explain innovation output.

In addition, only a couple of studies focus on MNEs' patenting in host countries but they resort to macro level observations and can only associate country level patents distribution with macroeconomic or institutional characteristics (Allred and Park, 2007a). In order to be able to capture the motivation behind patenting behaviour of foreign firms, one has to adopt micro level data.

Moreover, the nascent literature on foreign firms' innovation in emerging economies has discussed the differences in innovation between foreign and domestic firms, and the innovation advantages that foreign firms enjoy over domestic counterparts, such as access to rich capital resources (Un and Cuervo-Cazurra, 2008; Un, 2011). However, capital markets and financial systems in emerging countries are perceived to be inefficient and weak (Du and Girma, 2007). The puzzle of how the ability to access external finance can shape foreign firm innovation has not been untangled yet.

Chapter 3 hence seeks to further the understanding of foreign firms' innovation and patenting behaviour in emerging host countries. Firstly, it highlights the importance of regional intellectual property rights (IPR) protection for foreign firms patenting, following the burgeoning literature linking IPR protection and domestic patenting activities using macro country level evidence (Park, 2008b). It also extends the literature by investigating such relationship by distinguishing patents of different levels of novelty and technological contents. Secondly, chapter 3 links FDI motivation with its innovation. Given that FDI motivation has heterogeneous influence on its potential to transfer technologies to host countries (Driffield and Love, 2007), it is perhaps surprising to observe that there is a paucity of work analysing how FDI motivation matters for their innovation. Thirdly, chapter 3 accounts for the effect of how the level of industry dependence on external finance may shape innovation of foreign firms, as formal analysis in this area are scant.

The empirical analysis in chapter 3 draws on a linked data generated from two large firm level datasets from China. The linked data show that foreign firms have considerably expanded patenting activities in China during 2000-2008. The number of patents granted to foreign firms surges, and the average number of patents owned by foreign firms has doubled during this period.

Chapter 3 reaches three major conclusions. First, better IPR protection encourages foreign firms to innovate and produce patents in general, and more importantly, promotes them to produce the most novel type of patents with high level of technological elements. Such positive relationship is the most discernible in high-tech industries, capital-intensive industries, and industries that are more dependent on external finance. Second, motivation behind FDI has important implications for foreign firms' patenting. Market-seeking firms are more likely to patent, while export-oriented efficiency-seeking ones do not seem to patent. Third, foreign firms appear to innovate and patent in industries that are more dependent on external finance. Firstly, due to the underdevelopment of financial systems in emerging countries such as China, industries that are more dependent on external finance tend to attract more FDI. Secondly, in the industries that are more dependent on external finance, firms may face more serious finance constraints when engage in innovation. Foreign firms seem to be relevantly more resource abundant in terms of accessing external finance. Hence, they tend to have ownership advantages in innovation.

The reminder of chapter 3 is structured as follows. Section 3.2 reviews literature and develops hypotheses. Section 3.3 introduces the data and summary statistics. Section 3.4 presents the empirical model and variables. Section 3.5 discusses the findings and section 3.6 concludes.

3.2 Literature Review

To explain what drives foreign firms to patent in an emerging host country, three hypotheses have been developed based on the discussion of institutional factors, business environment, as well as FDI motivation.

3.2.1 Institution and innovation

Institutional-based literature suggests that business environment such as government, culture, market and competition affects firms' business strategies, investment and innovation (Peng, 2002; Du, Lu and Tao, 2008; Yang, Liu, Gao and Li, 2012; Wang, 2013). Better institution systems will not only reduce firms' production costs, but also lower transaction costs such as the costs to establish contracts, inspect and implement contracts (Yasar, Paul, and Ward, 2011). Countries with better institutions tend to growth faster, adopt technologies and close technology gaps more quickly than those with poor institutions (Manca, 2010). Instable regulations and insufficient financial support from the government can discourage firms to achieve long-term growth (Ahlstrom and Bruton, 2010). Poor regulation quality, inability to uphold laws, as well as corruption will deteriorate firms' innovation and performance (Chadee and Roxas, 2013). Zhu, Wittmann and Peng (2012) summarise that the innovation abilities of small and medium-sized Chinese firms are restricted by difficulties in accessing financial resources, unfair industry competition, lack of regulations and high tax expense. This chapter specifically focuses on the institutional effect of IPR protection on patenting.

Another business environment aspect that can shape firms' innovation is industry dependence on external finance. This is especially relevant for emerging countries where financial markets tend to allocate resources inefficiently. Imperfect financial markets will discourage firms in industries that are more dependent on external finance to pursue innovation, because they face higher marginal costs to innovate (Hyytinen and Toivanen, 2005). Underdeveloped financial systems will hinder firm growth, particularly small and medium-sized ones, which will inhibit firms' innovation (Beck, Demirguc-Kunt, Laeven, and Levine 2008). As for China, rather than distributing finance resources to the most productive or innovative firms, banks generally lend the majority of bank loans to SOEs, leaving private sectors having difficulties to find external loans (Arora, 2009). Therefore, the question remains that how industry dependence on external finance can shape foreign firms' patenting behaviour when the private sector are likely to find it difficult to access external finance to innovate.

3.2.2 IPR and innovation

Improved IPR protection provides greater incentive to innovate, because it enhances the

appropriability of innovation (Landes and Posner, 2003; Allred and Park, 2007b). In addition, better IPR protection will support business operation, contract enforcement and encourage firms to invest in R&D in the first place (Lin, Lin and Song, 2010). Firms are more likely to reinvest in innovation activities when the IPR protection is stronger (Johnson, McMillan and Woodruff, 2002). With regard to emerging countries, when FDI is the main knowledge channel for local firms, stronger IPR protection will encourage technology transfer from foreign to local firms and increase innovation rate of domestic firms (Lai, 1998; Branstetter and Saggi, 2011).

However, empirical evidence of whether or not stronger IPR protection will induce innovation is controversial (Park, 2008b). Using OECD country-level panel data during 1998-2004, Blind (2012) reports that stronger IPR protection is associated with higher patent intensity (measured by patent application per employee) and R&D intensity. On the contrary, Barbosa and Faria (2011) observe that stronger IPR protection reduces the proportion of innovative firms in OECD industries. When considering only technology-intensive industries, IPR protection does not have any impact on innovation.

The contradictory findings on the relationship between IPR protection and innovation spur an investigation of a non-linear relationship. IPR protection encourages innovation because it grants innovators monopoly power in the product market. However, IPR protection may also deter innovation in competing firms if the protection is too wide (Mazzoleni and Nelson, 1998). Moreover, a very long patent life can reduce rivalry and incentives to innovate, resulting in an inverted U relationship between IPR protection and innovation (Horowitz and Lai, 1996). In addition, the mixed empirical evidence could be due to the heterogeneous stages of economic development. Allred and Park (2007a) summarise that stronger patent rights protection increases the appropriability of innovation returns in developed countries. In developing countries, the positive effect could be offset by lack of motivation to innovate if patents are protected for a too long period of time, especially when innovators in less advanced countries tend to produce imitation type of innovation. Kim et al. (2012) use data for over 70 countries, and posit that the impact of patent rights protection on grant patents depends on the level of economic development. Better patent protection is an important determinant of patent production in

high income countries, but not in other countries. Similar findings are also reported by Chen and Puttitanun (2005), Hudson and Minea (2013) and Schneider (2005). Moreover, a few studies argue that the relationship between IPR protection and overseas R&D investment is moderated by host country characteristics such as local R&D, human capital quality and market competition (Chuang and Lin, 2011; Aghion, Howitt and Prantl, 2013; Fan, Gillan and Yu, 2013).

While the above studies focusing on patenting behaviour of domestic residents, some studies specifically examine foreign residents' patenting activities. Lerner (2009) suggests that at the beginning of a foreign firm's entry, it tends to sell a small proportion of products in a host country. Positive changes in patent protection policies aiming to enhance patent protection, such as patent protection breadth and protection length, may not lead to higher level of patent filings of a foreign firm. However, the policy changes may encourage a foreign firm to pursue patent protection for its innovation in the host country over time. Using 60 countries over 150 years, he finds that foreign patent filings increase as a result of positive patent policy changes.

Using a sample of 35 countries during 1965-2000, Allred and Park (2007a) study the effect of patent rights protection on innovation of foreign firms. They specifically distinguish innovation output, captured by patent applications, and innovation input, proxied by R&D investment. They observe an inverted U-shaped relationship between the level of patent rights protection and foreign patent applications. Very strong patent rights protection will reduce competition and hinder the motivation to patent. As for R&D input, they find that stronger patent rights protection encourages firms' R&D investment, even when the protection is very strong. However, the above findings only hold for developed countries, suggesting that better patent rights protection appear to stimulate innovation only in countries that have well-developed patent systems.

Employing panel data of US MNEs during 1982-1999, Branstetter, Fisman and Foley (2006) demonstrate that IPR reforms in host countries increase the technology transfer from parent firms to foreign subsidiaries. Moreover, foreign subsidiaries increase their R&D investment after the IPR reforms in host countries. Foreign patent filings expand at the time of IPR reforms and continue

increasing in the following years.

Moreover, another strand of studies investigates the specific strategies of how foreign firms protect knowledge in general (Amara, Landry and Traore, 2008) and specifically in weak IPR protection countries (Zhao, 2006; Keupp, Beckenbauer and Gassmann, 2009; Keupp, Friesike and von Zedtwitz, 2012). De Faria and Sofka (2010) suggest that MNEs tend to employ stricter knowledge protection measures in host countries which have less potential for knowledge-sourcing (Portugal) than those have more abundant knowledge sources (Germany). Nevertheless, there is still a lack of general evidence of how foreign firms' patenting activities are shaped by IPR protection, especially in emerging host countries.

In short, the literature specifically examining the relationship between IPR protection and foreign patenting appears to favour a positive relationship, at least before the optimal level of IPR protection. Given that emerging economies such as China is still in the process of harmonising its IPR laws and practices with international standards, it is reasonable to argue that the IPR protection is not likely to be too strong to impede firms' motivation to patent. I propose:

Hypothesis 1 (H1): Better intellectual property rights protection in an emerging host country will encourage foreign firms to produce patents locally.

3.2.3 Industry dependence on external finance and innovation

Firms' innovation is closely linked to financial system development and the level of industry dependence on external finance. Firms usually have two finance sources to fund innovation: internal sources which typically generated from profits, and external sources such as bank loans. Obtaining external finance to fund innovation can be costly, because firms often have to provide physical assets as guaranty and they cannot receive immediate returns from innovation (Alderson and Betker, 1996). Firms that suffer from financial constraints will be less likely to have innovation, even when they have high innovation capabilities (Hottenrott and Peters, 2012). Hyytinen and Toivanen (2005) demonstrate that firms' R&D investment is determined by the equilibrium of marginal capital cost and marginal

rate of return. When the capital market is perfect, firms' marginal capital cost is constant. When the capital market is imperfect, firms will face an upward marginal capital cost. Given that the marginal rate of return of R&D investment is decreasing as R&D investment increases, the optimal point of R&D investment is lower in imperfect capital market than that in a perfect capital market. As a result, firms in industries that are more dependent on external finance are more likely to cease innovation than those in other industries which are less dependent on external finance. Hall (2002) stresses that small and medium-sized enterprises (SMEs) in R&D intensive industries are more likely to have less innovation than their counterparts in other industries. This is because in R&D intensive industries, firms are faced with steeper upward marginal capital cost which is driven by uncertain return to R&D investment and unpredictable market growth opportunities. In addition, underdeveloped financial market cannot distribute capital resources efficiently, such as withdrawing capital from declining industries and allocating capital to high growth industries (Arizala, Cavallo and Galindo, 2013). Industry growth will be hindered when they are more dependent on external finance and when they are located in countries with underdeveloped financial systems (Beck, Demirguc-Kunt, Laeven, and Levine, 2008). Consequently, innovation in the long-run could be adversely affected by low growth.

The patenting behaviour of foreign firms is shaped by how dependent industries are on external finance. First, industries that are more dependent on external finance are more likely to be penetrated by FDI. This is because in emerging economies such as China, financial systems tend to be biased against private firms. For example, private Chinese firms are found to have difficulties in accessing external finance such as bank loans, providing large potential for export-oriented FDI to expand their penetration in China. Especially in labour-intensive industries, foreign expansion can deprive exporting orientation of indigenous firms (Huang, 2003). Empirical support has also been reported by Du and Girma (2007).

Second, in the sectors that are more dependent on external finance, firms may face more serious finance constraints when engaging in innovation. Foreign firms seem to have ownership advantages to innovate. Foreign firms can access external finance from other developed capital marekts (Un and Cuervo-Cazurra, 2008), and enjoy the ownership advantage of utilising internal capital markets to

overcome weak financial markets where they operate (Aggarwal and Kyaw, 2008). In addition, foreign firms could utilise technology transferred from parent firms or other subsidiaries within the MNEs organisation, and thus have advantages to innovate (Un, 2011).

In short, foreign firms could have advantages to innovate in industries that are more depend on external finance. An important question that has not yet been addressed is the extent to which such advantage can shape foreign firms' patenting activities. Categorising industries by the level of dependence on external finance according to Rajan and Zingales (1998), I propose:

Hypothesis 2 (H2): Foreign firms are more likely to produce patents in emerging host country industries which are more dependent on external finance and domestic firms tend to have difficulties in obtaining external finance.

3.2.4 FDI motivation and innovation

The third hypothesis links the motives behind FDI and foreign firms' patenting activities. In particular, the focus is on the distinctions between efficiency-seeking and market-seeking FDI.

Firms engage in efficiency-seeking FDI to exploit relative cheap factors or to take advantage of economic policies in host economies. MNEs can obtain economies of scale and risk diversification by expanding and governing subsidiaries in global markets. They tend to be large and experienced firms, and produce standardised products (Dunning and Lundan, 2008). Even the FDI from emerging market-based firms investing in other emerging countries may aim to take advantage of local factors in order to complement their domestic cost advantages (Child and Rodrigues, 2005).

Another important motivation for conducting FDI is to seek markets. These foreign subsidiaries could be in pursuit of main suppliers and customers or need to adapt to local language and business practices. They may consider it necessary to have physical presence in major foreign markets, or overseas markets are large and growing fast, providing large potential for foreign firms to grow (Dunning and Lundan, 2008). Especially among the MNEs from home markets where there is intense

competition and squeezed profit margins, their foreign subsidiaries tend to be market-seekers (Child and Rodrigues, 2005).

Empirical studies tend to explain overseas R&D investment from perspectives such as host country conditions including market size, knowledge stock and industrial policies (Hegde and Hicks, 2008; Shimizutani and Todo, 2008; Franco, Ray and Ray, 2011; Giroud, et al., 2011), or knowledge exploiting and creating FDI motivation (Veliyath and Sambharya, 2011; Liu and Chen, 2012). However, it is less clear what factors drive foreign subsidiaries' to produce innovation output. Specifically in emerging host countries, the majority of the inward FDI arguably tend to seek efficiency and markets rather than technologies. Gassmann and Han (2004) argue that foreign investors investing in R&D facilities in China to facilitate product adaptation and customer services rather than seeking technologies.

Studies linking FDI motivation with R&D internationalisation propose that foreign firms that are international market-oriented tend to invest more in R&D in host countries and then export intensively. They posit that export-oriented foreign firms are more likely to innovate than local market-oriented foreign firms because the former need to tailor their products to serve a wider range of markets. It is profitable for the export-oriented foreign firms to invest in R&D and launch innovation. For Japan-based MNEs, Ito and Wakasugi (2007) observe that foreign firms with higher export sales tend to be more likely to conduct R&D in order to support local production and source knowledge from host countries. Kampik and Dachs (2011) report that German MNEs' subsidiaries tend to innovate more in and export intensively from European host countries if the subsidiaries are international market-oriented. Zejan (1990) and Marin and Sasidharan (2010) also support this argument based on the analysis of foreign subsidiaries of Swedish MNEs. Nevertheless, using data from the Netherlands, Sadowski and Sadowski-Rasters (2006) suggest that higher exporting intensity of foreign firms can encourage their imitation type of innovation (new to the firm but not new to the market), but will reduce real innovation output that is new to the market.

However, it is not clear if the above findings hold in an emerging country background where a

non-trivial proportion of inward FDI does not mainly seek technologies as that in developed host countries, but is in pursuit of local market and efficiency. More importantly, FDI motivation will influence the nature of technology transfer within MNEs organisations and affect innovation of foreign subsidiaries. For efficiency-seeking FDI, the technology transfer from the parent firms to foreign subsidiaries may involve transferring relatively standard technologies to low cost production locations in host countries. The quality and frequency of technology transfer could be limited. In contrast, domestic market-oriented FDI aims to expand in host countries, and often involves leveraging parent firms' ownership advantages to foreign subsidiaries. Domestic market-seeking FDI may involve transferring high quality technologies from parent firms to subsidiaries. Market-seeking foreign firms are therefore more likely to produce innovation in host countries than efficiency seekers.

In summary, some questions remain unanswered by the existing literature. First, recent studies show that foreign firms in emerging countries no longer only focus on product adaptation. They also create knowledge and launch innovation of high quality (Dellestrand and Kappen, 2012; Figueiredo and Brito, 2012). Second, foreign firms that export intensively from developed host countries to other countries can be international market-oriented. Their high export intensity allows them to expand markets and recoup R&D investment (Kampik and Dachs, 2011). However, it is not clear if the same argument can be made in emerging host countries. Arguably FDI into emerging countries is driven by efficiency-seeking, taking advantage of cheap factor endowment for manufacturing and then exporting heavily (Zheng and Tan, 2011). Hence, the intensive exporting activities of foreign firms in emerging economies may not indicate that these foreign firms are international market-driven and thus are innovative, as suggested by the literature. Third, if foreign firms are better embedded in business networks in host countries, they are more exposed to local knowledge and ideas in host countries. They may enhance the competence in the local market, attract more resources to develop innovation, and even improve innovation performance over time (Marin and Bell, 2010; Ciabuschi, Dellestrand and Martin, 2011). Finally, the level of technology transfer from parent firms to foreign subsidiaries is related to FDI motivation. Market-seeking FDI may receive more and better technologies from parent firms than efficiency-seeking FDI, and thus the former could be better placed to innovate and patent in

host countries. I hypothesise that FDI aiming at market expansion in a host country is more likely to innovate in an emerging host country. In comparison, efficiency-seeking foreign firms that mainly engage in processing and exporting are less likely to patent.

Hypothesis 3 (H3): Market-seeking foreign firms in an emerging host country are more likely to produce patents, while export-oriented efficiency-seeking foreign firms are less likely to produce patents.

3.3 Data

This section first introduces data sources, followed by summary statistics of the linked data. The last part of this section proposes an innovative approach to construct an intellectual property rights (IPR) protection index at provincial level, which is to be used in the empirical model.

3.3.1 Data sources

Chapter 3 employs a linked dataset generated from linking two large firm level datasets, because there are no firm level patent data covering a large population that are publically available for China. The first dataset is collected from the Annual Report of Industrial Enterprise Statistics maintained by the National Bureau of Statistics (NBS) of China. The NBS data cover the population of state-owned enterprises and all non-state firms with an annual turnover of over five million Renminbi yuan (about 600,000 US dollars). The firms in the dataset account for about 85-90% of total output in most industries reported in the national aggregate annual statistics. It includes information on firms' financial information, R&D expenditure, export, labour training and ownership structure. The second dataset is patent registration data collected from the State Intellectual Property Office (SIPO) of China. It provides detailed information on both applied patents and granted patents. These two datasets are linked over the period of 2001 to 2008 based on the identifications of firm and legal person, as well as location and time of observation. The econometric analysis in chapter 3 is restricted to foreign invested firms in the linked data, including investors from Hong Kong, Macau, Taiwan, and investors

from other economies. A detailed report of how the two datasets are linked can be found in Appendix 3.

