Spillovers from FDI and Their Determinants: the Case of China

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A thesis submitted for the degree of Doctor of Philosophy of
The Australian National University

July 2008

Candidate Statement

I, Sizhong Sun, hereby declare that, except where acknowledged, this thesis is my own original work and has not been submitted for a higher degree at any other university or institution.

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Acknowledgements

First of all, I would like to thank my supervisory panel, Ligang Song, Peter Drysdale, and Martin Richardson. Without their guidance, encouragement, insightful advice, and constructive feedback, this thesis would not be possible. I would also like to thank Jane Golley. She is not in my supervisory panel, but has been supportive in a way comparable to a supervisor. Chunlai Chen commented on several chapters of this thesis. His comments are greatly appreciated.

During the past three years, I have attended the CBE/Crawford School Joint Economics Ph.D. Seminar, where I presented chapters of this thesis. I would like to thank seminar participants for their comments and suggestions that help to improve this thesis. Chapter 5 was presented at the 2007 annual Ph.D. Conference in Economics and Business at the University of Western Australia. The conference participants, particularly Prof. Xiangkang Yin of La Trobe University, have given very helpful comments and suggestions, which I gratefully appreciate. Several chapters of this thesis were also presented at the 18th, 19th, and 20th Annual Conference of the Association for Chinese Economic Studies Australia (ACESA). I would like to thank the conference participants' inputs to this thesis.

My last year of Ph.D. study was sponsored by the Rio Tinto–ANU China Partnership. I gratefully acknowledge the financial support from the Rio Tinto–ANU China Partnership.

Finally, I would like to dedicate this thesis to my parents. They have been so supportive in my whole life that I can not describe in words how much I owe to them.

Abstract

The thesis examines technology and export spillovers from foreign direct investment (FDI) and their determinants in China, both at an aggregate industry level and disaggregated firm level, using both cross-sectional and panel data.

At the industry level, we examine technology spillovers by estimating industry value-added as a function of the interaction terms of the technology transfer of FDI with the technology gap, relative capital intensity and relative labour supply over an eight-year panel data set from 1995 to 2003. It is found that technology spillovers vary across both industries and time, and the technology gap plays a negative role in technology spillovers, while relative capital intensity and relative labour supply play positive roles in technology spillovers. At the firm level, using a simultaneous equation model estimated over a comprehensive cross-sectional micro-data set that covers over 180,000 firms in the manufacturing sector in China for 2003, we find positive and substantial technology spillovers from FDI. However technology spillovers do not exist across all industries. In the cultural, educational, and sporting product manufacturing industry, we find no evidence of technology spillovers. In an analysis of technology spillovers in Gansu province, we find positive spillovers, with the scale depending on firm's R&D.

On export spillovers, the thesis first set up a partial equilibrium model to show that if the presence of FDI reduces domestic firm's export costs, for example by spillovers of knowledge about foreign markets and through labour movement, then domestic firms' export intensity, which is equal to the share of firms' exports in their total sales, will be unambiguously promoted. This hypothesis is tested using a Heckman sample selection model, estimated over both the comprehensive cross-sectional micro-data in China' manufacturing sector in 2003 and the four year panel data in the cultural, educational, and sporting product manufacturing industry. We find that FDI generates export spillovers, with the scale of spillovers depending on firm characteristics, such as firm size, age, and geographical location.

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1. Introduction

Since the 1980s foreign direct investment[1] (hereafter FDI) has played an important role in Chinese economic development. FDI inflows contribute to physical capital accumulation, help to boost domestic employment, and may increase domestic competition, particularly in the short run. In addition, it is argued that FDI can positively affect domestic industries and firms, namely that there exist positive spillovers to domestically owned industry from FDI[2].

These spillovers can happen through many channels (see Blomstrom and Kokko, 1998, for more discussions). For example, domestic firms can learn from FDI-invested firms about the production process and ways of doing business, labour can move from FDI-invested firms to domestic firms, and bring expertise from FDI-invested firms, market competition can increase due to the presence of FDI and force domestic firms to increase their efficiency, and the backward and forward linkages with FDI-invested firms will benefit domestic firms. The positive spillovers from FDI are important in the sense that they not only imply benefit to domestic firms and industries but also justify the favourable government policies towards FDI, which have been adopted by many countries. In China, for the past decade the corporate tax rate for FDI-invested firms has ranged from 15 to 24 per cent, while in contrast their domestic counterparts have to pay a corporate tax rate as high as 33 per cent[3]. The favourable policy treatment of FDI was premised on the hope that FDI-invested firms in China will

[1] The foreign direct investment in China is defined as the investment, which participates in productive activities, from foreign firms, including firms from Taiwan, Hong Kong, and Macau. The firms with the share of foreign capital in the total registered capital above 25 per cent are classified as FDI-invested firms, and all the other firms are called domestic firms.

[2] Throughout this thesis, spillovers from FDI are defined as the impact of FDI on domestic firms or industries, or mathematically $spillovers = \left.\frac{\partial(DOMESTIC)}{\partial(FDI)}\right|_{\bar{\kappa}}$, where *DOMESTIC* denotes domestic firms or industries, *FDI* denotes FDI-invested firms or industries, and $\bar{\kappa}$ denotes holding all other factors constant. If the impact is positive, then there exist positive spillovers from FDI. In this thesis, we study two types of FDI spillovers, namely technology spillovers, which are the impact on domestic firms or industries' productivity, and export spillovers, which are the impact on domestic firms' exports.

[3] The different corporate tax rates have now been converged into 25 per cent.

promote the economic development, through such channels as positive spillovers from FDI. Hence, the non-existence of, or even the negative effect of, spillovers from FDI will not support the favourable policy treatments.

Little is known about extent of spillover effects and what form they are likely to take. Besides, different channels for spillovers imply that different domestic firms will be affected differently by FDI. Domestic firms with different characteristics, such as size and ownership, may respond differently to the presence of FDI. For example, bigger firms are more capable of imitating their FDI-invested competitors, as they can devote more resources to investment in learning. Again, little is known as to what kind of domestic firms will benefit or suffer from the presence of FDI.

This thesis aims to examine the spillovers from FDI in China systematically, including both technology spillovers, a field that has been extensively explored (for example Li et al., 2001, Buckley et al., 2002, Chuang and Hsu, 2004, Liu, 2002, 2008, Caves, 1974, Sinani and Meyer, 2004, Branstetter, 2006, Kohpaiboon, 2006, Aitken and Harrison, 1999, and Sadik and Bolbol, 2001), and export spillovers, a field that is much less studied. The thesis also tries to explore the determinants of, and the scale of, FDI spillovers.

To test for the existence of technology and export spillovers from FDI and their determinants is of both analytic interest and policy importance. Analytically it enables us to better understand how domestic firms and industries respond to FDI. In terms of policy, a better understanding of the impact of FDI on domestic industries and firms will enable governments to formulate FDI policies that can alleviate the negative impacts from FDI. In China, FDI has been playing an important role in economic development over the past three decades, as discussed in the following section. Hence, examination of spillovers from FDI in China is of particular interest. Then we discuss the FDI policy setting in China, which provides background to subsequent empirical analysis. In the last section, we present the structure for this thesis.

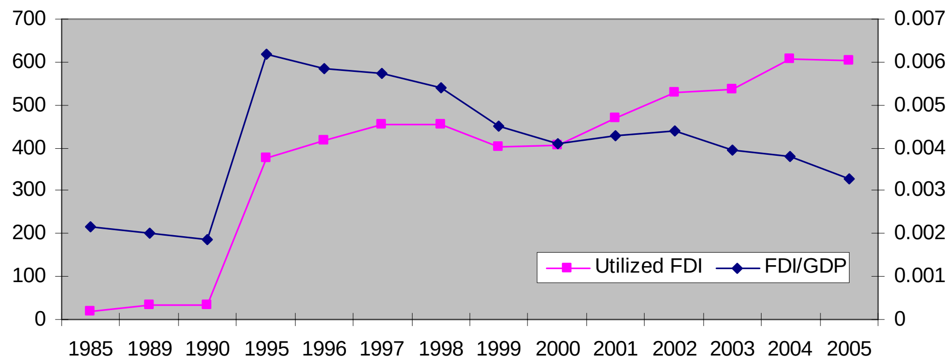
Importance of FDI in China

Since 1985, the inflow of FDI actually-utilized has been increasing rapidly although the Chinese economy is also growing bigger. A bigger economy tends to attract more FDI inflow. Hence if we account for this impact by dividing FDI by GDP, we find that the inflow of FDI every RMB of GDP has been declining (see Figure 1.1). In 1995, for every RMB of GDP, there was 0.0062 US dollar FDI in China. In contrast, this number decreased to 0.0033 US dollar in 2005, which is roughly about 50 per cent of the 1995 level. So the share of FDI inflow in Chinese economy overall actually displays a declining trend, while the level of inflow exhibits an increasing trend.

Even with this declining trend in the “real” inflow of FDI in the Chinese economy, the contribution of FDI to the industrial output and exports has been increasing steadily (see Figure 1.2). In 1995, 14 per cent of total industrial output was made by FDI-invested firms, and in 2005, FDI-invested firms’ output accounted for 31 per cent of total industrial output, which is more than double that of 1995. Figure 1.2 also shows the contribution of FDI in terms of exports. The proportion of FDI-invested firms’ exports in the total exports has continued to increase since 1990. In 1990, 13 per cent of exports were produced by FDI invested firms, and in contrast in 2006, 58 per cent of exports came from FDI invested firms, almost five times that in 1990.