3.3.2 Patent data

Both patent application and granted patent records are available in the linked data. However, following Sun and Du (2010), I prefer using grant patent dummy as the dependent variable instead of patent application. Grant patents present the authenticity of innovation where the holding firm has legal rights and could receive economic benefits (Filatotchev et al., 2011). Chapter 3 selects two types of patents, invention patent and utility model patents, because they have high level of technology contents.[i]

After carefully cleaning the linked data, 297,254 observations for 82,624 foreign firms are identified over the period 2001-2008 that have the necessary information for econometric estimations. The linked data maintain three critical advantages in terms of the sample coverage, the patent measures and the data quality. First, this firm level patent dataset reflects the most novel and innovative patenting activities of the majority of foreign firms in the most recent years. Second, the existing studies examining patenting behaviour in China tend to employ patent data aggregated at province or industry level. However, such data not only cannot distinguish patent producers between manufacturing firms, domestic individuals, research institutes, higher education institutions and other organisations (Fu, 2008; Yueh, 2009), but also are unable to distinguish between domestic and foreign patent filings. Different from these studies, the linked data employed by chapter 3 are restricted to foreign invested manufacturing firms as patent producers. Third, as reported in more detail in the Appendix 3, the linked data are of high quality as they are fairly closed to the official data documented in the literature.

3.3.3 Foreign firms' patenting activities in China

The summary statistics in Table 3.1 show that across all years, on average there are about 4 percent of foreign firms have patents (either invention or UM patents, or have both). About 2 percent of foreign

firms have the most innovative type of patents: invention patents. China is an interesting country for studying patenting behaviour of foreign firms for several reasons. First, Figure 3.1 shows that foreign firms have considerably expanded their patenting activities in China in the last decade. The number of patents granted to foreign firms expands between 2000 and 2008 from less than 1,000 to over 17,000. This foreign patent surge is driven by two forces. The percentage of foreign firms that have grant patents has tripled from about 1.6% in 2000 to approximately 4.99% in 2008. Additionally, among foreign firms that have grant patents, the average patent count has doubled from 2.2 in 2000 to 4.8 in 2008.

Table 3.1: Definition and summary statistics of variables

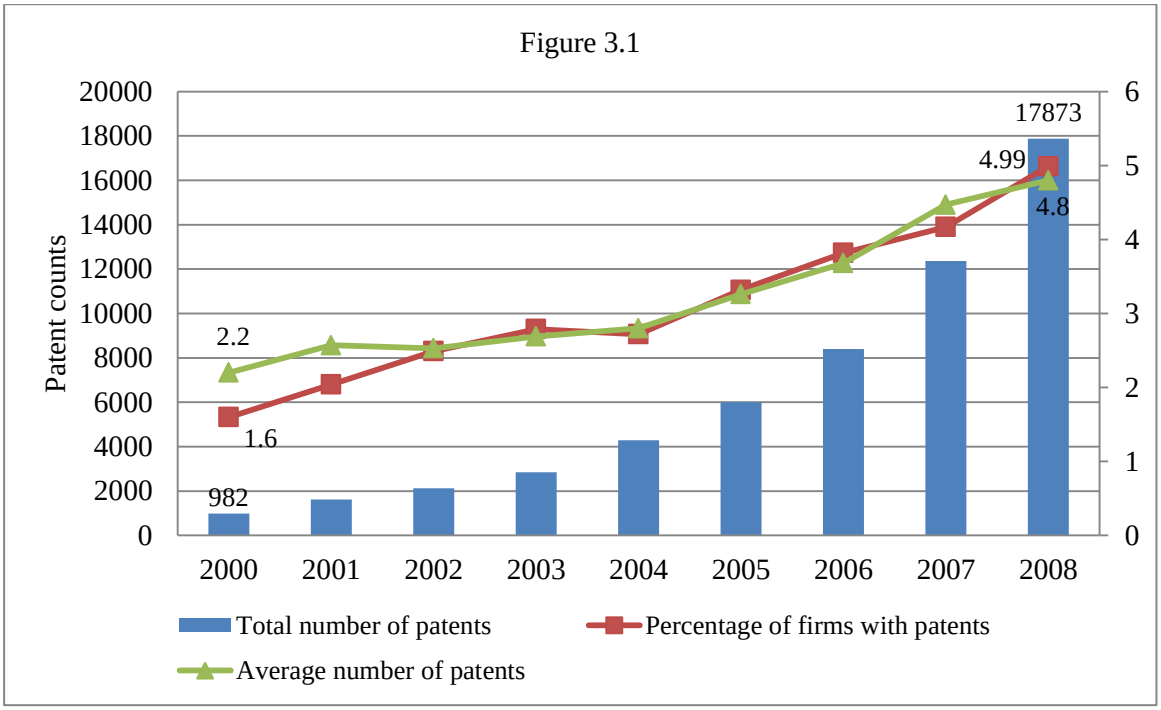
Variable	Definition	Mean	S.D	Min	Max
Dependent Variables					
Patent binary	1 if a firm has a grant patent (either an invention or a utility patent, or both), 0 if it has no grant patent	0.04	0.20	0	1
Invention patent binary	1 if a firm has an invention patent, 0 if it has no invention patent	0.02	0.13	0	1
UM patent binary	1 if a firm has a utility model (UM) patent, 0 if it has no UM patent	0.03	0.17	0	1
Independent Variables					
IPR Index					
IPR	The total number of resolved patent disputes divided by the total number of registered patent disputes in province *r* in year *t* (*rt*)	0.87	0.10	0	1.2
FDI Motivation					
Export-oriented FDI	The share of export sales to total sales	0.45	0.44	0	1
Absorptive Capacity					
Past dependence (patent)	1 if a firm has at least one grant patent (either an invention or a utility model patent, or both) in any of the previous years, 0 if it has no grant patent in all of the previous years	0.06	0.25	0	1
Past dependence (invention patent)	1 if a firm has at least one grant invention patent in any of the previous years, 0 if it has no grant invention patent in all previous years	0.02	0.15	0	1
Past dependence (UM patent)	1 if a firm has at least one grant UM patent in any of the previous years, 0 if the firm has no grant UM patent in all of the previous years	0.05	0.22	0	1
R&D intensity	R&D expenditure per hundred employees in logarithm form	0.58	1.65	0	10.76
Distance to frontier	Distance to technology frontier: (Maximum TFP in industry *j* province *r* at time *t* – firm TFP)/Maximum TFP in *jrt*	0.31	0.12	0	4.50
Labour quality	Differences between a firm's wage and the average wage in industry *j* province *r* at time *t* (*jrt*) divided by the average wage in *jrt*	0.48	2.10	-0.96	11.96
Training intensity	Training expenditure per hundred employees	0.91	1.41	0	8.86

	in logarithm form				
Firm Performance					
Profitability	The share of operating profit to total sales	0.03	0.11	-0.56	0.33
Sales share	The share of a foreign firm's sales to total sales of all firms (domestic and foreign firms) in *jrt*				
Market Structure					
CR	Concentration ratio based on the largest four firms in industry *j* at time *t* (*jt*)	0.11	0.07	0.03	1
Herfindahl	Normalised Herfindahl index in *jt*	0.01	0.01	0.00	1
Knowledge Stock					
Patent per graduate	Total grant patent counts divided by total number of university graduates in province *r* at time *t* (*rt*)				
Control Variables					
Log employees	Number of employees in logarithm form	5.14	1.08	1.95	7.70
Age	Firm age	8.96	4.97	1	52
Observations	297,254				

Table 3.2: Correlation matrix

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
(1) Patent binary	1																	
(2) Invention patent binary	0.628	1																
(3) UM patent binary	0.872	0.293	1															
(4) Past dependence: patent	0.401	0.268	0.373	1														
(5) Past dependence: invention patent	0.307	0.321	0.241	0.596	1													
(6) Past dependence: UM patent	0.373	0.210	0.382	0.899	0.320	1												
(7) IPR	0.015	0.011	0.012	0.017	0.015	0.011	1											
(8) Export-oriented FDI	-0.029	-0.037	-0.014	-0.036	-0.045	-0.018	-0.010	1										
(9) Concentration ratio	0.071	0.053	0.062	0.078	0.056	0.072	0.029	-0.075	1									
(10) R&D intensity	0.196	0.169	0.160	0.205	0.183	0.169	0.000	-0.095	0.136	1								
(11) Labour quality	0.136	0.122	0.122	0.144	0.130	0.133	0.009	0.052	-0.019	0.159	1							
(12) Distance to frontier	-0.107	-0.093	-0.089	-0.115	-0.099	-0.098	-0.005	0.070	-0.129	-0.179	-0.446	1						
(13) Traning intensity	0.080	0.076	0.060	0.088	0.083	0.070	0.037	-0.139	0.079	0.279	0.134	-0.173	1					
(14) Profitability	0.046	0.041	0.034	0.040	0.034	0.032	0.013	-0.077	0.016	0.075	0.070	-0.313	0.094	1				
(15) Sales share	0.045	0.039	0.037	0.051	0.047	0.045	0.009	-0.074	0.213	0.090	0.230	-0.250	0.100	0.057	1			
(16) Patent per graduate	0.016	-0.007	0.028	0.011	-0.010	0.022	0.131	0.230	0.001	-0.028	-0.013	0.054	-0.112	-0.063	-0.175	1		
(17) Log employees	0.106	0.082	0.098	0.111	0.087	0.105	-0.061	0.250	0.000	0.093	0.611	-0.404	-0.004	-0.002	0.146	0.109	1	
(18) Age	0.051	0.043	0.043	0.120	0.085	0.110	0.007	0.041	-0.001	0.065	0.158	-0.104	0.054	-0.003	0.045	0.062	0.171	1

Figure 3.1: Foreign firms' patent production year distribution



Notes: (1) The values on the right-hand side vertical axis should be interpreted as percentage values for the "Percentage of firms with patents" line, and it should be interpreted as patent counts for the "Average number of patents" line. For example, in year 2008, there are about 4.99% of foreign firms have patents, and among foreign firms that own patents, the average patent counts is 4.8. (2) The statistics in Figure 3.1 are calculated based on the author's linked data; (3) Total number of patents is the total number of invention patents and utility model patents owned by foreign firms; (4) Percentage of firms with patents is the share of the number of foreign firms that have grant patents to the total number of firms (all domestic and foreign firms); (5) Average number of patents is the average number of patents (both invention and utility model patents) owned foreign firms.

Second, the legal system with regard to IPR protection has been improved during the sample period. After the enforcement of China's Patent Law in 1985, it has been revised in 1992, 2000 and 2008 in order to enhance intellectual property rights (IPR) protection, reduce patent infringements and meet international IPR protection standards (Liegsalz and Wagner, 2013).

Third, China is characterised by heterogeneity. China has considerable disparity in economic and institutional development at regional level. The period of the foreign patent surge coincides with the improvement of IPR protection in China, although the empirical links between the two phenomena have been largely overlooked.

3.3.4 Provincial intellectual property rights protection

The level of IPR protection is one of the key elements for patent production (Park, 2008b). The existing literature tends to capture the IPR protection at country level using the index developed by Ginarte and Park (1997) and updated by Park (2008a), such as Kanwar and Evenson (2003), Allred and Park (2007a), Hudson and Minea (2013). Others employ IPR protection indices from other sources such as patent rights index from the World Development Indicators (Kim et al., 2012) and IPR enforcement index constructed by the World Economic Forum (Chuang and Lin, 2011). Only a few attempts have been made to capture the IPR protection at regional level. Du, Lu and Tao (2008), Kawai (2009), and Wei et al. (2013) use the number of applied or grant patents per capita at provincial level. Fan, Gillan and Yu (2013) employ the IPR index extracted from the National Economic Research Institute (NERI) of China. Nevertheless, the index reported by the NERI report is still based on the weighted applied and grant patents at provincial level. It is challenging to proxy the level of IPR protection using patents per capita, because it may reflect how active patenting activities are at regional level rather than how well patent law is enforced and patents are protected. Chapter 3 therefore proposes an innovative approach to capture IPR protection by taking advantage of the data from the Patent Annual Report of China. The report provides information on patent dispute counts that have been registered and resolved annually by the patent law enforcement authorities at provincial level. An IPR protection index is constructed based on these data, which will be discussed in the next section.

3.4 Model

The purpose of chapter 3 is to study what drives foreign firms to patent in an emerging country. This section first presents the basic econometric specification, followed by a discussion of the variables employed in the model.

A binary outcome model is adopted. The probability for a firm obtaining a patent is given by:

$$Patent^{*}_{ijrt} = \beta_0 + IPR_{rt} * \beta_1 + X_{ijrt} * \beta_2 + MS_{jt} * \beta_3 + KS_{rt} * \beta_4 + \varepsilon_{ijrt}$$

$$Patent_{ijrt} = 1\left[Patent^{*}_{ijrt} > 0\right] \quad (1)$$

where $Patent_{ijrt}$ is a binary variable to capture a foreign firm *i* obtaining a grant patent in 3-digit industry *j* in province *r* at time *t*. A Probit model is specified based on a latent variable $Patent^*_{ijrt}$ that is hypothesised to depend on IPR protection, FDI motivation, firms' absorptive capacity, performance, market structure, regional knowledge stock and control variables. The binary patent variable is measured in three ways: (1) whether or not a firm has any kind of grant patent (either an invention or a utility model patent, or both), (2) whether or not a firm has a grant invention patent that is more innovative, or (3) whether or not a firm has a grant utility model patent. In order to mitigate the potential endogeneity, all of the explanatory variables are one-year lagged, apart from firm age, province, industry and year dummy variables.

3.4.1 IPR index

Turning to the explanatory variables, first, business environment that provides firms with better intellectual property rights (IPR) protection is more likely to secure innovators to obtain economic benefits. Hence, firms in such environment are more likely to innovate. Indeed, cross country evidence has shown that better IPR protection simulates patenting activities (Park, 2008b). Therefore, in order to capture the effect of improved IPR protection, data of patent disputes from the Patent Annual Report of China are extracted to construct an IPR index. The variable *IPR* is defined as the total number of resolved patent disputes divided by the total number of registered patent disputes in province *r* at time *t*. The index aims to capture the efficiency of the patent law enforcement authorities settling patent disputes in order to protect IPR. I posit that higher value of the IPR index indicates better IPR protection.

3.4.2 FDI motivation

X_{ijrt} is a vector of variables that are postulated to affect patent production. It includes FDI motivation, absorptive capacity, firm performance, as well as control variables.

Foreign firms engaging in FDI have heterogeneous motives which have important implications for their innovation in host economies (Driffield and Love 2007; Marin and Bell, 2010). Following

Girma, Gorg and Pisu (2008) and Smeets and Wei (2010), chapter 3 distinguishes between export-oriented FDI and domestic market-oriented FDI. Export intensity is used to capture FDI motivation and it is measured by the share of export sales to total sales of foreign firms (Franco, 2013). Low export intensity suggests that a foreign firm aims for the local market demand and is driven by domestic market-seeking motive. Foreign firms that have high export intensity are considered as export-oriented firms which are driven by efficiency-seeking motivation.

3.4.3 Absorptive capacity

The role of absorptive capacity has been highlighted in determining innovation (Hausman, Hall and Griliches, 1984). Absorptive capacity is dependent on firms' prior innovation investment and practices. Firms with better absorptive capacity can better explore and utilise external knowledge to launch innovation (Cohen and Levinthal, 1990). Absorptive capacity is captured from different aspects including past dependence, R&D investment, distance to technology frontier, labour quality and labour training.

Specifically, the dynamic process of patent production is captured by past dependence variable which equals to 1 if a firm has a grant patent in any of the past years in the sample period, and 0 if a firm has never produced any patents in all of the previous years. Firms that have been trying and successfully obtained patents in the past are more likely to produce new patents (Garcia, Jin and Salomon, 2013). R&D investment is an important input of innovation and it is measured by R&D expenditure per hundred employees (Allred and Park, 2007b). Closeness to technology leaders is vital for creating knowledge and innovation. Firm closer to technology frontiers are found to be more likely to innovate (Aghion et al., 2005). The distance to technology frontier is measured by 1 minus a foreign firm's total factor productivity (TFP) divided by the highest TFP of all firms (both indigenous and foreign firms) in a province *r*, industry *j* and year *t*. In addition, labour quality plays an important role in generating innovation. It is measured by the differences between a foreign firm's wage and the average wage of all firms (both indigenous and foreign firms) in province *r*, industry *j* and year *t* divided by the average wage of all firms. Foreign firms which pay higher than average wages are

assumed to have better labour quality. Additionally, labour training intensity is measured by labour training expenditure per hundred employees.

3.4.4 Firm performance

I also control for firm performance by profitability and sales share. Profitability is measured by the operating profit weighted by sales. More profitable firms are expected to be more likely to invest in and generate innovation (Bhattacharya and Bloch, 2004). Sales share is to capture market power of foreign firms (Blundell, Griffith and van Reenen, 1999). It is measured by the share of a foreign firm's sales to total sales in province *r* industry *j* at time *t*.

3.4.5 Market structure

The industrial organisation literature stresses the importance of market structure for innovation (Gilbert, 2006; Sanna-Randaccio and Veugelers, 2007). Schumpeter (1934) and his supports argue that monopoly power increases innovation, because the expected return from R&D investment will increase as markets become more concentrated. On the other hand, Arrow (1962) suggests that monopolies are not faced with immediate threat. Therefore, they lack incentive to innovate. Market structure is proxied by concentration ratio defined as the sum of sales shares of the four largest firms in industry *j* at time *t* (Lipczynski, Wilson and Goddard, 2005). Herfindahl index is also used to check the robustness of the results. It is defined as the sum of squares of sales shares of all firms in 3-digit industry (Castellacci, 2011).[ii]

3.4.6 Knowledge stock

Firms located in regions that are endowed with more knowledge stock and more active in innovation are more likely to innovate. They can receive knowledge spillovers or they are driven by the innovation competition within the region to launch innovation (Kampik and Dachs 2011; Chyi, Lai and Liu, 2012). Knowledge stock is proxied by the total grant patent counts divided by the total number of university graduates in province *r* at time *t*.

3.4.7 Control variables

Control variables include firm age, and size which is measured by the number of employees. Older and larger firms are on average more innovative (Atkeson and Kehoe, 2005). Province and industry dummies are included in all estimations to control for any time-invariant heterogeneity related to provincial and industrial characteristics that may affect firms within each group homogeneously. Year dummies are also included to control for any macroeconomic condition, national regulation and policy changes.

3.4.8 Econometric issues

The model (1) is estimated by panel Probit random effects estimator using three different patent measures. The main econometric issue to consider in this context is path dependence of innovation. More specifically, a firm's initial status of producing patent may predict its future path of patenting. Ignoring the initial condition in the model specification could then result in omitted variable problems. A standard way to address initial condition problem is to apply a dynamic Probit model, most notably Wooldridge (2005). In this analysis, I adopt this approach with modification, due to the nature of firm patenting cyclical patterns. Instead of specifying a lagged dependent variable, I include a dummy variable which equals to 1 if a firm has ever produced a patent in any of the previous years, and 0 otherwise.

3.5 Findings

This section presents estimation results for the drivers of foreign firms' producing patents. Table 3.3 shows the estimations for whether or not a firm has any kind of grant patent (either an invention or a utility model patent, or both). Marginal effects from panel Probit random effect estimation are presented. All of the explanatory variables are one-year lagged to mitigate the potential endogeneity problem, except for firm age, province, industry and year dummy variables.

For Table 3.3, Table 3.4 and Table 3.5, industries are grouped together in column (1), and divided

into high-low technology industries based on OECD industry classification in columns (2)-(4), labour and capital-intensive industries according to Du and Girma (2007) in columns (5)-(6), and further by the level of industry dependence on external finance based on Rajan and Zingales (1998) in columns (7)-(9).

3.5.1 Patent

Table 3.3: Patent binary

		High to low-tech industries			Labour vs. capital industries		Industry dependence on external finance		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	All industries	High-tech	Medium-tech	Low-tech	Labour intensive	Capital intensive	Low dependence	Medium dependence	High dependence
IPR Index									
IPR	0.242**	0.275**	0.158	0.230	0.172	0.280**	0.440	0.0904	0.382***
	(0.0994)	(0.128)	(0.237)	(0.216)	(0.163)	(0.126)	(0.425)	(0.147)	(0.144)
FDI Motivation									
Export-oriented FDI	-0.139***	-0.219***	0.00148	-0.0776**	-0.0533**	-0.212***	-0.0612	-0.0768***	-0.224***
	(0.0157)	(0.0218)	(0.0328)	(0.0315)	(0.0232)	(0.0215)	(0.0595)	(0.0228)	(0.0236)
Absorptive Capacity									
Past dependence (patent)	1.218***	1.207***	1.251***	1.305***	1.282***	1.197***	1.313***	1.215***	1.234***
	(0.0161)	(0.0200)	(0.0329)	(0.0390)	(0.0259)	(0.0199)	(0.0692)	(0.0238)	(0.0218)
R&D intensity	0.0902***	0.0910***	0.0855***	0.0889***	0.0875***	0.0913***	0.0817***	0.0845***	0.0933***
	(0.00276)	(0.00325)	(0.00724)	(0.00785)	(0.00554)	(0.00321)	(0.0128)	(0.00438)	(0.00375)
Distance to frontier	-0.217***	-0.152*	-0.0228	-0.674***	-0.335***	-0.141	-0.372	-0.231**	-0.195**
	(0.0678)	(0.0898)	(0.130)	(0.156)	(0.109)	(0.0875)	(0.254)	(0.102)	(0.0985)
Labour quality	0.0233***	0.0215***	0.0123*	0.0306***	0.0232***	0.0221***	0.0226**	0.0215***	0.0220***
	(0.00309)	(0.00411)	(0.00696)	(0.00638)	(0.00486)	(0.00402)	(0.0110)	(0.00448)	(0.00471)
Training intensity	0.0140***	0.0101**	0.0142	0.0301***	0.0207***	0.0115**	0.0369**	0.00738	0.0190***
	(0.00408)	(0.00508)	(0.00967)	(0.00956)	(0.00704)	(0.00500)	(0.0166)	(0.00602)	(0.00589)
Firm Performance									
Profitability	0.333***	0.343***	0.337***	0.237*	0.284***	0.356***	0.318	0.341***	0.329***
	(0.0570)	(0.0711)	(0.128)	(0.141)	(0.0974)	(0.0703)	(0.254)	(0.0889)	(0.0780)
Sales share	0.169**	0.121	0.429**	-0.0558	0.159	0.137	0.451	0.0565	0.142
	(0.0844)	(0.117)	(0.184)	(0.178)	(0.131)	(0.113)	(0.279)	(0.127)	(0.129)
Market Structure									
CR	1.351***	1.276***	1.421**	1.957***	1.660***	1.239***	2.422***	1.173***	1.442***
	(0.241)	(0.327)	(0.629)	(0.445)	(0.367)	(0.322)	(0.691)	(0.371)	(0.384)
CR_square	-2.402***	-2.283***	-3.866**	-2.267**	-2.659***	-2.194***	-1.768	-2.922***	-2.333**
	(0.615)	(0.821)	(1.860)	(1.041)	(0.948)	(0.811)	(1.262)	(0.998)	(0.965)
Knowledge Stock									
Patent per graduate	0.740***	1.384***	0.733	-1.058*	-0.295	1.450***	-0.514	0.274	1.364***
	(0.272)	(0.356)	(0.595)	(0.601)	(0.433)	(0.351)	(1.141)	(0.397)	(0.399)
Control Variables									
Log employees	0.143***	0.145***	0.186***	0.110***	0.146***	0.146***	0.149***	0.171***	0.130***
	(0.00817)	(0.0106)	(0.0186)	(0.0180)	(0.0134)	(0.0104)	(0.0319)	(0.0126)	(0.0117)

Age	-0.00421***	-0.00477***	-0.00670**	-0.000323	-0.00453**	-0.00419***	-0.00321	-0.00357**	-0.00479***
	(0.00119)	(0.00152)	(0.00274)	(0.00261)	(0.00196)	(0.00149)	(0.00432)	(0.00172)	(0.00175)
Province, industry, year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
lnsig2u	-1.434***	-1.406***	-1.549***	-1.619***	-1.606***	-1.376***	-1.540***	-1.641***	-1.301***
	(0.0544)	(0.0694)	(0.121)	(0.141)	(0.0948)	(0.0673)	(0.235)	(0.0931)	(0.0706)
Observations	297,254	119,806	57,519	119,929	169,348	127,906	53,555	139,714	103,985
Number of firms	82,624	35,596	17,623	34,659	48,382	37,875	16,410	41,915	31,063

Notes: (1) Panel Probit random effect regression estimation is used and marginal effects are presented. The dependent variable equals to 1 if a foreign firm has a grant patent (either an invention or a utility model patent, or both), 0 if it has no grant patent. The past dependence variable equals to 1 if a foreign firm has a grant patent in any of the previous years, and 0 if it has no grant patent in any of the previous years. Province, industry and year dummies are included in all estimations. All explanatory variables (except firm age, province, industry and year dummies) are lagged one year. (2) Significance levels: *0.10; **0.05; ***0.01. (3) Herfindahl index is used as an alternative measure of the market structure. The results are consistent with that using concentration ratio (CR).

In Table 3.3, the first key result is the importance of IPR protection for foreign firm patenting. Better IPR protection encourages them to innovate and patent, supporting Hypothesis 1. This is consistent with the results reported by Branstetter, Fisman and Foley (2006) and Lerner (2009), and chapter 3 expands their argument by finding that the link between IPR protection and patent production is more important in industries where knowledge and technologies tend to be essential. More specifically, chapter 3 finds that such positive relationship is driven by high-tech industries, capital-intensive industries and industries that are the most dependent on external finance. However, the result reported here is running contrary to the findings of Athukorala and Kohpaiboon (2010) who do not observe any effect from IPR protection at country level on US based MNEs' R&D investment into developed countries. Additionally, the finding reported in this chapter also contrasts with Allred and Park (2007a) who do not observe any impact from patent rights protection on foreign residence patenting among developing countries. I propose that local IPR protection is important to encourage foreign firms to pursue patent protection for their innovation, which may not be reflected using macro level evidence. Once MNEs have decided which host country to invest in, they tend to produce patents in regions that provide better IPR protection.

Another key result is the role played by FDI motivation in determining foreign firms' patenting behaviour. More export-oriented foreign firms are less likely to patent, while domestic market-seeking ones tend to produce patents, supporting Hypothesis 2. More specifically, higher export intensity is related to lower probability of patenting, given other things the same. This result runs contrary to the results of Kampik and Dachs (2011) that international market-oriented foreign firms invest more in R&D than market-seeking ones. However, I propose that market-seeking foreign firms are more likely to receive high level of technology transfer from parent firms than efficiency-seeking ones. This is because the former usually involves leveraging ownership advantages from parent firms to host countries, making the subsidiaries more likely to innovate. In contrast, efficiency-seeking foreign firms may receive more standardised technologies from parent firms and are less motivated to innovate. Second, foreign firms that export intensively from China to other countries mainly engage in processing, manufacturing and exporting. China is part of their global value-adding chain rather than

the main product market. Such efficiency-seeking FDI in China aims to take advantage of the factor endowments at low costs, and thus less likely to produce innovation (Zheng and Tan, 2011). Therefore, these foreign firms do not seem to be international market-oriented which tend to invest more in R&D and innovate more than marketing seeking foreign firms, as found by Kampik and Dachs (2011) for foreign subsidiaries in developed host countries.

Interestingly, the importance of domestic market-seeking motivation for innovation is the most prominent in industries where innovation tends to be more important. For instance, in high-tech industries, the importance of market orientation for innovation reveals that foreign firms may have been upgrading their activities in China. Instead of focusing mainly on manufacturing, they also innovate in these knowledge-intensive industries and therefore can have greater potential for technology transfer to local firms than efficiency-seekers. This contrasts the traditional view that FDI in China is mainly driven by the relatively cheap labour costs (Cheng and Kwan, 2000). Moreover, in industries that are more dependent on external finance, market-seeking foreign firms are more likely to innovate and produce patents. The most likely explanation is that domestic firms may have difficulties in accessing external finance due to the weak financial system, discouraging their innovation. However, this leaves plenty of space for foreign firms to innovate and expand their market share in China, as they may have access to external finance sources from parent firms (Un and Cuervo-Cazurra, 2008).

Furthermore, comparing the results in columns (7), (8) and (9), it appears that the foreign firms' patenting behaviour is better explained for firms in industries that are more dependent on external finance, supporting Hypothesis 3. IPR protection, domestic market orientation, and profitability have no effect on patenting in industries that are the least dependent on external finance, but they have strong effects on patenting activities in industries that are more dependent on external finance. In line with Un and Cuervo-Cazurra (2008) who find that foreign subsidiaries invest in R&D more intensively than domestic counterparts, I expand the literature by suggesting that foreign firms tend to innovate and patent in industries where domestic firms are likely to be financially restrained to innovate, which may hinder the ability of domestic sectors contributing to economic development in

the long-run.

Other effects from explanatory variables on the dependent variable are largely as expected and consistent across different industries. The first notable result is the overwhelming importance of absorptive capacity in determining innovation. For example, the past dependence variable suggests that firms that have successfully produced patents in the past are more likely to produce patents in the future, consistent with Garcia, Jin and Salomon. (2013). Firms that invest in R&D more intensively have higher probability of producing patents, highlighting the importance of internal R&D efforts in generating innovation (Cohen and Levinthal, 1989). Also, firms that are closer to the technology frontier in the industry are more likely to produce patents. It confirms the results of Girma (2005) that technology leaders are better at launching innovation. Labour quality is important for innovation. Foreign firms that have better labour quality and providing more labour training are more likely to patent, consistent with Chuang and Lin (2011).

In addition, firm performance does have impact on innovation, particularly in high-tech industries and industries that are more dependent on external finance. Higher profitability encourages foreign firms to patent, because these firms could have abundant internal funding to re-invest in innovation (Choi, Lee and Williams, 2011).

With regard to market structure, the results are consistent with the literature that the relationship between innovation and market structure is non-linear (Aghion, et al., 2005; Lee, 2009). Innovation is low when the market is too competitive or too concentrated. Before the optimal level of market competition, higher market concentration encourages innovation because the perceived return of innovation is higher in more concentrated markets. Monopolies are motivated to invest in knowledge creating activities in order to charge prices higher than marginal costs (Schumpeter, 1934). After the optimal point, however, higher market concentration can hinder innovation, because monopolists have less incentive to innovate. They enjoy large profit margins than firms in competitive markets, even without innovation (Arrow, 1962).

Furthermore, foreign firms in provinces that have more knowledge stock are more likely to innovate, indicating that they may utilise knowledge flows sourced locally and are incentivised to innovate to compete with other patenting active firms and organisations, supporting the findings of Phene and Almeida (2008) and Kampik and Dachs (2011).

3.5.2 Invention patent

I specifically distinguish patent types and present the results in Table 3.4 to invest the drivers of producing invention patents and in Table 3.5 to explore the determinants of producing utility model patents. The key results are highlighted.

Table 3.4: Invention patent binary

		High to low-tech industries			Labour vs. capital industries		Industry dependence on external finance		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	All industries	High-tech	Medium-tech	Low-tech	Labour intensive	Capital intensive	Low dependence	Medium dependence	High dependence
IPR Index									
IPR	0.356***	0.372**	0.588*	0.155	0.252	0.409**	0.474	0.187	0.512***
	(0.133)	(0.169)	(0.333)	(0.284)	(0.222)	(0.166)	(0.552)	(0.199)	(0.187)
FDI Motivation									
Export-oriented FDI	-0.206***	-0.253***	-0.0747*	-0.196***	-0.132***	-0.249***	0.0384	-0.202***	-0.246***
	(0.0216)	(0.0299)	(0.0440)	(0.0445)	(0.0319)	(0.0295)	(0.0843)	(0.0315)	(0.0320)
Absorptive Capacity									
Past dependence (invention)	1.071***	1.029***	1.187***	1.154***	1.176***	1.027***	1.112***	1.117***	1.079***
	(0.0291)	(0.0364)	(0.0584)	(0.0719)	(0.0473)	(0.0359)	(0.121)	(0.0431)	(0.0380)
R&D intensity	0.0992***	0.101***	0.0927***	0.0946***	0.0929***	0.102***	0.103***	0.0880***	0.101***
	(0.00346)	(0.00415)	(0.00865)	(0.00961)	(0.00670)	(0.00410)	(0.0152)	(0.00530)	(0.00472)
Distance to frontier	-0.452***	-0.372***	-0.205	-0.818***	-0.559***	-0.328***	-0.347	-0.206	-0.581***
	(0.0938)	(0.123)	(0.194)	(0.218)	(0.153)	(0.119)	(0.336)	(0.138)	(0.136)
Labour quality	0.0283***	0.0234***	0.0229***	0.0404***	0.0321***	0.0246***	0.0385***	0.0271***	0.0280***
	(0.00372)	(0.00489)	(0.00846)	(0.00794)	(0.00595)	(0.00478)	(0.0135)	(0.00533)	(0.00556)
Training intensity	0.0234***	0.0151**	0.0303**	0.0442***	0.0355***	0.0166**	0.0445**	0.0212***	0.0222***
	(0.00527)	(0.00660)	(0.0123)	(0.0125)	(0.00908)	(0.00648)	(0.0211)	(0.00769)	(0.00758)
Firm Performance									
Profitability	0.362***	0.356***	0.481***	0.255	0.341**	0.379***	0.188	0.624***	0.215**
	(0.0754)	(0.0931)	(0.175)	(0.192)	(0.133)	(0.0919)	(0.325)	(0.121)	(0.100)
Sales share	-0.104	-0.120	0.312	-0.288	-0.000999	-0.0850	0.190	-0.153	-0.0676
	(0.109)	(0.151)	(0.227)	(0.241)	(0.168)	(0.144)	(0.352)	(0.167)	(0.161)
Market Structure									
CR	0.824***	0.848**	0.785	0.882	0.546	0.917**	2.448***	-0.0739	1.527***
	(0.299)	(0.422)	(0.768)	(0.551)	(0.435)	(0.413)	(0.885)	(0.462)	(0.507)
CR_square	-0.444	-0.687	-1.098	0.153	0.239	-0.849	-1.567	0.199	-1.795
	(0.739)	(1.049)	(2.199)	(1.157)	(1.013)	(1.030)	(1.516)	(1.224)	(1.256)
Knowledge Stock									
Patent per graduate	0.506	0.706	1.989**	-1.776**	-0.0927	0.820*	0.677	-0.0673	0.970*
	(0.384)	(0.498)	(0.844)	(0.883)	(0.623)	(0.490)	(1.620)	(0.564)	(0.556)
Control Variables									
Log employees	0.152***	0.181***	0.158***	0.0903***	0.123***	0.179***	0.110***	0.180***	0.141***
	(0.0109)	(0.0143)	(0.0244)	(0.0247)	(0.0180)	(0.0140)	(0.0415)	(0.0167)	(0.0155)
Age	-8.82e-05	-0.00213	-0.00135	0.00753**	0.00311	-0.00177	0.00199	0.000245	-0.000954
	(0.00145)	(0.00188)	(0.00330)	(0.00324)	(0.00240)	(0.00183)	(0.00526)	(0.00210)	(0.00213)

Province, industry, year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
lnsig2u	-1.576***	-1.437***	-2.195***	-1.818***	-2.055***	-1.408***	-1.562***	-2.113***	-1.485***
	(0.0991)	(0.117)	(0.315)	(0.268)	(0.218)	(0.113)	(0.370)	(0.219)	(0.127)
Observations	297,254	119,806	57,519	119,929	169,348	127,906	53,555	139,714	103,985
Number of firms	82,624	35,596	17,623	34,659	48,382	37,875	16,410	41,915	31,063

Notes: (1) Panel Probit random effect regression estimation is used and marginal effects are presented. The dependent variable equals to 1 if a foreign firm has a grant invention patent, 0 if it has no invention patent. The past dependence variable equals to 1 if a foreign firm has a grant invention patent in any of the previous years, and 0 if it has no invention patent in all of the previous years. Province, industry and year dummies are included in all estimations. All explanatory variables (except firm age, province, industry and year dummies) are lagged one year. (2) Significance levels: *0.10; **0.05; ***0.01. (3) Herfindahl index is used as an alternative measure of the market structure. The results are consistent with that using concentration ratio (CR).

The first notable finding is that better IPR protection not only encourages innovation in general, it also promotes the production of the most novel innovation captured by invention patent. Different from the literature which does not distinguish innovation types (Lerner, 2009), this result stresses the importance of IPR protection in stimulating the most innovative type of patents.

Interestingly, there is limited support for a non-linear relationship between invention patent production and market structure, different from the results demonstrated in Table 3.3. It suggests that it is in more concentrated markets that foreign firms tend to produce the most innovative types of patents. Particularly, such relationship is the most prominent in high-tech and capital-intensive industries, and industries more dependent on external finance. I interpret it as in these industries foreign firms are more likely to enjoy ownership advantages in terms of rich knowledge pool and capital resources. More monopoly power incentivised them to utilise such advantages and produce high quality innovation. The result provides empirical evidence for the theoretical framework proposed by Sanna-Randaccio and Veugelers (2007) that MNEs' R&D decentralisation is more profitable when the local competition in a host country is sparse.

Another key finding is that closeness to technology frontier is essential for generating high quality innovation especially in high-tech industries and industries that are the most dependent on external finance. This highlights the importance of technology capability of foreign firms in determining their innovation activities in host countries.

Moreover, compared with the effect of knowledge stock on patenting reported in Table 3.3, this factor turns out to be insignificant in Table 3.4. It reveals that while locating in provinces that are endowed with more knowledge stock encourages foreign firms to patent in general, it has little effect on the most innovative type of patents.

3.5.3 Utility model patent

Table 3.5: Utility model patent binary

		High to low-tech industries			Labour vs. capital industries		Industry dependence on external finance		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	All industries	High-tech	Medium-tech	Low-tech	Labour intensive	Capital intensive	Low dependence	Medium dependence	High dependence
IPR Index									
IPR	0.137	0.201	0.0261	0.114	0.0759	0.184	0.390	0.0448	0.223
	(0.111)	(0.145)	(0.253)	(0.250)	(0.181)	(0.143)	(0.550)	(0.164)	(0.161)
FDI Motivation									
Export-oriented FDI	-0.111***	-0.213***	0.0260	-0.0250	-0.0192	-0.206***	-0.120*	-0.0308	-0.212***
	(0.0168)	(0.0231)	(0.0343)	(0.0348)	(0.0250)	(0.0228)	(0.0663)	(0.0247)	(0.0247)
Absorptive Capacity									
Past dependence (Utility model)	1.255***	1.237***	1.259***	1.353***	1.294***	1.233***	1.426***	1.257***	1.238***
	(0.0175)	(0.0218)	(0.0352)	(0.0433)	(0.0283)	(0.0216)	(0.0817)	(0.0259)	(0.0236)
R&D intensity	0.0830***	0.0838***	0.0839***	0.0813***	0.0829***	0.0840***	0.0720***	0.0802***	0.0865***
	(0.00300)	(0.00355)	(0.00764)	(0.00897)	(0.00607)	(0.00350)	(0.0150)	(0.00487)	(0.00402)
Distance to frontier	-0.135*	-0.0713	-0.0900	-0.564***	-0.285**	-0.0813	-0.523*	-0.220**	-0.106
	(0.0728)	(0.0976)	(0.142)	(0.175)	(0.118)	(0.0952)	(0.297)	(0.112)	(0.104)
Labour quality	0.0224***	0.0243***	0.0105	0.0274***	0.0204***	0.0241***	0.0158	0.0213***	0.0203***
	(0.00329)	(0.00435)	(0.00726)	(0.00713)	(0.00528)	(0.00424)	(0.0124)	(0.00487)	(0.00493)
Training intensity	0.00417	0.00310	0.00113	0.0227**	0.0102	0.00401	0.0347*	-0.00299	0.0113*
	(0.00449)	(0.00560)	(0.0104)	(0.0109)	(0.00780)	(0.00551)	(0.0195)	(0.00676)	(0.00637)
Firm Performance									
Profitability	0.282***	0.307***	0.210	0.217	0.232**	0.305***	0.284	0.219**	0.324***
	(0.0627)	(0.0791)	(0.136)	(0.161)	(0.107)	(0.0779)	(0.304)	(0.0977)	(0.0860)
Sales share	0.351***	0.357***	0.381*	0.0380	0.178	0.358***	0.626*	0.152	0.363***
	(0.0906)	(0.125)	(0.200)	(0.201)	(0.146)	(0.120)	(0.320)	(0.137)	(0.138)
Market Structure									
CR	1.792***	1.878***	1.637**	2.743***	2.521***	1.781***	1.680**	1.990***	1.733***
	(0.279)	(0.368)	(0.698)	(0.570)	(0.461)	(0.362)	(0.845)	(0.420)	(0.426)
CR_square	-3.955***	-3.848***	-5.551***	-4.678***	-5.605***	-3.623***	-1.261	-4.557***	-3.519***
	(0.730)	(0.931)	(2.138)	(1.505)	(1.311)	(0.915)	(1.692)	(1.143)	(1.085)
Knowledge Stock									
Patent per graduate	0.984***	1.651***	0.452	-0.270	0.0722	1.654***	-0.524	0.656	1.527***
	(0.293)	(0.384)	(0.630)	(0.662)	(0.468)	(0.378)	(1.289)	(0.432)	(0.425)
Control Variables									
Log employees	0.134***	0.122***	0.179***	0.111***	0.145***	0.124***	0.176***	0.156***	0.120***
	(0.00877)	(0.0114)	(0.0197)	(0.0201)	(0.0146)	(0.0111)	(0.0372)	(0.0139)	(0.0124)
Age	-0.00375***	-0.00358**	-0.00588**	-0.00125	-0.00513**	-0.00292*	-0.00464	-0.00342*	-0.00325*
	(0.00128)	(0.00165)	(0.00285)	(0.00295)	(0.00215)	(0.00161)	(0.00493)	(0.00189)	(0.00188)

Province, industry, year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
lnsig2u	-1.570***	-1.516***	-1.758***	-1.766***	-1.728***	-1.516***	-1.758***	-1.771***	-1.412***
	(0.0643)	(0.0804)	(0.149)	(0.173)	(0.112)	(0.0793)	(0.325)	(0.111)	(0.0814)
Observations	297,254	119,806	57,519	119,929	169,348	127,906	53,555	139,714	103,985
Number of firms	82,624	35,596	17,623	34,659	48,382	37,875	16,410	41,915	31,063

Notes: (1) Panel Probit random effect regression estimation is used and marginal effects are presented. The dependent variable equals to 1 if a foreign firm has a grant utility model patent, 0 if it has no utility model patent. The past dependence variable equals to 1 if a foreign firm has a grant utility model patent in any of the previous years, and 0 if it has no utility model patent in all of the previous years. Province, industry and year dummies are included in all estimations. All explanatory variables (except firm age, province, industry and year dummies) are lagged one year. (2) Significance levels: *0.10; **0.05; ***0.01. (3) Herfindahl index is used as an alternative measure of the market structure. The results are consistent with that using concentration ratio (CR).

The key result in Table 3.5 is that there is little effect from IPR protection on utility model (UM) patent production. The most likely explanation is that UM patents generally aim to improve the practical use of products. They may be more related to local customer needs and preferences, and foreign firms' experience of serving the host country. Therefore, IPR protection may not have apparent effect on it.

Another interesting finding is that while firms' sales share in the market does not seem to contribute to the overall patent production as shown in Table 3.3, it has strong effect on promoting UM patenting activities. This suggests that having larger market share helps foreign firms become more experienced in serving the local market, have better understanding of the local demand patterns and engage in product adaptation. This effect again is the most important in high-tech and capital-intensive industries.

3.6 Conclusions

Chapter 3 aims to contribute to the understanding of foreign firms' patenting activities in emerging countries using a large linked dataset for China during 2001-2008. It is found that business environment in terms of protecting intellectual property rights (IPR), FDI motivation and access to external finance are important drivers of foreign firms patenting activities. Better IPR protection stimulates not only patent production in general, but also the production of the most innovative type of patents.

In addition, FDI motivation has important implications for the patenting behaviour of foreign firms. Different from what has been found by the literature for developed countries (Ito and Wakasugi, 2007), in an emerging host country, export-oriented FDI is more likely to be efficiency-seeking and is less likely to innovate and patent compared with domestic market-seeking FDI. This is because the former is likely to employ more standardised technologies in low production cost locations, while the latter tends to involve leveraging ownership advantages from parent firms to expand market in host countries, and conducting innovation activities.

Furthermore, foreign firms are more likely to patent in high-tech, capital-intensive industries, and industries that are more dependent on external finance. This could be because (1) these industries are more likely to be penetrated by foreign firms, and (2) foreign firms are less financially constrained in these industries because they may have access to external finance from parent firms.

Chapter 3 also finds that firms with better absorptive capacity are more likely to innovate. For example, firms which have successfully produced patents are more likely to produce patents in the future. More internal R&D investment is positively related to higher probability of patenting.

Chapter 3 contributes to the understanding of foreign firms' patenting in emerging host countries in several ways. Firstly, it has highlighted the importance of business environment for innovation from the perspective of institutional theory. This chapter specifically focuses on the effect of IPR protection on innovation. I propose an innovative approach to capture how well patents are protected at regional level. This is among the few attempts to examine the relationship between IPR protection and innovation by foreign firms. While the existing literature tends to examine the effect of IPR protection on innovation at macro level and have reported mixed findings, this chapter provides micro-level evidence of this relationship in different industries and for different types of innovation. It shows that better IPR protection not only attract firms to patent, but also to produce the most innovative type of patents. This positive relationship is strong in technology-intensive and capital-intensive industries.

Secondly, chapter 3 links innovation with industry dependence on external finance. Previous studies have stressed the importance of financial development for industry growth, and how financial constraints will affect innovation. They find that financial development disproportionally encourage industry growth in industries that are more dependence on external finance, and financial constraints can hinder innovation. Linking financial market development, industry dependence on external finance and innovation, chapter 3 suggests that as China has inefficient financial market, foreign firms which enjoy financial ownership advantages are more likely to penetrate and innovate in industries that are more dependent on external finance.

Thirdly, this empirical work extends the R&D internationalisation literature by (1) examining the determinants of innovation output (captured by grant patent) rather than input (such as R&D investment) which is widely investigated by the literature, and by (2) making a clear distinction between different types of innovation output (invention patents and utility model patents). Given that the innovation literature suggests that the drivers of innovation input are different from the drivers of innovation output (Lover, Roper and Bryson, 2011), it is important to distinguish these influencing factors to have a thorough understanding of R&D internationalisation.

Fourthly, chapter 3 highlights the links between FDI motivation and foreign firm patenting in an emerging economy context. The findings emphasise the importance of domestic market-oriented FDI for patenting, suggesting they types of FDI that emerging host countries should attract. This finding is in contrast to the existing studies which argue that export-oriented foreign firms are more innovative than domestic market-oriented ones. This is because the former are international market looking, and are capable to serve a wider range of markets.

In policy terms chapter 3 has two main implications. First, local market-oriented foreign firms are more likely to innovate and patent, providing greater potential for technology transfer to indigenous firms, while export-oriented efficiency-seeking FDI may have limited potential for technology transfer. It is therefore important to understand the heterogeneous FDI motivation, their technology endowment and innovation potential in an emerging host country. Second, the fact that foreign firms innovate in industries where domestic firms are likely to have difficulties in financing innovation raises the question of the extent to which domestic sectors are deprived of innovation potential that would have been better if the financial system would be more efficient.

Chapter 3 has some limitations that may be addressed by future research. First, this study only distinguishes between efficiency-seeking and market-seeking FDI. It is interesting to examine other FDI motivation. Given that foreign firms which engage in different activities such as sales agency, distribution, manufacturing and R&D may have different motives, it is interesting to examine the linkages between foreign firm innovation and other FDI motives. Second, chapter 3 reveals that

having access to external finance is an important ownership advantage for foreign firms to innovate, it is important to understand the differences between domestic and foreign firms, as well as heterogeneous drivers of innovation by domestic and foreign firms. This issue is critical for technology upgrading in emerging economies. Finally, it could be fruitful to examine foreign firms' patenting behaviour in other emerging countries to check whether or not the findings reported in chapter 3 are robust across countries.

CHAPTER 4: INNOVATION SPILLOVERS FROM INWARD FOREIGN DIRECT INVESTMENT: A GRANTED PATENT APPROACH

4.1 Introduction

The theoretical basis for believing that FDI contributes to technological development and productivity growth in host countries is grounded in Dunning's (1979) paradigm of firm specific advantages, and the extent to which these are transferred from home to host country through their embodiment in FDI flows. This in turn has led to a burgeoning literature seeking to determine the scale and scope of this typically by focusing on productivity (growth) (Gorg and Strobl, 2001; Irsova and Havranek, 2013).

However, it is often the case that the direct indicators of technology transfer are rather confused in the literature with "spillovers" — that is the informal transfer of technology from inward investors to host country firms. As is widely understood, there are many reasons for why inward investment may act to increase productivity in domestic sectors, including demand effects, labour mobility between firms, training, competition effects, linkages, capital deepening and upgrading, and finally externalities in technology or productivity. Many of these effects are often labeled as spillovers, or discussed within the spillovers literature, often because the empirical approach is unable to distinguish between these effects (Driffield and Jindra, 2012). The purpose of chapter 4 is to suggest a solution to this problem.

Despite the theoretical framework regarding how domestic firms can benefit from spillovers, there has always been controversies in the empirical studies surrounding whether or not such effects take place (see surveys such as Blomstrom and Kokko, 1998; Gorg and Greenaway, 2004; Smeets 2008). Drawing from the literature, I posit that the mixed findings are partly due to the indirect methodology linking productivity with FDI. The challenge lies in capturing knowledge flows by productivity measures, the way it is estimated and the variety of the influencing factors (MacGarvie, 2006). Typically the literature seeks to infer the impact from FDI on productivity of local firms as technological benefits. However, productivity growth could be the result of non-technological factors such as having access to better quality inputs which improves the overall efficiency of production.

Innovation, on the other hand, is a more direct way to capture learning (Salomon and Shaver, 2005). The rationale is that firms produce innovation by exploiting externally sourced knowledge and combining it with internal knowledge. Such innovation, especially the one that has been codified into products or processes, will result in improved productivity eventually (Roper, Du and Love, 2008).

Chapter 4 therefore seeks to further the understanding of technology spillovers between inward investors and host country firms by focusing on innovation directly rather than through the indirect lens of productivity. Spillover effects seem to be more discernible in direct technological improvement in terms of innovation than productivity. Chapter 4 also seeks to expand the rather new literature that focuses on spillovers in innovation, which hitherto has been limited to intra-sector effects (see for example Hu and Jefferson, 2009; Eberhardt, Helmers and Yu, 2012).

Chapter 4 contributes to the literature in four ways. First, it employs innovation (measured by granted patents) rather than productivity to directly capture the technological benefits from inward FDI. This is the key because productivity growth could be the result of pecuniary externalities from FDI which have little to do with technology (Castellani, 2012). Second, chapter 4 examines vertical spillovers in addition to horizontal spillovers. Even though the existing studies have attempted to look for innovation spillovers, they still stress the intra-sector (horizontal) effect. Ignoring vertical channels could prevent the technological benefits from being revealed. Third, while the literature that examines productivity spillovers from FDI tends to fail to find any spillovers from forward linkages with FDI (Kugler, 2006), this chapter suggests that the most advanced firms can benefit from forward FDI to produce more invention patents, providing empirical support for the FDI spillover channels framework. Last but not least, the data used in this empirical work distinguish patents that are of different levels of technology contents. Invention patents are the most novel and creative type of patents, and embed knowledge and technologies that are new to the world. Utility model patents aim to improve the practical use of products. The findings show that there are heterogeneous spillover effects on different type of patents, depending on firms' absorptive capacity. The most advanced firms with high absorptive capacity can receive innovation spillovers from horizontal and vertical FDI to produce the most innovative patents. By contrast, less technologically advanced firms with less absorptive capacity

mainly receive innovation spillovers from backward linkages with FDI, in that FDI help them overcome the hurdle of obtaining utility patents.

The empirical analysis of chapter 4 draws on a linked data by linking two rich firm level datasets from China. It provides a rich platform to study technology transfer from inward FDI for two reasons. First, MNEs have expanded their penetration in China considerably in the last three decades. China is now the second largest FDI recipient in the world, reaching 121 billion US dollars at the end of 2012 (UNCTAD, 2013). Its vast geographic coverage and the gradual and stepwise opening to FDI allow regional heterogeneity in attracting and nurturing inward investment, which creates a natural rich laboratory to study technology transfer.[11] In the meantime, improving technological competence has always been the main motive behind the long-standing FDI policy in China. In the context of the evident economic slowdown after three decades of fast growth (Du, Liu and Zhou, 2014), innovation plays a crucial role in sustaining the future economic growth. Patent applications in China have surged since the introduction and revision of the China's Patent Law.[12] Appendix 4 presents an introduction to the patent law in China. The period of the soaring patenting is adjoined with the large inflow of FDI in China, although the empirical links between the two phenomena have been largely overlooked.

The reminder of chapter 4 is structured as follows. Section 4.2 reviews literature on spillovers and recent development of spillover studies. Section 4.3 introduces the data and summary statistics. Section 4.4 presents the empirical model and variables. Section 4.5 discusses the findings and section 4.6 concludes.

4.2 Literature Review

The existing literature has identified the main channels through which FDI spillovers occur, including

[11] FDI in China is characterised by an uneven regional distribution (Du and Girma, 2007). However, a large amount of recent FDI inflows are seen to be directed to the central and western regions from previously concentrated coastal regions, mainly seeking more favourable investment conditions (UNCTAD, 2009).

[12] China's Patent Law was introduced in 1985 and has been revised three times in 1992, 2000 and 2009 (Liegsalz and Wagner, 2013). The lasted revision involves considerable changes aiming to provide more effective patent rights protection, to reconcile with international development, and to encourage innovation and patent applications (IPR2, 2010).

demonstration effect, labour turnover, training and vertical linkages with FDI. I propose that a more direct output of technological improvement is host country innovation. Productivity performance does not include all innovation or necessarily generate innovation output. Improvement of productivity may be the result of pecuniary externality rather than technology transfer (Castellani, 2012). Moreover, innovation, especially that codified into products or processes, represents new offerings to the market and will be eventually reflected in productivity (Roper, Du and Love, 2008). Firms which can combine external and internal learning are found to achieve high level of innovative capability such as to implement innovative activities, to develop competitive advantages based on innovation, and to catch up with global leaders in introducing innovative products (Figueiredo, Cohen and Gomes, 2013). Innovation is at least as important as the indirect spillovers in terms of productivity (Garcia, Jin and Salomon, 2013).

4.2.1 Intra and inter-industry productivity spillovers

This section discusses the studies that explain how intra and inter-industry spillovers take place. There are several reasons to expect that foreign presence will increase productivity of domestic firms. On average, MNEs tend to use advanced technologies more intensively than domestic firms (Driffield and Taylor, 2005). The potential users of knowledge in a particular location have an incentive to source the technology and other advantages that accompany FDI. Being exposed to the advanced technologies employed by MNEs, local firms can update production methods (Barrios and Strobl, 2002), imitate and reverse engineer products produced by MNEs (Saggi, 2002), and apply better management practices and organisational innovations. The scope of demonstration effects depends on the complexity of the products and production processes. The simpler the manufacturing processes are, the easier it is for local firms to imitate (Gorg and Greenaway, 2004).

Another channel of technology transfer takes place via labour mobility. MNEs generally have superior technologies to the domestic firms in host countries. They provide employees with more intensive training and work experience than indigenous firms do (Smeets, 2008). Fosfuri, Motta and Ronde (2001) model how technologies can be transferred when workers who have been trained by

MNEs are employed by local firms later. The model shows that technologies are expected to be transferred if the labour turnover rate is high and local firms are not in fierce competition with MNEs. Empirical evidence shows that the transferred knowledge and technologies could be confined to the local firms operating in the same industry as the MNEs (Gorg and Strobl, 2005). Filatotchev, Liu, Lu and Wright (2011) show that returnee entrepreneurs have generated spillovers to other local firms in science park to generate innovation.

With regard to spillovers via vertical linkages with FDI, MNEs have incentives to prevent knowledge leaking to local competitors, nevertheless, they have motivation to transfer technology to local suppliers in order to reduce input costs and increase product quality (Javorcik, 2004). Rather than transferring knowledge to a single supplier, diffusing to multiple suppliers can create diverse supply sources of improved inputs at lower prices for MNEs (Blalock and Gertler, 2008). Such knowledge could take a variety of forms such as training employees, quality control, delivery, and process technologies (Blalock and Simon, 2009). Lall (1980) identifies that local suppliers of MNEs can receive transferred knowledge such as technical assistance, training, management and operation. Suppliers may be forced to meet higher standards set by MNEs such as quality control and reliable delivery (Javorcik, Keller and Tybout, 2008). In addition, the demand for intermediate inputs from downstream sectors increases due to the entry of foreign firms. Local suppliers could reap the benefits of economies of scale and product prices will be lower. Local firms competing with MNEs in the same downstream industry can also benefit from lower input costs (Rodriguez-Clare, 1996).

Technology transfer also takes place where, following the entry of MNEs, local firms have access to a variety of inputs with technical complexity (Markusen and Venables, 1999). In addition, better complementary services by MNEs could also be available so that the qualities of final products of indigenous firms can be improved (Javorcik, 2004). Forward linkages may promote local firms to adopt new technologies and solve contract implementation problems (Gow and Swinnen, 1998). As manufacturers in less developed countries tend to lack the ability to achieve economies of scale and therefore lack the motivation to invest heavily on R&D, purchasing innovative inputs from MNEs is a way to launch innovative products (Javorcik, Keller and Tybout, 2008).

4.2.2 Intra-industry innovation effect

Foreign firms' innovation stimulates innovation of local competitors (Javorcik, Keller and Tybout, 2008). The entry of MNEs could encourage domestic firms to pursue more radical innovation to protect market share (Zhou and Li, 2012). Frequent introduction of new technologies by MNEs creates competition encouraging domestic firms to adopt innovation at higher pace. This is because domestic firms will use innovation to defend their market share after the entry of MNEs, or they are more motivated to do reverse engineering (Blomstrom and Kokko, 1998; Blomstrom, Globerman and Kokko, 1999). Hallin and Lind (2012) show that the competitive pressure from MNEs encourages domestic firms to generate new products. Aghion et al. (2009) find that the threat of MNEs entry will spur innovation of firms that are close to the technology frontier, but will decrease innovation of technological laggards.

In addition, domestic firms can benefit from innovation spillovers through developing business networks with MNEs (Li, Chen and Shapiro, 2010). Employee movement is an important channel of knowledge flowing from MNEs to local firms and this process usually involves more tacit and embedded knowledge diffusion (Spencer, 2008). It is reasonable to argue that apart from productivity augmentation, tacit knowledge embedded in employees is intrinsically important for technology transfer and to generate innovation output. This is supported by empirical findings of Liu et al. (2010), and Filatotchev et al. (2011).

To sum up, the literature suggests that innovation spillovers from inward FDI (captured by foreign capital participation) could occur through demonstration and competition effects, augmented by training and labour mobility between MNEs and indigenous firms. Accordingly, I propose:

Hypothesis 1 (H1): FDI is positively related to innovation of domestic firms within the same sector.

There is nascent literature on innovation spillovers from inward FDI (Hu and Jefferson, 2009; Wang and Kafouros, 2009; Yueh, 2009; Li, Chen and Shapiro, 2010; Garcia, Jin and Salomon, 2013). The main limitation of these studies is that vertical channels have been largely overlooked.

Nevertheless, the existing spillovers literature suggests that vertical linkages are very important conduits for technology transfer (Havranek and Irsova, 2011).

4.2.3 Inter-industry linkages with MNEs

Although MNEs try to protect their knowledge from leaking to competitors in host countries, domestic firms along the value chain could have more opportunities to learn from MNEs, because MNEs could receive benefits from transferring knowledge to indigenous suppliers and buyers (Javorcik, 2004). Diffusing knowledge to multiple suppliers can create diverse supply sources of improved inputs at lower prices for MNEs. Empirical evidence suggests that MNEs help domestic firms improve product quality, productivity, process technologies, delivery, as well as offer technical assistance, training, management and operation advice (Brash, 1966; Lall, 1980; Hobday, 1995; Javorcik, Keller and Tybout, 2008; Blalock and Simon, 2009).

Focusing now on innovation, communicating with MNEs in downstream sectors may improve innovation performance of domestic suppliers (ie. backward linkages with FDI). MNEs may provide information that is complementary to suppliers' knowledge pool. Suppliers can also have a better understanding of customer needs and refine products to generate innovation (Shaw, 1994). When Proctor & Gamble launched a new detergent in Mexico, local chemical firms are encouraged to develop new inputs. MNEs may engage small-scale local suppliers to be more efficient and innovative (Javorcik, Keller and Tybout, 2008). Furthermore, interactions with foreign buyers helps local firms create new marketing practices and obtain product details that are important for building innovation abilities (Figueiredo, Cohen and Gomes, 2013).

Turning to the communication between local buyers and foreign suppliers (ie. forward linkages with FDI), local firms can have access to a variety of inputs with technical complexity (Markusen and Venables, 1999; Javorcik, 2004). The forward linkages may encourage domestic firms to adopt new technologies and solve contract implementation problems (Gow and Swinnen, 1998). As manufacturers in less developed countries tend to lack the ability to achieve economies of scale and

incentive to invest in R&D, having access to more innovative inputs from foreign suppliers is a way to update final products (Javorcik, Keller and Tybout, 2008).

More importantly, in developing countries where firms tend to launch products with incremental improvement, technology transferred from MNEs in supplying sectors is important for domestic manufacturers to access innovation and produce technologically complex products (Javorcik, Keller and Tybout, 2008). Training from foreign suppliers enhances local firms' abilities to innovate such as training to introduce technical and organisational innovation, product design and development (Figueiredo, Cohen and Gomes, 2013). I therefore propose:

Hypothesis 2 (H2): FDI is positively related to innovation of domestic firm in vertically related sectors

4.2.4 Strength of spillovers

Furthermore, the magnitude of the spillovers from backward and forward linkages with FDI may vary. The existing literature finds that linkages back up the supply chain (backward linkage with FDI) appear to lead to greater spillovers than that from vertical linkages down the value chain (forward linkages with FDI). For example, Javorcik (2004) and Kugler (2006) observe positive spillovers from backward linkages with FDI but no spillovers from forward linkages in Lithuania and Colombia, respectively. In a meta-analysis, Havranek and Irsova (2011) summarise that productivity spillovers from vertical linkages are significant, but the magnitude is larger from backward FDI than from forward FDI.

There are three possible reasons to explain the differences in the magnitude of vertical FDI spillovers. First of all, FDI into emerging or developing countries are likely to be export-oriented efficiency-seeking (Blalock and Gertler, 2008). These MNEs do not tend to serve domestic customers in host countries. Hence, the linkages between domestic buyers and foreign suppliers are weak and domestic firms may have few opportunities to learn. Second, domestic buyers can have access to a variety of inputs from foreign suppliers to upgrade final produces. However, for the buyers that have limited absorptive capacity or not motivated to innovate, they are not likely to receive technology

benefits from the forward linkages with FDI. On the contrary, domestic suppliers can have strong incentives to improve efficiency and upgrade technologies in order to win contracts from MNEs. For instance, domestic suppliers in Mexico need to be able to cope with low profit margins because MNEs have strong bargaining power to drive down prices (Javorcik, Keller and Tybout, 2008). Third, MNEs that establish forward linkages with local buyers may be motivated by accessing distribution channels in a host country. Domestic firms could receive benefits such as improved revenue and expand firm size due to increased demand (Kubny and Voss, 2014). However, the benefits may not be in terms of training and technical assistance that directly shape domestic buyers' technologies.

Much of the productivity based literature has struggled to show the differences in backward and forward spillovers from FDI. Driffield, Munday and Roberts (2002) and Driffield and Jindra (2012) for example argue that productivity is an extremely imperfect way of capturing this, as increased technological progress in suppliers may encourage the MNEs to drive down prices, thus depressing value-added or output based measures of productivity. I posit however that analysing innovation will generate a clearer distinction between the apparent competing effects one observes in productivity, and the magnitude of backward and forward FDI spillovers may be different.

Hypothesis 3 (H3): Innovation spillovers from FDI are stronger from backward linkages with FDI than from forwards linkages.

4.2.5 Heterogeneous innovation

The technological contents of innovation are heterogeneous. For example, with regard to patents in China, invention patents have the highest level of novelty and practicality, and they are the most technologically complicated innovation, followed by utility model patents and external design patents (Li, 2012). However, the existing literature does not distinguish between different forms of innovation or patenting, despite the nascent literature on innovation spillovers from FDI. These studies either pool all patents together (Fu, 2008; Hu and Jefferson, 2009) or only examine the production of one particular type of patents (Li, 2009, 2011). The next hypothesis therefore seeks to advance this literature, from the perspective of absorptive capacity. The existing literature highlights the importance

of firms' absorptive capacity which is determined by prior innovation investment and practices (Cohen and Levinthal, 1990; Crespo and Fontoura 2007; Li, 2011). Firms with better absorptive capacity can better explore and utilise external knowledge in order to launch innovation. Park and Ghauri (2011) find that for small and medium-sized firms, the absorptive capacity of local firms such as human capital endowment, willingness and efforts to learn is important to absorb technologies from MNEs. Similar results are also reported by Junni and Sarala (2013) for Finland firms, Hamida and Gugler (2009) and Hamida (2013) for Swiss firms. Furthermore, Blalock and Simon (2009) find that the magnitude of FDI spillovers via backward linkages with foreign buyers is heterogeneous for local suppliers. Firms with higher absorptive capacity can benefit productivity spillovers from backward linkages with MNEs the most. Miozzo and Grimshaw (2008) report that for service firms in Argentina and Brazil, the absorptive capacity of local buyers are important for them to internalise knowledge from foreign suppliers via forward linkages. Recent meta-analysis by Meyer and Sinani (2009) also confirms the importance of absorptive capacity in utilising FDI spillovers to boost productivity. I therefore hypothesise that only the most technologically advanced firms will create invention patents, and that in general inward investment will not push firms over the hurdle to become invention patentees in the absence of sufficient absorptive capacity. By contrast, for firms with sufficient absorptive capacity, innovation spillovers will help them to innovate even more.

Hypothesis 4a (H4a): Innovation spillovers increase the intensity of invention patent production among the most advanced firms, but do not influence the propensity of producing invention patents.

In contrast, patents with less technological contents, such as utility model patents, require lower levels of absorptive capacity. Inward investment may act to increase the propensity to create utility patents. The literature on the importance of knowledge from backward linkages with foreign buyers is instructive for chapter 4. Knowledge absorbed by local suppliers could take a variety of forms such as training employees, quality control, delivery, and process technologies (Blalock and Simon, 2009). MNEs may provide information that is complementary local suppliers' knowledge. Suppliers can also have a better understanding of customers' needs and refine products to generate innovation (Shaw, 1994). Such literature indicates that it is the buyer-supplier link from inward investors to local firms

that stimulates utility types patenting, because the inward investment can encourage local suppliers to improve the practical use of products and to overcome the hurdle to become patentees. I therefore propose that technology transfer between inward investors and domestic suppliers will lead to an increase in the propensity of those suppliers taking out utility patents, in order to protect innovation.

Hypothesis 4b (H4b): Backward linkages with FDI increase the probability of domestic firms taking out utility model patents, but do not increase the intensity of producing such patents.

4.3 Data

The empirical analysis of chapter 4 is based on a linked data generated from linking two large rich firm level datasets from China. The first dataset is the Annual Report of Industrial Enterprise Statistics maintained by the National Bureau of Statistics (NBS) of China, which has been widely used in Chinese firm level studies (Du and Girma, 2007; Brandt, Van Biesebroeck and Zhang, 2012). The NBS data cover the population of state-owned enterprises and all non-state firms with an annual turnover of over five million Renminbi yuan (about 600,000 US dollars). The firms in the dataset account for about 85-90% of total output in most industries reported in the national aggregate annual statistics. It includes information on firms' financial information, R&D expenditure, export, capital and ownership structure. The second dataset is the population of granted patents registered by the State Intellectual Property Office (SIPO) of China. It provides detailed information on both applied patents and granted patents. Since there is no existing firm level patent data covering a large population of firms in China, I link the two datasets over the period of 2001 to 2008 based on the identifications of firm and legal person, as well as location and time of observation. This dataset allows me to link domestic firms' innovation output and inward FDI, which has not been done before at the firm level covering a long time period. Appendix 3 presents a report with details of how the two datasets are linked.

Patents as a way of measuring innovation output have both advantages and disadvantages. On the one hand, criticisms argue that not all innovation is patentable, that the quality and economic values of patents vary greatly (Griliches, 1990), and sometimes firms protect their innovation by secrecy and

lead time rather than filing patent applications (Cohen, Nelson and Walsh, 2000). On the other hand, patents possess the advantage of capturing embodied technologies more directly, compared with productivity and other measures of innovation which can be determined by non-technological factors. Patenting can protect valuable innovation and generate profits. Therefore, they have economic values (Hall et al., 2013). This explains why patents are widely adopted as measures of tangible innovation output. In addition, Hussinger (2006) reports that keeping innovative secrets internally may be important at an early stage of innovation development, but does not seem to contribute to commercial performance. She finds that firms with patents have better innovation performance in terms of turnovers from new products than firms that do not have patents and keep the innovation in secrecy.

Both patent application records and granted patents are available in the linked data. However, following Acs, Anselin and Varga (2002) and Sun and Du (2010), I prefer using patent counts that have been granted to a firm in a given year as the dependent variable instead of patent application counts because the former indicates higher innovation quality. Obtained patent counts present the authenticity of innovation where the holding firm has legal rights and could receive economic benefits (Filatotchev et al., 2011).

China's Patent Law classifies three types of patents reflecting different levels of technological contents. An invention patent is a technical scheme for products or methods which have high novelty, creativity and practicality. Invention patent applications are required by the law to go through a complicated examination by the SIPO before granting a patent. A utility model (UM) patent is a new technical proposal regarding a product's shape and/or structure in order to improve its practical use. An external design patents is the design in shape, pattern, colour or the combination of them in a product (Eberhardt, Helmers and Yu, 2012). To decide whether or not to grant a UM or an external design patent, the SIPO usually checks the completeness of application files and ensure that the innovation has not been patented before (Liegsalz and Wagner, 2013). I exclude external design patents in chapter 4 analysis and only focus on the first two types of patents which have the most technological contents.

The linked data maintain three critical advantages in terms of the sample coverage, the patent measures, and the data quality. First, the firm level patent data reflect the most novel and innovative patenting activities of the majority of Chinese industrial firms in the most recent years. This allows me to capture the crystallised effects in technology improvement as a result of FDI. Second, the firm-level patent information in the linked data provides more accurate account of the patent output of Chinese firms than what has been previously achieved by aggregate level patent data either at industry or province level. Different types of patent applications cannot be distinguished because the aggregate level patent data pool all types of applications together. Apart from industrial firms, there are also a large proportion of domestic individuals, research institutes, higher education institutions, and other organisations apply for and obtain patents. Isolating manufacturing firms from other applicants is important to avoid overestimating innovation performance of firms. Third, the linked data are of high quality as they are fairly closed to the official data documented in the literature. A data quality report is presented in Appendix 3.

After carefully cleaning the data, 995,757 observations for 339,636 domestic Chinese firms have been identified over the period 2001-2008 that have the necessary information for econometric estimations. Table 4.1 has three panels. Panel A gives the summary statistics of three patent dummy variables based on the regression sample used for the econometric analysis. There are 3.3% of firms have grant patents, either invention patents or UM patents, or both. There are 1.5% of firms have invention patents in the sample and 2.4% firms have UM patents. Panel B gives the summary of patent counts among firms that have patents. On average, firms have 3 patents regardless of patent types, ranging from 1 to 357 patents. Average invention and UM patent counts are 2.3 and 2.8, respectively. The maximum UM patent count is higher (301) than invention patent count (141). Panel C gives the summary statistic of all the variables used in the econometric estimations.

Table 4.1: Definition and summary statistics of variables

Panel A: regression sample					
	Definition	**Mean**	**S.D.**	**Min**	**Max**
Grant patent dummy	1 if a firm has a grant patent (either invention or utility patent, or both), 0 if it has no patents	0.033	0.179	0	1
Grant invention dummy	1 if a firm has a grant invention patents, 0 if has no invention patent	0.015	0.121	0	1
Grant UM dummy	1 if a firm has a utility model patent, 0 if has no utility model patent	0.024	0.153	0	1
Panel B: among firms that have patents in the regression sample					
Grant patent counts	The number of grant patents (the sum of invention and utility model patents)	3.072	7.700	1	357
Grant invention patent counts	The number of grant invention patents	2.306	4.066	1	141
Grant UM patent counts	The number of grant utility model patents	2.817	6.928	1	301
Panel C: variables in the model in the regression sample					
	Definition	**Mean**	**S.D.**	**Min**	**Max**
Dependent Variables					
Grant patent counts	Granted patent counts (the sum of invention and utility model patents)	0.102	1.505	0	357
Grant invention counts	Granted invention patent counts	0.034	0.568	0	141
Grant UM counts	Granted utility model patent counts	0.068	1.156	0	301
Independent Variables					
Technology Transfer					
Horizontal FDI	Horizontal FDI in 3-digit industry *j* province *r* at time *t* (*jrt*)	0.196	0.174	0	0.985
Forward FDI	Forward FDI in 3-digit industry *j* province *r* at time *t* (*jrt*)	0.098	0.147	0	1.746
Backward FDI	Backward FDI in 3-digit industry *j* province *r* at time *t* (*jrt*)	0.069	0.070	0	0.526
Firm Resources					
R&D intensity	R&D expenditure per hundred employees in logarithm form	0.571	1.615	0	11.043
Exporter	1 if a firm is an exporter, 0 otherwise	0.199	0.400	0	1
State share	State capital share of a firm	0.066	0.239	0	1
Distance to frontier	Distance to technology frontier: (Maximum TFP in industry *j* province *r* at time *t* – firm TFP)/Maximum TFP in *jrt*	0.261	0.120	0	0.648
Industry Characteristics					
Sales share	Sales share in province industry year	0.018	0.074	0	1
Herfindahl	Normalised Herfindahl index	0.052	0.098	0	1
Additional Variables in the Inflation Estimation					
Subsidy intensity	Government subsidies per hundred employees in logarithm form	0.713	1.885	0	10.870
Training intensity	Training expenditure per hundred employees in logarithm form	1.142	1.502	0	8.864

Firm Characteristics					
Log emp	Number of employees in logarithm form	4.663	1.033	1.946	7.698
Age	Firm age	11.660	10.463	1	52
Coastal	1 if a firm is in coastal region of China, 0 otherwise	0.718	0.450	0	1
Central	1 if a firm is in central region of China, 0 otherwise	0.190	0.393	0	1
West	1 if a firm is in western region of China, 0 otherwise	0.091	0.288	0	1
Observations	995,757				

Notes: (1) The statistics are based on the linked data I have constructed from two data sources: the National Bureau of Statistics and the State Intellectual Property Office of China. (2) Panel A presents the summary statistics of three patent dummy variables based on the sample used in the econometric analysis. Panel B shows the patent counts summary statistics among the firms that have patents. Panel C shows the summary statistics of the variables used in the regression sample.

Table 4.2: Correlation matrix

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
(1) Grant patent dummy	1															
(2) Grant invention dummy	0.762	1														
(3) Grant UM dummy	0.911	0.426	1													
(4) Horizontal FDI	0.017	0.013	0.015	1												
(5) Forward FDI	-0.006	-0.001	-0.007	0.316	1											
(6) Backward FDI	0.026	0.012	0.028	0.743	0.200	1										
(7) R&D intensity	0.123	0.103	0.106	0.024	-0.050	0.049	1									
(8) Exporter	0.052	0.036	0.049	0.098	-0.022	0.104	0.097	1								
(9) State share	0.009	0.008	0.007	-0.085	-0.074	-0.065	0.042	-0.037	1							
(10) Distance to frontier	-0.076	-0.059	-0.068	0.119	0.087	0.099	-0.185	-0.083	0.041	1						
(11) Sales share	0.045	0.039	0.038	-0.117	-0.077	-0.098	0.108	0.021	0.123	-0.376	1					
(12) Herfindahl	0.012	0.013	0.009	-0.143	-0.118	-0.149	0.069	-0.071	0.197	-0.169	0.665	1				
(13) Subsidy intensity	0.046	0.041	0.039	-0.008	0.003	0.000	0.132	0.042	0.039	-0.102	0.056	0.023	1			
(14) Training intensity	0.052	0.041	0.047	-0.038	-0.037	-0.017	0.275	0.067	0.050	-0.143	0.069	0.031	0.136	1		
(15) Log emp	0.085	0.065	0.078	-0.065	-0.103	-0.049	0.167	0.241	0.121	-0.425	0.200	0.052	0.097	0.130	1	
(16) Age	0.028	0.020	0.026	-0.062	-0.043	-0.031	0.082	0.040	0.363	-0.063	0.098	0.121	0.073	0.096	0.272	1

4.4 Model

This section first presents the basic model specification and variable definitions. It then discusses the potential econometric issues and the estimation strategies, and finally highlights issues of interpreting the results.

4.4.1 Empirical model

To examine innovation spillovers from inward FDI in China on innovation output among domestic firms, a count outcome model of grant patents is set up, following Hall, Griliches and Hausman (1986). Assuming patent production follows a Poisson process:

$$E(Y_{ijrt}) = \mu_{ijrt} = \exp(X'_{ijrt}\beta)$$

$$\Pr(Y_{ijrt} = y_{ijrt}) = \exp(-\mu_{ijrt})\,{\mu_{ijrt}}^{y_{ijrt}}/y_{ijrt}! \quad \text{for } y = 0, 1, 2, \ldots \quad (1)$$

where the dependent variable μ_{ijrt} is the expected grant patent counts of domestic Chinese firm *i* in 3-digit industry *j* in province *r* at time *t*. It takes non-negative integer values. Three measures of dependent variables are empirically tested, closely related to each other but also reflect patent production of different quality: (1) the number of total patents, (2) the number of invention patents, and (3) the number of utility model (UM) patents. *X* is a vector of three sets of variables that are postulated to affect patent production, including technology transfer variables, firm resources and control variables. Details of how the variables included in *X* are presented in Appendix 2. In order to mitigate potential endogeneity, explanatory variables are one-year lagged, except for the technology transfer variables which are 3-year lagged. Current values of firm age, industry and year dummies are employed in all estimations.

4.4.2 Technology transfer variables

The main interests of chapter 4 are the variables which capture the technology transfer from MNEs to domestic firms. Within the same industry (ie. horizontal FDI), higher MNEs penetration can stimulate higher innovation of domestic firms. Competition from MNEs encourages domestic firms produce

new products (Hallin and Lind, 2012). MNEs trained employees who move to work in local firms can transfer tacit knowledge to local firms to generate innovation (Liu, et al, 2010). A standard measurement of horizontal FDI is employed which is the foreign capital participation in 3-digit industry *j* in province *r* at time *t*.

In addition, vertical linkages with MNEs are important channels for domestic firms to receive technological benefits. Indigenous firms may acquire knowledge from foreign buyers (ie. backward linkages with FDI) in the form of employees training and quality control, which increases their abilities to launch innovation (Blalock and Simon, 2009). For domestic buyers, foreign suppliers (ie. forward linkages with FDI) offer a wide range of inputs, providing them with more opportunities to take advantage of technologies and thus inspire innovation (Javorcik, Keller and Tybout, 2008). To capture the potential communication between foreign buyers and domestic suppliers, backward linkages with FDI is measured by the share of output purchased by foreign buyers from domestic suppliers in an upstream industry. Forward linkages with FDI are measured by the share of input purchased by domestic buyers from upstream foreign suppliers. The information used to construct backward and forward FDI variables is from the 2007 Input-Output Table of China published by the National Bureau of Statistics which is the most recent version. The table gives the proportion of goods sold from one industry to other industries (3-digit). The higher the proportion of goods purchased from or supplied to domestic suppliers or customers by MNEs, the greater the degree of linkages between MNEs and domestic firms, and the more knowledge could be acquired by domestic firms. Details of how the technology transfer variables are constructed are available in Appendix 2.

4.4.3 Firm resources

Resource-based view has highlighted the importance of firms' internal resources for developing competitive advantages and producing innovation (Terziovski, 2010). Firms endowed with stronger resources are more capable to transform knowledge into innovation output (Roper, Du and Love, 2008). Four variables are employed to capture different aspects of firm resources. As an important input of innovation, R&D investment improves firms' abilities to absorb and apply knowledge from

external sources (Cohen and Levinthal, 1989). R&D intensity is used which is measured by R&D expenditure per hundred employees.

Endogenous innovation and growth theories predict that being exposed to overseas markets helps a firm acquire new knowledge that can build new value-creating skills and augment existing capability (Romer, 1990). Exporters can access knowledge that may not be available in the domestic market and produce more innovation (Salomon and Shaver, 2005). I therefore control for export status which enters the model as an export dummy.

State capital is employed in the model for two reasons. First of all, previous studies for China have found that a certain level of state capital can enhance firms' performance (Cai and Tylecote, 2008; Choi, Lee and Williams, 2011). Firms' connections with the government are advantageous for them to engage in innovation in an underdeveloped financial market like China. Government may provide these firms with business connections and facilitates access to external finance. The second reason stems out of the recent observations that state-owned firms in China may have been particularly encouraged by the state to innovate and push up the patent registration records (Li, 2011). State capital share is measured by the share of state capital in total capital of a firm.

Furthermore, firms need a minimum level of absorptive capacity to internalise external knowledge (Cohen and Levinthal, 1989). Following Aghion at el. (2005), distance to technology frontier is used and proxied as the difference between a firm's total factor productivity (TFP) and the highest TFP level in a 3-digit industry *j* in province *r* at time *t*. As productivity shocks will induce profit-maximising firms to change their inputs, productivity is likely to be correlated with inputs. Levinsohn and Petrin (2003) suggest a way to control for this potential correlation between firm level input and unobserved firm-specific productivity shocks. This method is widely used in the literature (Du and Girma, 2010) and this chapter adopts this method to construct TFP.

4.4.4 Control variables

The industrial organisation literature has a long tradition of modelling the important role of industry

structure in determining innovation (Schumpeter, 1934). Motivated by larger and stable profit, more monopoly power could encourage innovation (Romer, 1990), or reversely highly concentrated markets may also discourage innovation due to lack of competition pressure (Arrow, 1962). Market structure and a firm's position in competition are controlled for by using two variables. A firm's market share is measured by the share of a firm's sales to total sales of all firms in province *r*, industry *j* at time *t*. Herfindahl index is used to capture market concentration, which is the sum of squares of sales shares of all firms in 3-digit industry *j* at time *t* (Castellacci, 2011).

Firm age and size are included in the model as control variables which are expected to deliver positive signs. Older and larger firms are on average more innovative according to the literature (Atkeson and Kehoe, 2005). I also include regional and industry dummies in all estimations to control for any time-invariant heterogeneity related to regional and industrial characteristics that may affect firms' innovation within each group homogeneously. Year dummies are included to control for any macroeconomic condition, national regulation and policy changes.

4.4.5 Econometric issues and interpretations

The nature of the dependent variable being patent counts leads to several options of nonlinear models. The most commonly used model is Poisson model, although there are two issues that can prevent Poisson from generating efficient estimations. First, Poisson distribution assumes the conditional mean of the expected count being equal to its conditional variance. In practice though, the variance often exceeds the mean leading to the over-dispersion bias. The sample used for chapter 4 displays the exact feature, shown in Table 4.1 Panel C where the standard deviations of different measures of the dependent variables are larger than means. The consequence of applying Poisson estimator in this case is that the standard errors will be under-estimated and the statistical significance will be higher, although the estimation will still be consistent. The second issue is that the Poisson model assumes that all firms try to patent and all firms have positive probability of having patents. However, in reality, some types of firms may never patent because they never innovate.

Zero-Inflated Negative Binomial (ZINB) model, as an alternative to Poisson model, is considered more appropriate. It increases the conditional variance and the probability of zero counts and therefore addresses the over-dispersion bias. It also explicitly assumes that the zero counts have been generated by two different processes by first estimating the probability of having patents (the inflation estimation) and then estimating the predicted patent counts for firms that have positive probability of obtaining patents (the count estimation) (Mullahy, 1986; Lambert, 1992; Long, 1997).

The ZINB model makes an explicit assumption about how the patent decision is determined, which differs the decisions of whether or not to patent, and how much a firm patents. Hence, two additional variables are included in the inflation estimation that may be more important to determine the probability of patenting rather than the magnitude of patenting. One is government subsidy intensity measured by subsidies per hundred employees and the other is labour training intensity measured by labour training expenditure per hundred employees. Firms that have received more subsidies and trained employees more intensively are expected to be more likely to be able to produce patents. They are more likely to access advanced knowledge and are capable to absorb the knowledge to produce innovation (Bauernschuster, Falck and Heblich, 2009; Girma, Gong, Gorg and Yu, 2009).

Beyond the standard way of reporting odds ratios of nonlinear models, it is useful to discuss the interpretation of the two-part results delivered by the ZINB model. Note that when estimating the probability of obtaining patents in the inflation estimation, ZINB actually estimates the likelihood of not possible to have any patents. So an odds ratio in the inflation estimation should be interpreted in the opposite direction from what one does in a standard probability function (based on a Probit or Logit model for example). Thus an odds ratio of less than 1 means higher probability of patenting as the explanatory variable increases. In the count estimation, the interpretation is the opposite from the inflation estimation. An odds ratio of greater than 1 means higher expected patent counts as the explanatory variable increases.

4.5 Findings

This section presents estimations for the production of all patents in Table 4.3, followed by discussions about the production of invention patents and utility mode (UM) patents in Table 4.4 and Table 4.5. The technology transfer variables (horizontal and vertical FDI) are lagged three years. Current values for firm age, industry and year dummy variables are employed in all estimations. The rest of the explanatory variables are one-year lagged to mitigate the potential endogeneity problem. The consistency of the estimation results are checked using lagged one and two years technology transfer variables and the findings do not change with lag length much.

4.5.1 All patents

Table 4.3: All patents

	Count Estimation		**Inflation Estimation**	
	Odds ratio	Robust Std. Err.	Odds ratio	Robust Std. Err.
Technology Transfer				
Horizontal FDI	1.267	0.227	0.818	0.137
Forward FDI	1.062	0.157	0.831	0.114
Backward FDI	2.376 **	1.010	0.105 ***	0.042
Firm Resources				
R&D intensity	1.079 ***	0.007	0.722 ***	0.007
Exporter	1.088 *	0.052	0.602 ***	0.027
State share	0.994	0.101	1.477 ***	0.131
Distance to frontier	0.241 ***	0.051	7.171 ***	1.414
Industry Characteristics				
Sales share	3.283 ***	0.923	3.641 ***	1.150
Herfindahl	0.466 ***	0.122	0.144 ***	0.045
Firm Characteristics				
Log emp	1.507 ***	0.044	0.799 ***	0.020
Age	0.994 ***	0.002	1.000	0.002
Coastal	1.058	0.093	0.758 ***	0.061
Central	1.041	0.102	1.053	0.090
Subsidy intensity			0.905 ***	0.005
Training intensity			0.900 ***	0.007
Industry dummies	Yes			
Year dummies	Yes			
Likelihood	-109716.2			
Number of firms	320,688			
Observations	995,757			

Notes: (1) The dependent variable is the sum of invention and utility model patent counts that have been granted to a domestic firm. The two types of patents are pooled together to examine the production of patents without distinguishing patent types. (2) Odds ratios from Zero-Inflated Negative Binomial model estimation are reported. The standard errors are robust and clustered by firm ID. (3) Note that the interpretation of the two-part estimations are different. In the inflation estimation, if an odds ratio is smaller than 1, it means an increase in the explanatory variable increases the probability of having patents. In the count estimation, if an odds ratio is larger than 1, it means an increase in the explanatory variable increases the expected patent counts for firms that have positive probability of producing patents. (4) Technology transfer variables are three-year lagged. The consistency of the results is checked using lagged one and two years technology transfer variables and the results are similar. I prefer using further lags for FDI variables for practical administrative purposes. This is the case for Table 4.4 and Table 4.5. (5) Significance levels: *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Pooling invention and UM patent counts together, the estimation for innovation spillovers from FDI is presented in Table 4.3. The most notable result is the strong evidence that domestic firms receive innovation spillovers from backward linkages with FDI, supporting Hypothesis 3.

More specifically, the odds ratios of backward FDI is smaller than 1 in the inflation estimation and larger than 1 in the count estimation. It means that selling a higher proportion of products to MNEs in the downstream sectors will make domestic suppliers to be more likely to have patents on average, and for firms that have positive probability of producing patents, they can produce even more patents. This result is consistent with Havranek and Irsova (2011) that spillovers from backward linkages are strong. The local suppliers may have adopted advanced production methods and have incentive to innovate in order to meet the high requirements for products established by MNEs (Javorcik, 2004).

Other explanatory variables also show interesting patterns. R&D intensity highlights the importance of internal R&D efforts in producing innovation. Higher internal R&D expenditure intensity increases the likelihood of having patents and also augments patent production intensity. This confirms the dual role of R&D: to produce new knowledge and to enhance firms' abilities to absorb and exploit existing knowledge (Cohen and Levinthal, 1989; Griffith, Redding and van Reenen, 2004; Fu, 2008).

In addition, exporters have higher probability to produce patents and they can produce more patents than non-exporters, ceteris paribus, showing evidence of learning-by-exporting effect (Alvarez

and Lopez, 2005). Being exposed to international competition provides firms with new opportunities to learn than staying in domestic markets. Involving in a diversity of countries, technologies, culture and foreign markets can improve firms' abilities to absorb and utilise external knowledge (Zahra, Ireland and Hitt, 2000; Salomon and Shaver, 2005; Greenaway and Kneller, 2007).

Turning to the effect of state capital, higher state share will make domestic Chinese firms less likely to patent, indicating that SOEs could be less motivated to engage in innovation. The most likely explanation is that higher state control could prioritise other political goals rather than pursuing profit maximising and firms are less motivated to monitor managers, leading to deteriorated firm performance (Dewenter and Malatesta, 2001; Choi, Lee and Williams, 2011).

In addition, firms closer to the technology frontier in the industry are more likely to have patents and they tend to have higher quantity of patents, ceteris paribus. It confirms the results of Girma (2005) that technology leaders have better innovation performance. This is an important result in the context of an emerging country. Although this contrast the findings of Blalock and Gertler (2009) that technology laggards in Indonesia experience positive productivity spillovers from FDI, I suggest that while firms with larger technology gap may have wider space to improve efficiency and productivity at an early stage of technology catch-up, they need to be innovative and productive enough to be able to transform knowledge into innovation such as patents.

Market structure plays an important role in shaping innovation production. Consistent with Blundell, Griffith and van Reenen (1999), higher sales share in the industry encourages patent producers to obtain more patents. This indicates that firms that possess larger market share could have higher profit to do innovation and obtain patents. Also, more concentrated markets increases the propensity of producing patents, in line with Schumpeter (1934) and his supporters' view that monopoly power increases the expected return from R&D. Hence, firms are more likely to innovate in more concentrated markets. As expected, receiving more general production subsidies and training labour more intensively will increase the likelihood of having patents, as shown in the inflation estimation.

To sum up, domestic firms receive backward spillovers from FDI to produce patents. More internal R&D effort, closeness to technology frontiers and exporting experience will make firms more likely to innovate in terms of higher probability of obtaining patents and produce patents more intensively. It suggests that firms may consider combining foreign knowledge acquired from MNEs and exporting with internal innovation efforts in order to launch innovation.

4.5.2 Invention patents

Table 4.4 and Table 4.5 compare innovation spillovers from inward FDI across different types of patents. The same model specification is used to examine what determines invention and UM patent production, respectively.

Table 4.4: Invention patents

	Count Estimation		**Inflation Estimation**	
	Odds ratio	Robust Std. Err.	Odds ratio	Robust Std. Err.
Technology Transfer				
Horizontal FDI	1.854 ***	0.401	0.756	0.162
Forward FDI	1.424 **	0.241	1.014	0.153
Backward FDI	5.300 ***	3.305	1.073	0.604
Firm Resources				
R&D intensity	1.095 ***	0.011	0.747 ***	0.008
Exporter	1.013	0.068	0.638 ***	0.040
State share	1.044	0.132	1.325 **	0.147
Distance to frontier	0.281 ***	0.097	12.506 ***	3.912
Industry Characteristics				
Sales share	1.987	0.831	1.602	0.656
Herfindahl	1.097	0.451	0.565	0.230
Firm Characteristics				
Log emp	1.581 ***	0.065	0.865 ***	0.031
Age	0.991 ***	0.002	0.999	0.002
Coastal	0.795 *	0.099	0.533 ***	0.057
Central	0.822	0.105	0.837	0.092
Subsidy intensity			0.884 ***	0.006
Training intensity			0.902 ***	0.010
Industry dummies	Yes			
Year dummies	Yes			
Likelihood	-53871.04			
Number of firms	320,688			
Observations	995,757			

Note: (1) The dependent variable is invention patent counts that have been granted to a domestic firm. (2) Odds ratios from Zero-Inflated Negative Binomial model estimation are reported. The standard errors are robust and clustered by firm ID. The interpretation of the odds ratios is the same as that in Table 4.3. (3) Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Table 4.4 provides evidence of innovation spillovers from both horizontal and vertical FDI, supporting Hypothesis 1 and Hypothesis 2. Interestingly, the firms that have positive probabilities of producing invention patents can produce higher quantity of such patents with the help of inward FDI. However, FDI does not seem to encourage a wider range of firms to overcome the hurdle of becoming an invention patentee, supporting the Hypothesis 4a. I interpret it as invention patent producers may have better absorptive capacity and are best placed to absorb and utilise knowledge from FDI to produce patents. Only the firms with the best absorptive capacity can utilise knowledge from MNEs in the same sector as well as MNEs along the value chain.

The result is consistent with the conclusion of Hu and Jefferson (2009) that domestic firms receive technology spillovers from horizontal FDI. However, it affords an interesting contrast with the findings of Garcia, Jin and Salomon (2013) using Spanish firms who do not observe any innovation spillovers from horizontal FDI. The likely explanation of this is that MNEs in China are embodied with advanced technologies. Therefore, more opportunities could be available for the domestic firms to learn and patent with deepened penetration of MNEs.

Another key result is the importance of knowledge acquired from forward linkages with FDI in producing more invention patents, which is often not observed in productivity approach spillover studies (Bwalya, 2006; Kugler, 2006). Contrary to the finding of Girma and Gong (2008) that SOEs in China lack vertical linkages with foreign firms, I posit that domestic Chinese firms, both SOEs and non-SOEs, could receive technology spillovers from foreign suppliers to produce patents. The spillovers appear to be prominent when using the direct output of technological improvement captured by innovation rather than productivity.

Last but not least, for the best firms that can produce the most novel type of patents (invention), exporting experience does not seem to increase patent intensity. Firms need to have close linkages

with MNEs suppliers and buyers, and have strong internal resources in order to produce the most innovative patents.

4.5.3 Utility model patents

Compared with invention patents, UM patents aim to make products more practical by modifying shape and/or structure of products. They are not as drastic innovation as invention patents. This section investigates innovation spillovers on UM patent production. Odds ratios are reported in Table 4.5.

Table 4.5: Utility model patents

	Count Estimation		**Inflation Estimation**	
	Odds ratio	Robust Std. Err.	Odds ratio	Robust Std. Err.
Technology Transfer				
Horizontal FDI	0.885	0.150	0.798	0.147
Forward FDI	1.124	0.165	0.869	0.135
Backward FDI	1.858	0.708	0.039 ***	0.016
Firm Resources				
R&D intensity	1.060 ***	0.008	0.745 ***	0.007
Exporter	1.137 **	0.063	0.614 ***	0.032
State share	0.976	0.128	1.469 ***	0.162
Distance to frontier	0.187 ***	0.048	3.924 ***	0.945
Industry Characteristics				
Sales share	3.777 ***	1.249	3.455 ***	1.346
Herfindahl	0.245 ***	0.081	0.069 ***	0.030
Firm Characteristics				
Log emp	1.429 ***	0.048	0.750 ***	0.022
Age	0.995 **	0.002	1.001	0.002
Coastal	1.073	0.113	0.777 **	0.076
Central	1.125	0.128	1.055	0.104
Subsidy intensity			0.922 ***	0.006
Training intensity			0.903 ***	0.008
Industry dummies	Yes			
Year dummies	Yes			
Likelihood	-81104.52			
Number of firms	320,688			
Observations	995,760			

Notes: (1) The dependent variable is utility model patent counts that have been granted to a domestic firm. (2) Odds ratios from Zero-Inflated Negative Binomial model estimation are reported. The standard errors are robust and clustered by firm ID. The interpretation of the odds ratios is the same as that in Table 4.3. (3) Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

The most important finding is that unlike the production of invention patents, the main innovation

spillover effect is that FDI leads to higher probability of obtaining UM patents for firms in the industries that have more communication with MNEs in downstream industries, supporting Hypothesis 4b. These firms may have less absorptive capacity than invention patentees, but FDI still push them over the hurdle to become patent producers. Taken together the results in Table 4.4 and Table 4.5, I propose that the best firms can efficiently seek and absorb knowledge from various channels linking with MNEs to produce the most innovative types of patents. They could be more experienced in absorbing and internalising knowledge and more efficient in transferring knowledge into innovation than UM patentees.

To sum up, although there are several attempts to examine innovation spillovers from FDI (Garcia, Jin and Salomon, 2013), chapter 4 extends the literature by distinguishing different types of patents that have different levels of technological elements. The findings show that the channels through which domestic firms benefit from innovation spillovers and how much they can benefit is determined by absorptive capacity. The most capable firms tend to acquire technological benefits via all linkages with FDI are capable to produce the most innovative type of patents. In the meantime, less capable firms mainly benefit from buyer-supplier relationship with MNEs and they tend to produce utility patents.

4.6 Conclusions

Chapter 4 contributes to the understanding of technology spillovers from inward FDI to domestic firms in host countries. One of the most important contributions of this study is that it provides direct evidence that domestic firms receive technology spillovers from horizontal FDI and vertical linkages with FDI to produce patents. I propose that using the direct output of technological benefits is important to capture knowledge externalities or innovation spillovers from FDI. Innovation (measured by grant patent counts) rather than productivity performance is employed as the direct output of spillovers from inward FDI. Chapter 4 examines the impact from horizontal FDI and FDI along the value chain, after controlling for firm internal capability, market structure and firm characteristics.

Overall, domestic firms receive technology spillovers from intra and inter industry FDI. The spillovers are the largest from backward FDI linkages compared with that from horizontal and forward FDI linkages.

Chapter 4 extends the spillovers literature by finding that depending on patent types, innovation spillovers from FDI vary due to the heterogeneity of absorptive capacity. The most advanced firms receive innovation spillovers from FDI to produce more intensively the most innovative patents (invention patents). For less advanced firms, their communication with foreign buyers is important to overcome the hurdle to become utility model patentees. The buyer-supplier relationship has stimulated local suppliers to enhance the practical use of their products and enable them to take out utility model patents.

Moreover, looking at internal resources of firms, higher R&D expenditure intensity is very important for higher probability of producing patents as well as producing more patents, regardless of the types of patents. The same pattern is observed for firms that are closer to technology frontiers in the industry. Exporting experience also contributes positively to firms' innovation performance. Together with the innovation spillovers from FDI, I suggest that domestic firms need internal efforts and to be efficient enough to innovate, but this is not their only channel to acquire knowledge and launch innovation. Knowledge from foreign sources such as communication with foreign suppliers and customers, as well as from international markets via exporting, all contribute to improved innovation performance.

In policy terms chapter 4 have two main implications. First, with regard to producing the most technologically complex patents (invention), policymakers probably could initiate policies encouraging a wider range of domestic firms to launch drastic innovation, to develop capability to better absorb FDI knowledge, and to share innovation costs and risks. In China, co-operation between large industrial enterprises still only counts a small fraction of R&D projects (Schaaper, 2009). Second, technologies acquired from foreign suppliers appear to be a less explored source of knowledge. Domestic firms should be more proactive in exploring knowledge from foreign suppliers.

Chapter 4 has its limitations that future research could address. First, it would be interesting to use innovation as the direct output of technological benefits to test whether or not innovation spillovers from FDI take place in other countries, given that the results reported in chapter 4 contrast that of Garcia, Jin and Salomon (2013). Second, as the literature suggests that FDI with different motivation could have different potential to generate technology spillovers in host countries (Driffield and Love, 2007), chapter 4 does not distinguish FDI motivation. It is intriguing to investigate how different FDI motives can shape the potential of innovation spillovers in host countries. Third, the linked data show that there is a non-trivial and growing proportion of foreign firms filing patents in China. Given the relatively underdeveloped institutional environment such as intellectual property rights protection, future research could invest the determinants of patenting activities of foreign firms in host countries, especially in emerging countries.

CHAPTER 5: CONCLUSIONS

5.1 Summary of Findings and Policy Implications

This thesis contributes to the understanding of internationalisation and innovation. It studies three related research questions about how firms internationalise, what makes internationalised firms innovate, and how internationalised firms affect innovation in a host country. This section summarises the main findings for each empirical chapter and explains implications.

In a nutshell, I find that the most efficient firms not only can internationalise, but also are able to source knowledge from foreign countries via strategic asset-seeking FDI. In addition, the predicted exporting-leading-to-conducting-FDI relationship is more related to market-seeking FDI, but not to other types of FDI activities. Moreover, firms' past international experience is important for increasing their international expansion. For instance, serving a wider range of countries and more countries will make firms more likely to conduct FDI.

With regard to the innovation activities of internationalised firms, I find that patenting behaviour of foreign firms is shaped by external business environment and their motivation. First, better institutional factors such as IPR protection encourages foreign firms to innovate, and more importantly, to innovate in high-tech industries and capital-intensive industries. Second, while private local firms may have difficulties accessing external finance to innovate in emerging economies, foreign firms appear to have advantages to innovate, particularly in industries that are more dependent on external finance. This could be because foreign firms have better access to capital through the networks of MNEs' organisations. Third, foreign firms that are driven to explore the domestic market in a host country are more likely to innovate than those efficiency-seeking and export-oriented ones.

The activities of internationalised firms affect local firms via spillover effect. I find that the most advanced domestic firms can benefit from horizontal FDI and vertical linkages with FDI. They become more likely to produce invention patents, and produce more invention patents. Less advanced domestic firms mainly benefit from backward linkages with FDI to become more likely to be

patentees.

5.1.1 Chapter 2 conclusions and implications

Chapter 2 links firms' choice of internationalisation strategies with firm characteristics. The findings highlight the importance of productivity for conducting FDI, especially for conducting strategic asset-seeking FDI. This suggests that knowledge-seeking FDI by emerging market-based firms can enhance their ownership advantages, but that it requires firms to possess a key set of characteristics. They need to have strong internal resources to be able to seek strategic assets via FDI. Chapter 2 also re-states the stepwise internationalisation theory by distinguishing FDI motives. It posits that the predicted exporting leading to doing FDI relationship is more related to engaging in market-seeking FDI, but not to other FDI motives. In addition, it explains the mechanism of how exporting experience can affect firms' FDI strategy. Exporting to more demanding markets and to a variety of destinations allows exporters to access better knowledge and learn to conduct FDI in the future.

Chapter 2 has two practical implications. First, for firms that aim to enhance parent firms' ownership advantages via strategic asset-seeking FDI, they should seek to improve their ownership advantages such as efficiency and profitability to be able to seek and absorb knowledge abroad. Second, more support from the government should be given to private sectors to overcome ownership disadvantages, particularly in an emerging economy context. For example, the government could distribute technology development funding to private firms to improve technology competence. This could improve their abilities to export to more demanding markets, learn more from foreign countries and achieve higher level of internationalisation via FDI.

5.1.2 Chapter 3 conclusions and implications

Chapter 3 examines innovation spillovers from inward FDI and verifies that there are innovation spillovers from FDI received by domestic firms. The spillovers are more discernible from backward linkages with FDI than that from horizontal and forward FDI. In addition, innovation spillovers from FDI are heterogeneous depending on types of innovation and firms' absorptive capability. The most

advanced firms can receive spillovers from more channels (horizontal and vertical FDI) to produce the most innovative innovation (measured by invention patents) and produce such type of innovation more intensively. For less advanced firms, their communication with foreign buyers (backward FDI linkages) helps them overcome the hurdle of becoming utility model patentees, but has no effect on patent intensity. The buyer-supplier relationship has encouraged domestic firms to improve the practical use of their products and obtain utility model patents.

In policy terms, chapter 3 has three main implications. First, domestic firms should combine their internal innovation initiatives with knowledge spilled over from MNEs in order to launch innovation. Second, policymakers should allocate more resources to help domestic firms develop absorptive capacity in order to launch innovation with high level of technological contents. For example, policies could be made to encourage mutual learning between firms, and innovation cooperation to share costs and risks. Third, spillovers from forward linkages with FDI seem to be utilised by only the most advanced firms. Policies should facilitate communication between foreign suppliers and less advanced domestic firms in downstream sectors. For example, foreign firms could engage domestic buyers in training in order to take advantage of new technologies.

5.1.3 Chapter 4 conclusions and implications

Chapter 4 stresses the importance of local intellectual property rights (IPR) protection, FDI motivation and access to external finance for foreign firms to patent in an emerging host country. Specifically, better IPR protection encourages foreign firms to patent, and more importantly, to produce the most innovative type of patents (invention patent). In addition, domestic market-seeking FDI is more likely to produce patents, because it tends to involve leveraging ownership advantages from parent firms to foreign subsidiaries in order to expand market shares in host countries. In contrast, export-oriented efficiency-seeking FDI is not likely to patent, because they are likely to receive more standard technologies from parent firms and locate in low cost production regions. Moreover, foreign firms tend to innovate in industries that are more dependent on external finance. This is because these industries are more likely to be penetrated by foreign firms, as a result of inefficient financial system against

domestic firms in emerging economies. Also, foreign firms may face less financial constraints to innovate in these industries, because they may have access to rich external finance from parent firms.

Three main policy implications emerge from chapter 4. First, it supports the IPR reforms in emerging countries in order to better protect technologies and encourage innovation, especially to boost innovation of foreign investors. Thus, improved IPR protection in emerging countries could help upgrade technologies and innovation systems. Second, it is important to understand the nature of inward FDI. Emerging host countries should seek to attract domestic market-oriented FDI which is more innovative than efficiency-seeking FDI, because the former can produce more innovation and has larger potential for technology transfer to host countries. Third, chapter 4 calls for more financial support for domestic sectors to innovate. Government should provide more resources for domestic firms to launch innovation, especially when innovation could be constrained by the inefficient financial system in emerging countries. Given the importance of domestic sectors in economic development in the long-term, it is crucial to allocate more finance resources to nurture innovation in domestic sectors.

5.2 Theoretical Contributions

This thesis has made several theoretical contributions. First, it proposes a pecking order of firm performance in internationalisation strategy. It shows that only the most productive firms can conduct FDI. Additionally, I propose another pecking order which links firms' internationalisation motivation and their internationalisation strategies. While strategic asset-seeking FDI can help firms acquire knowledge and technologies abroad, not all firms can do so. Only the most efficient firms can seek strategic assets via FDI. Also, the thesis re-examines the stepwise internationalisation theory and suggests that the predicted exporting leading to conducting FDI relationship stands for market-seeking FDI, but not for other FDI motives.

Second, this thesis contributes to the understanding of R&D internationalisation by examining foreign firms' patenting behaviour through the lens of external business environment. It contributes to

the institutional theory with regard to IPR protection by examining the relationship between IPR protection and foreign firms' patenting in different industries and distinguishing different types of patents. Studies linking institutions and innovation tend to employ macro level evidence, whereas this thesis provides micro level support for improving institutions promoting innovation, especially in high-tech industries and capital-intensive industries.

Third, this thesis extends the recent empirical literature that discusses foreign subsidiaries' innovation and motivation in developed countries. This thesis argues that unlike international market-oriented FDI which could be innovative in developed countries, efficiency-seeking export-oriented FDI in emerging economies is not likely to produce patents. In contrast, domestic-market driven FDI are more likely to patent. This is an important finding suggesting that attracting domestic market-seeking FDI could be beneficial for host country innovation.

Fourth, this thesis proposes a more direct way to capture technology spillovers from inward FDI in host countries. The existing literature typically employs a productivity approach. However, there could measurement and estimation problems with the productivity approach. Also, the observed productivity improvement could be the result of pecuniary externalities from FDI which have little to do with technologies. Therefore, the thesis adopts a grant patent approach to directly capture technology benefits from FDI. Additionally, a high quality linked dataset has been generated from the thesis. It contains patent data information of the majority of Chinese industrial firms in the most recent years, and distinguishes patents of different levels of technology contents, which can be used for future research.

5.3 Limitations and Suggestions for Future Research

In this thesis, a number of limitations point to opportunities for future research. This section proposes research questions that could generate fruitful findings.

5.3.1 Chapter 2 limitations and possible future research questions

Chapter 2 links firms' characteristics with their choices of internationalisation strategies. It proposes that internal resources are important for conducting strategic asset-seeking FDI in order to enhance parent firms' ownership advantages. Future research could explore the strategies of how emerging countries-based MNEs can better seek strategic assets via FDI. For example, case studies could be conducted to investigate business models that have been adopted by Chinese firms' investing in R&D facilities in developed countries, innovative methods to facilitate learning, and how the sourced knowledge can be adapted and implemented within its organisation. This would help the emerging market-based MNEs which in general lack ownership advantages form strategies to learn and develop internationally.

In addition, chapter 2 finds that exporting to more developed countries and to a variety of countries helps firms to conduct FDI in the future. It is interesting to study the communication and knowledge exchange between exporters and their business partners in foreign countries in more detail using case studies. Possible research questions could be: what are the channels that exporters can learn from exporting markets, what information can exporters collect from foreign business partners, and to what extent does the knowledge from exporting market contribute to firms' FDI decision, how can exporters establish business networks with foreign partners to conduct FDI in the future.

Third, chapter 2 does not examine the consequence of strategic asset-seeking FDI. It could be fruitful to examine the extent to with the FDI can affect parent firms' ownership advantages, economic performance as a result of high level of internationalisation, as well as whether or not FDI may help firms export to and compete in more demanding markets. These research questions could be addressed by collecting panel data from Chinese firms on their internationalisation strategies, types and scale of FDI, host country features, firm performance and other firm characteristics.

Last but not least, given that there may be reverse causation from exports to productivity, chapter 2 employs a lagged explanatory variable approach to mitigate this potential endogeneity. Future research could employ instrumental variable approach to verify the findings of pecking order I and pecking order II.

5.3.2 Chapter 3 limitations and possible future research questions

Chapter 3 highlights the importance of improved institutional environment, specifically IPR protection, in encouraging foreign firms to patent not only in general, but also in high-tech and capital-intensive industries. How other institutional factors such as government support, regulation quality, laws and corruption can affect foreign firms' innovation are open for future discussion. Future research could link country or industry level data with firm level data to examine the effect of institutions on innovation.

Chapter 3 only distinguishes FDI motivation between export-oriented FDI and domestic market-seeking FDI. It would be interesting to investigate how different FDI motivation can shape foreign firms' innovation. For example, one could collect survey data on FDI motivation such as natural resource-seeking, market-seeking, efficiency-seeking, strategic asset-seeking, foreign firms' innovation input (such as internal and external R&D expenditure) and output (new product, product and process innovation), host country and industry characteristics.

Third, chapter 3 highlights that foreign firms tend to patent in industries that are more dependent on external finance. However, it has not investigated the differences in domestic and foreign firms' innovation behaviour in these industries, to what extent domestic firms' innovation is financially constrained as a result of inefficient financial markets in an emerging economy. Firm level data such as innovation and financial resources could be collected to study these questions.

Fourth, there is new research showing that foreign firms have advantages such as obtaining knowledge from parent firms or internal networks to produce innovation, whereas domestic firms do not have access to such knowledge. However, chapter 3 does not investigate the questions such as the extent to which foreign firms source knowledge from parent firms or foreign subsidiaries in other host countries, and how well such knowledge is employed by foreign firms to produce innovation. These questions are important for host countries to attract the most innovative type of FDI for technology upgrading.

5.3.3 Chapter 4 limitations and possible future research questions

Chapter 4 finds positive innovation spillovers in China, but is running contrary to what has been observed in Spain (Garcia, Jin and Salomon, 2013). Future research should test innovation spillovers in other countries if data are available in order to verify the findings in this chapter. Future research could also study how FDI motivation and different FDI activities can affect innovation spillovers, how FDI from different countries and ownership types can influence FDI spillovers. These questions are important for host countries to evaluate the policies of attracting FDI and help design schemes to better utilise FDI for technology upgrading purposes.

Secondly, chapter 4 does not examine the role of national innovation system in shaping innovation spillovers. It is interesting to study how innovation systems can facilitate technology spillovers from FDI. Possible research questions could be how political system, legal system, industry regulations, financial market development, infrastructure and public spending can promote domestic sectors to obtain technology spillovers from FDI. This question is important for governments to design strategies and nurture an environment that favours technology transfer from inward FDI.

In addition, case studies are needed to explore specific channels through which domestic firms establish networks with MNEs, how they obtain knowledge and technologies from MNEs, especially via vertical linkages, how domestic firms build up abilities to learn from different sources of knowledge and innovate. These questions could be useful to help managers learn from other firms' experience in upgrading innovative capabilities.

Thirdly, chapter 4 stresses the importance of absorptive capacity in obtaining innovation spillovers. Question remains in terms of how domestic sectors can improve their absorptive capacity. This research question is important as high absorptive capacity would not only promote domestic firms learning from FDI through a wider range of channels, but also help these firms produce better quality innovation.

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APPENDICES

Appendix 1: Additional summary statistics

Appendix Table 1.1: Summary statistics by export destinations

	Export to other countries		**Export to the richest countries**	
	Observations		Observations	
Exporting only firms	176	77.9 %	325	62.3 %
Exporting and FDI firms	50	22.1 %	197	37.7 %
Total	226	100 %	522	100 %
	Mean	**Std. Dev.**	**Mean**	**Std. Dev.**
Number of destinations	2.814	1.552	3.998	1.732
Performance				
Labour productivity	4.159	0.801	3.950	0.805
ROA	0.064	0.056	0.071	0.056
Resources				
Has patents	0.571	0.496	0.648	0.478
Gov subsidy	0.080	0.220	0.069	0.197
Reformed	0.279	0.449	0.331	0.471
Technology level				
Int'l leading	0.031	0.174	0.048	0.214
Domestic advanced	0.566	0.497	0.563	0.496
Types of FDI activities				
Manufacturing	0.058	0.235	0.059	0.235
Sales agency	0.170	0.377	0.315	0.465
R&D centre	0.018	0.133	0.067	0.249
Natural resources	0.013	0.115	0.025	0.158
Contracting for construction	0.000	0.000	0.018	0.132
Control variables				
Log emp	7.188	1.103	7.455	1.038
Age	14.796	11.798	16.318	11.359

Notes: (1) The richest countries are defined the same way as that in Table 2.1. These countries have real GDP per capita within the top 10 percentile distribution of real GDP per capita of all the countries, including Australia, Austria, Belgium, Canada, Denmark, Finland, Ireland, Japan, Kuwait, the Netherlands, New Zealand, Norway, Sweden, Switzerland, United Kingdom, the United States. (2) Appendix Table 1.1 shows that 522 firms are able to export to the richest countries, while 226 firms only export to the other countries. The proportion of firms that export and conduct FDI is higher (37.7%) among firms exporting to the richest countries than the proportion (22.1%) among firms that can only export to other countries. For firms that can export to the riches countries, they have higher number of export destinations than that of firms only exporting to other countries.

Appendix Table 1.2: Summary statistics by types of FDI activities

	Manufacturing		**Sales agency**		**R&D centre**		**Natural resources**		**Contracting construction**	
	Obs		Obs		Obs		Obs		Obs	
FDI only	10	8.9 %	33	7.2 %	14	14.1 %	10	21.3 %	25	35.2 %
FDI and exporting	102	91.1 %	425	92.8 %	85	85.9 %	37	78.7 %	46	64.8 %
Total	112	100 %	458	100 %	99	100 %	47	100 %	71	100 %
	Mean	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
Performance										
Labour productivity	4.26	0.93	4.17	0.90	4.16	0.80	4.66	0.92	3.87	0.87
ROA	0.07	0.06	0.07	0.06	0.09	0.07	0.07	0.06	0.06	0.05
Resources										
Has patents	0.86	0.35	0.76	0.43	0.86	0.35	0.66	0.48	0.80	0.40
Gov subsidy	0.09	0.18	0.11	0.24	0.13	0.30	0.06	0.14	0.04	0.18
Reformed	0.29	0.46	0.33	0.47	0.32	0.47	0.30	0.46	0.54	0.50
Technology level										
Int'l leading	0.17	0.38	0.09	0.29	0.17	0.38	0.13	0.34	0.03	0.17
Domestic advanced	0.40	0.49	0.54	0.50	0.45	0.50	0.49	0.51	0.61	0.49
Export destinations										
Export to the richest countries	0.61	0.49	0.72	0.45	0.72	0.45	0.57	0.51	0.38	0.50
Number of destinations	3.41	2.18	3.60	2.01	3.62	2.37	2.29	1.90	2.08	2.61
Control variables										
Log emp	8.28	1.18	7.72	1.13	8.11	1.07	7.68	1.27	8.88	1.40
Age	18.74	12.00	17.88	11.75	16.44	9.19	17.60	14.30	27.76	15.99

Appendix 2: Methods of constructing variables

(1) Horizontal FDI:

$$Horizontal\ FDI_{jrt} = [\sum_{i\ for\ all\ i \in jrt} Foreign\ share_{ijrt} * Sales_{ijrt}] \Big/ \sum_{i\ for\ all\ i \in jrt} Sales_{ijrt}$$

where *Foreign share*$_{ijrt}$ is the share of foreign capital to total capital of firm *i* in (3-digit) industry *j* in province *r* at time *t*, and *Sales*$_{ijrt}$ is industry sales value of firm *i* in (3-digit) industry *j* in province *r* at time *t*.

(2) Backward FDI:

$$Backward\ FDI_{jrt} = \sum_{for\ all\ k\ if\ k \neq j} \alpha_{jk} * Horizontal\ FDI_{krt}$$

where α_{jk} is the proportion of output supplied by industry *j* to industry *k*.

(3) Forward FDI:

$$Forward\ FDI_{jrt} = \sum_{m\ if\ m \neq j} \delta_{jm} * [\frac{[\sum_{i\ for\ all\ i \in m} Foreign\ share_{imrt} * (Sales_{imrt} - Export_{imrt})]}{\sum_{i\ for\ all\ i \in m}(Sales_{imrt} - Export_{imrt})}]$$

where δ_{jm} is the share of inputs purchased by industry *j* from industry *m* to total inputs purchased by industry *j*. Sales and export are industry sales value and sales from export of firm *i* in a 3-digit industry *m* in province *r* at time *t*.

(4) Distance to Technology Frontier:

$$Distance\ to\ technology\ frontier_{ijrt} = (Max\ TFP_{jrt} - TFP_{ijrt}) / Max\ TFP_{jrt}$$

where *TFP*$_{ijrt}$ is total factor productivity of firm *i* in a 3-digit industry *j* in province *r* at time *t*. TFP is constructed using the method proposed by Levinsohn and Petrin (2003). *Max TFP*$_{jrt}$ is the highest TFP of all firms in industry *j* in province *r* at time *t*.

(5) Sales Share in the Market:

$$Sales\ share_{ijrt} = Sales_{ijrt} \Big/ \sum_{i \in jrt} Sales_{ijrt}$$

where $Sales_{ijrt}$ is industry sales value of firm *i* in industry *j* province *r* at time *t*.

(6) Concentration Ratio (CR):

$$\mathrm{CR_{jt}} = \sum_{\mathrm{i=1}}^{4} \mathrm{s_i}$$

where s_i is the sales share of the four largest firms in terms of sales in 3-digit industry *j* at time *t*.

(7) Herfindahl Index:

$$\text{Normalised Herfindahl}_{\mathrm{jt}} = (\mathrm{N} * \mathrm{S_{jt}} - 1) \Big/ (\mathrm{N} - 1)\,, \text{ where } \mathrm{S_{jt}} = \sum_{\mathrm{i \in jt}} \mathrm{s_i}^2$$

where *N* is the number of firms in industry *j* in year *t*. s_i is the market share of firm *i* in 3-digit industry *j* at time *t* (Jacob and Meister, 2005).

(8) Labour quality (measured by wage):

$$\mathrm{Wage_{ijrt}} = (\mathrm{Wage_{ijrt}} - \mathrm{Mean\_wage_{jrt}})/\mathrm{Mean\_wage_{jrt}}$$

where $Mean\_Wage_{ijrt}$ is the average wage of all firms (including domestic and foreign firms) in industry *j* in province *r* at time *t*.

Appendix 3: Data quality report

Description of the Two Data Sources

Two datasets are linked to generate a new dataset that has patent information at firm level, such as whether or not a firm has any patents, types of patents, and patent counts. The first dataset is called the Annual Report of Industrial Enterprise Statistics collected from the National Bureau of Statistics of China (NBS). It is a panel dataset covering all state-owned and above-scale firms that have an annual turnover above five million Renminbi yuan (about 600,000 US dollars) in manufacturing industries. The firms in the survey account for about 85-90% of total output in most industries. The data include information on ownership, industry, location, value added, capital, number of employees and sales from new products. The linked data contain 2,107,722 observations for 625,226 firms during 2000-2008. The graph below shows the distribution of the linked data.

```
      id:  1, 2, ..., 625226                              n =     625226
    year:  2000, 2001, ..., 2008                          T =          9
           Delta(year) = 1 unit
           Span(year)  = 9 periods
           (id*year uniquely identifies each observation)

Distribution of T_i:   min      5%     25%       50%       75%     95%     max
                         1       1       1         3         5       9       9
```

Freq.	Percent	Cum.	Pattern
106164	16.98	16.98	1
61371	9.82	26.80	11111
46211	7.39	34.19	11
36285	5.80	39.99	111
33637	5.38	45.37	111111111
33295	5.33	50.70	1........
22606	3.62	54.31	1111
20237	3.24	57.55	....1....
19730	3.16	60.70	...111111
245690	39.30	100.00	(other patterns)
625226	100.00		XXXXXXXXX

The second data are extracted from a CD-ROM developed by the State Intellectual Property Office of People's Republic of China (SIPO). The data have information on all types of patents, namely invention patent, utility model (UM) patent and external design patent. Information include of name(s) of inventor(s), patent applicant(s) name(s), year of application and the year when a patent is granted to the applicant(s), address of applicant(s) and a brief summary about the patent. A patent could have one or several inventors and applicants. Patent applicants include domestic and foreign

individuals, firms, universities and institutions that file patent applications within China.

China's Patent Law (1985) classifies three types of patents reflecting different levels of technological sophistication. An invention patent is a technical scheme for products or methods which have high novelty, creativity and practicality. Invention patent applications are required by the law to go through a complicated examination by the SIPO before granting a patent. A utility model (UM) patent is a new technical proposal regarding a product's shape and/or structure in order to improve its practical use. An external design patents is the design in shape, pattern, colour or the combination of them in a product (Eberhardt, Helmers and Yu, 2012). To decide whether or not to grant a UM or an external design patent, the SIPO usually checks the completeness of application files and ensure that it has not been patented before (Liegsalz and Wagner, 2013). For this thesis, only information on invention and UM patents has been used because they have high novelty and technical complexity.

Data Matching Process

1. Step 1: extracting information on invention and UM patents from SIPO data

Information extracted from the CD-ROM developed by the SIPO includes patent application ID, applicant(s)' name(s), applicant(s)' address, year of patent application and the year when a patent is granted. The original information is in the form as presented in Appendix Table 3.1. A patent may have several applicants and below are examples that have maximum two patent applicants.

Appendix Table 3.1: Original patent data

Application ID	Applicant name	Applicant name	Year applied	Year granted	Address
CN00137426.5	松下电器产业株式会社		2000	2001	日本大阪府
CN00136414.6	松下电器产业株式会社		2000	2001	日本大阪府
CN00137475.3	佳能株式会社		2000	2001	日本东京
CN99125705.7	富士康(昆山)电脑接插件有限公司	鸿海精密工业股份有限公司	1999	2001	215316 江苏省昆山市城北镇北门路 999 号
CN99125710.3	富士康(昆山)电脑接插件有限公司	鸿海精密工业股份有限公司	1999	2001	215316 江苏省昆山市城北镇北门路 999 号

CN99125704.9	富士康(昆山)电脑接插件有限公司	鸿海精密工业股份有限公司	1999	2001	215316 江苏省昆山市城北镇北门路 999 号
CN99125707.3	富士康(昆山)电脑接插件有限公司	鸿海精密工业股份有限公司	1999	2001	215316 江苏省昆山市城北镇北门路 999 号
CN00136445.6	安普泰科电子有限公司		2000	2001	日本神奈川县

2. Step 2: use identical names as the identifier to link datasets

The purpose of linking the two datasets described above is to have a linked dataset with information on firm characteristics, whether or not a firm has applied or been granted with a patent, patent types and patent counts.

First of all, I choose firm name and patent application year, firm name and grant patent year as the identifiers to link the NBS data and the SIPO data. This is conducted by using the command "merge" in Stata.[13] The aim is to find patent information in the SIPO data for firms that are recorded by the NBS survey data. If a firm is recorded in the NBS data, and it has applied or been granted with a patent, its name can be found in the SIPO data. The "merge" command only links firms that have been recorded using identical firm names in both datasets.

At the end of this step, a linked dataset is generated and several examples from the linked dataset are presented in Appendix Table 3.2. For instance, one firm (中国海洋石油渤海公司, firm ID: 000133268) has applied for one invention patent in 1998, and it has applied for six invention patents in 2003.

The linked data from this step show that there are 122,134 invention patents applied by 15,386 firms during 2000-2008. There are 120,302 invention patents which have been applied by individual firms, and the rest of the patents are jointly applied by multiple applicants. In addition, there are 94,487 invention patents that have been granted to 13,087 firms. 93,384 invention patents have been granted to individual firms, and the rest of the invention patents are owned by multiple owners.

Appendix Table 3.2: Linked data example (step 2)

[13] "Merge" command can match two datasets using one or more variables that are identical in both datasets.

Year	Application ID	Firm name	Firm ID	Legal person name	Address
1998	CN98101992.7	中国海洋石油渤海公司	000133268	林绍东	300452 天津市塘沽区501 信箱
2003	CN03109646.8	中国海洋石油渤海公司	000133268	曹兴和	100027 北京市东城区东直门外小街 6 号
2003	CN03109645.X	中国海洋石油渤海公司	000133268	曹兴和	100027 北京市东城区东直门外小街 6 号
2003	CN03129868.0	中国海洋石油渤海公司	000133268	曹兴和	100027 北京市东城区东直门外小街 6 号
2003	CN03129869.9	中国海洋石油渤海公司	000133268	曹兴和	100027 北京市东城区东直门外小街 6 号
2003	CN03129984.9	中国海洋石油渤海公司	000133268	曹兴和	100027 北京市东城区东直门外小街 6 号
2003	CN03109647.6	中国海洋石油渤海公司	000133268	曹兴和	100027 北京市东城区东直门外小街 6 号
2007	CN200610135198.X	沈阳东宇精细化工有限公司	001623437	王瑞杰	110172 辽宁省沈阳市东陵区汪家镇下伯官村
2007	CN200610135197.5	沈阳东宇精细化工有限公司	001623437	王瑞杰	110172 辽宁省沈阳市东陵区汪家镇下伯官村
2005	CN200410023566.2	山东信得药业有限公司	002803608	李朝阳	262200 山东省诸城市棉织街 7 号

3. Step 3: link firms that have been recorded by different firm names in the two datasets

If a firm is recorded in the NBS data, but is recorded using a different name in the SIPO patent data, the "merge" command in Stata will regard this firm as having no patent. This is clearly not the case. For example, if a firm name is recorded as "ABC company (Shanghai)" in the NBS data but is recorded as "ABC (Shanghai) company" in the SIPO data, this firm should have been recorded in the linked data as having a patent, but will be recorded as not having a patent in the linked data after step 2.

At the end of step 2, there are 2,082,587 observations in the NBS data that cannot be found in the SIPO invention patent data, and 1,068,725 observations cannot be found in the SIPO utility model patent data. These observations are used in step 3 and step 4 to examine if they indeed do not have any patents.

First of all, a tailored computer programme is designed to link the unmatched observations in step 2 with the SIPO patent data.

(1) The first step is to clean the two datasets to ensure that they can be read by the computer programme. This step involves translating traditional Chinese characters into simplified Chinese characters in both datasets.

(2) The second step adopts "approximate string matching technique" meaning matching by key words. All of the firm names in the NBS data are disassembled into key words. The aim is to use them as identifiers to locate similar applicant(s) name(s) appeared in the SIPO patent data. If the key words of a firm's name can be identified in the patent data, the programme will keep this observation because it reckons that this firm has been recorded in the patent data. If the key words representing a firm from the NBS data cannot be identified by any records in the patent data, this firm is regarded as having no patent. Since there are some common words and phrases in firms' names in the NBS data that are useless to identify a certain firm, these terms are ignored. These words include "province（省）", "city（市）", "district（区）", "county（镇）", "firm（公司）", "limited company（有限公司）", "group（集团）" and "plant（厂）". Phrases that have a meaning are grouped together as one key word such as "机械（machinary）". Characters that do not make sense individually such as "安 (an)" "达 (da)" are used as two different key words on their own to match. If a firm name recorded in the NBS data have four or more key words and at least three of the key words can be matched with one or several applicant(s)' name(s) in the patent data, then the programme will regard this firm as having patent(s) and will record this information. If a firm name in the NBS data only have three or less than three key words, then all of them have to be matched with applicant(s)' name(s) in the patent data in order to be stored as having patent(s). If none of the key words in the firm name can be matched with the patent data, the programme will drop this record assuming that the firm name do not appear in the patent data and therefore do not have any patent.

However, the above two steps may generate some mistakes. For example, one firm which is called "北京爱生科技发展有限公司" in the NBS data is wrongly recorded as having an invention patent because one patent applicant is called "北京三泰恒生科技发展有限公司" in the SIPO data.[14] They are clearly different firms, but the matching rules of the computer programme will regard these

[14] Here I used different underlines to highlight the key words that were used to match.

two records as the same firm. Therefore, I manually deleted these wrongly matched observations to ensure that the linked data have patents. I also manually checked if the dropped observations indeed do not appear in the SIPO patent data.

At the end of step 3, I find 11,395 invention patents that are applied by 1,742 firms, and 9,321 utility model patents have been applied by 1,890 firms during 2000-2008.

4. Step 4: use year, legal person's name, post code as the identifier

Furthermore, I use legal person's name, post code and year as an additional identifier to link the two datasets. This is because legal persons from some firms may prefer applying for patents by their own names and thus the applicant names in the patent data will be the same as the legal person's name. Only firms that cannot be matched using step 2 and step 3 have been used to match in step 4 in order to avoid duplication.

At the end of step 4, for invention patents, there are 8,401 invention patents identified to have applied invention patents by 3,728 firms. There are 26,025 utility model patents found to be applied by 7,443 firms.

5. Combined the linked data from all the steps

The matched data from all of the steps are then combined together using "append" command in Stata. In total, there are 30,979 firms that have applied for 140,332 invention patents during 2000-2008. In the meantime, 26,275 firms have been granted with 111,110 invention patents. As for utility model patents, 51,621 firms have applied for 174,520 patents and 45,938 firms have been granted with 137,654 patents.

Up till now, the data are in the same format as shown in Appendix Table 3.2. The next step is to construct a panel data with information on patent counts at firm level, as shown in Appendix Table 3.3. For example, the second firm (firm code: 1623437) has applied two invention patents in 2006 and it has been granted with two invention patents in 2007.

Appendix Table 3.3: Linked invention patent counts data

Firm ID	Firm name	Year	Applied invention counts	Granted invention counts
1613431	沈阳新松维尔康科技有限公司	2008	2	0
1623437	沈阳东宇精细化工有限公司	2006	2	0
1623437	沈阳东宇精细化工有限公司	2007	1	2
1623437	沈阳东宇精细化工有限公司	2008	0	1
2803608	山东信得药业有限公司	2005	0	1

Data Quality Assessment

I compare the linked data with official published aggregate patent data and a paper that employs firm level patent data in order to assess the quality of the linked data.

Appendix Table 3.4: Invention patent applications by large and medium-sized industrial enterprises

	2006		**2007**		**2008**	
	NBS	**Linked data**	**NBS**	**Linked data**	**NBS**	**Linked data**
NBS large and medium-sized firms	25,685	26,584	36,074	33,736	43,773	31,893
# domestic funded	19,000	20,190	27,741	26,753	33,507	27,330
# HMT funded	3,425	2,772	3,299	3,126	4,332	7,218
# foreign funded	3,260	4,160	5,034	4,701	5,934	8,182

Appendix Table 3.4 compares the invention patent applications from the NBS with that from the linked data. The NBS data is for large and medium-sized firms over 2006-2008. The linked data are very similar to that reported by the official data.

In addition, according to the patent data for manufacturing firms published by the NBS, there are 13,547 invention patent applications in 2004 and 17,983 in 2005. In the linked data, there are 12,734 invention patent applications in 2004 and 17,263 in 2005.

Hu and Jefferson (2009) have access to unpublished official patent data of Chinese manufacturing firms over 1995 to 2001 and give a summary of patent application data only in 2001. Unfortunately they are unable to distinguish the three types of patents. The linked data used by this thesis covers the period of 2000-2008. I compare the linked data with the data employed by Hu and Jefferson (2009) for year 2001. The total number of patent applications for all industries in Hu and Jefferson's data in 2001 is 8,399 which consist of 6,226 domestic patent applications, and 2,173 applications by foreign firms. In the linked data, there are 8,614 patent applications including 6,259 filed by domestic firms and

2,355 filed by foreign firms. Therefore, the linked data have patent information that is very close to the official patent data.

Appendix 4: China's Patent Law

China's Patent Law was first introduced in 1985. In order to correspond to international standards, it has been revised in 1992 by extending the length of patent protection from 15 to 20 years for invention patents, and from 5 to 10 years for utility model and external design patents. The scope of patent protection has also been expanded to include pharmaceutical products, beverages, flavouring and foods (Yang, Kuo and Ramstetter, 2011).

China's Patent Law has undergone further revision in 2000 to promote China's participation in the WTO and to meet the criteria under the Agreement on Trade-related Aspects of Intellectual Property Rights (TRIPs Agreement). The revision of the patent law increases the protection scope further and punishment for infringement. More recently, when the China State Council initiated the National IP Strategy in 2008, the patent law has been revised further and taken effect in October 2009 (Venulex Legal Summaries, 2012). An important revision of the law is that if a patent has been granted to a firm elsewhere in the world by a patent office, the firm does not have to file an application in China in order to claim novelty. Given that the patent applications from foreign firms have been increasing considerably, the implication is that foreign patentees in China are launching new patents rather than replicate what has already been patented (Keupp, Friesike and von Zedtwitz, 2012).

There are two ways to patent owners can protect their rights against infringement. One is through the State Council and other local government agencies such as the State Intellectual Property Office (SIPO) at national and local level. Patent owners could file a complaint and require the administrative offices to investigate the infringement. The administrative offices could seize the counterfeited goods, impose pecuniary penalty, and launch highly advertised campaigns to fight against IPR infringement. However, the administrative authorities can only issue injunctions to stop the infringement. They have no fixed appeal procedures. The fines that are paid by the IPR offenders are to the authorities but not to the IP owners. Another way to protect patent rights is to go through the court procedure, which is usually chosen by foreign firms. The courts can provide IP owners with remedies, but the amount of damages estimated by the courts is often small compared with international standards. In addition, there is no formal procedure to collect information of actual damages of patent rights violation.

However, the IP owners generally do not prosecute in China for recovering damages. They often seek a ban of further infringing patents (Ross, 2012). Moreover, in 2004 China has illuminated the thresholds for criminal IP infringement for the first time by the enactment of the Interpretations.[15] Later on in 2007, another set of the Interpretations was introduced where the threshold of criminal IP infringement has been considerably lowered, and the amount of fines paid by the offenders has been fixed (Venulex Legal Summaries, 2012).

The Medium and Long Term Plan for Science and Technology Development (MLP) in China was issued in 2006 with the primary aim of turning China to a technology-driven economy. Three initiatives have been stressed including policies to promote domestic innovation capacity, launch special campaigns against IPR infringement and pursuing the National Patent Development Strategy (Williams and Mihalkanin, 2011).

[i] The China's Patent Law distinguishes three types of patents: invention patent, utility model (UM) patent and external design patent. An invention patent is a technical scheme for products or methods which have high novelty, creativity and practicality. It has the highest technological contents among the three types of patents. A UM patent is defined as a new technical proposal regarding a product's shape and/or structure in order to improve its practicality. An external design patent is the design in shape, pattern, colour or the combination of them in a product (Eberhardt, Helmers and Yu, 2012). This study excludes the external design patents in the analysis because they have the least technology elements.

[ii] For the robustness check, Herfindahl index is used as an alternative measurement of market structure. The results are consistent with that using concentration ratio.

[15] The full name of the Interpretation is the Interpretations of the Supreme People's Court and the Supreme People's Procuratorate on the Several Issues of Application of Laws When Hearing the Criminal Cases of Infringing on the Intellectual Property Rights (Venulex Legal Summaries, 2012).