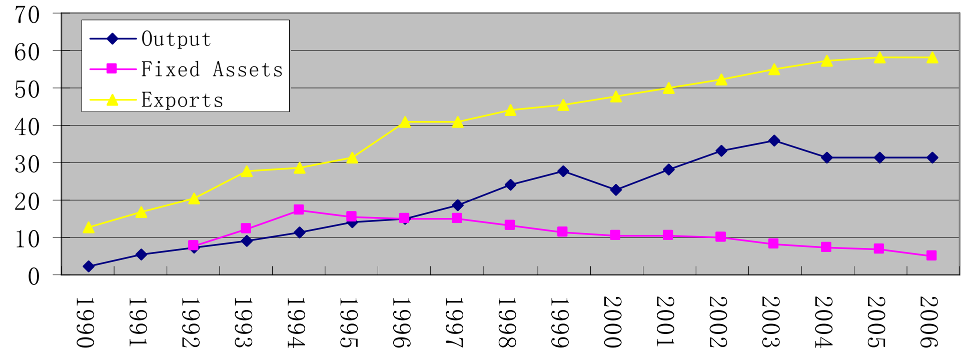
FDI also contributes significantly to physical capital accumulation. From 1992 to 2006, FDI actually-utilized accounted for 11 per cent of total fixed asset formation on average, but this proportion exhibited a declining trend (see Figure 1.2). In 2006, FDI actually-utilized only accounted for 5 per cent of total fixed asset formation.

Figure 1.1 FDI Inflow since 1985



Source: *Statistical Yearbook of China*, 2006

Figure 1.2 Contribution of FDI (per cent)



Note: Output denotes the proportion of FDI invested firms' output in total industrial output; Fixed assets denotes the proportion of FDI actually utilized in the total fixed asset formation; Exports denotes the proportion of FDI invested firms' output in the total exports.
Source: MOFCOM, 2007

Even though the FDI inflow for every RMB in GDP and FDI'scontribution to fixed capital accumulation have been declining, the share of FDI-invested firms in the total industrial output and exports have been increasing, and this implies that domestic firms' shares were decreasing. So compared with domestic firms, FDI-invested firms have become more productive and export-oriented. This could happen if FDI-invested firms have technological superiority and more knowledge of export markets. This technological superiority and knowledge about the world market can benefit domestic firms and industries. Given that the Chinese economy has been performing very well in the past three decades, it could be reasonably argued that FDI spillovers have been playing a significant role. Positive FDI technology spillovers will promote domestic firms' productivity and increase their production capacity, while positive export spillovers will boost domestic firms' export activities and increase the whole industry's exports. Thus, this thesis focuses on the analysis of these spillover effects from FDI in China.

FDI Policy Settings

Before we turn to empirical analysis of FDI spillovers, we discuss the current FDI policy settings. China's FDI policy settings can be characterized from four perspectives, namely the legislation, which is the foundation of the FDI policy, national treatment, under which, until now, FDI invested firms have been enjoying treatment more favourable than their domestic counterparts, industrial composition, and regional distribution.

The legislation

The legislation on foreign investment is a fundamental part of China's FDI policy. Up to now, China has built up a relatively complete legal framework for FDI. This legal framework comprises of three parts: 1) national laws, 2) local laws, and 3) international agreements.

China's *Constitution* permits foreigners to invest in China and their legitimate rights are protected, and these rights form the basis of China's legislation on foreign investment. At the national level, there are also other laws passed by National People's Congress, and rules and stipulations established by Department of State and other councils, among which *the Law of Sino-foreign Contractual Joint Venture*, *the Law on Foreign Enterprises*, and *the Law on Chinese-foreign Cooperative Enterprises* are the most important laws in this area. Four amendments were made to this legislation after accession to WTO. They are related to 1) the article on foreign exchange balance, 2) the article on local content, 3) the requirement on export performance, and 4) the article on firm's production plans (Wang, 2004). In (1), the requirement that FDI invested firms must retain its foreign exchange balances was cancelled. In (2), the requirement that FDI invested firms must purchase in China as a priority was cancelled. In (3), the requirement that FDI invested firms must export all or most of their outputs was cancelled. FDI-invested firms can sell their outputs freely. In (4), the requirement that FDI invested firms must report their production plans to the government was cancelled. All these four amendments were made in order to comply with WTO rules, particularly the TRIMs.

In addition to the national laws, the local People's Congress and governments also establish their own laws on foreign investment, under the condition that the laws will not contradict national laws. The laws are actually supplementary to the national laws, and are only applicable within the local region. In this respect, Chinese FDI laws are quite different with most Southeast Asian countries, where the regulation over FDI is made only at the national level.

In order to encourage investment and protect the interests of foreign investors, the Chinese government also signed bilateral agreements with foreign governments on the protection of investment, avoidance of double taxation, and prevention of tax evasion. China also acceded to the multilateral agreements that are related to investment, such as *Multilateral Investment Guarantee Agency Convention*.

National treatment

Since the introduction of FDI, FDI invested firms have been treated differently from domestic firms. The aim of different treatment is to induce FDI to flow into particular industries and particular regions. These different treatments have involved 1) better than national treatment and 2) less favourable than national treatment.

Treatment that is better than national treatment includes 1) preferential tax treatment, 2) special rights in respect of import-export licensing 3) privileges in respect of foreign exchange management, 4) privileges in respect of overseas bank credit, 5) privileges in respect of enterprise establishment procedures (Bu and Zhen, 2005). In regard to (1), it is estimated that the nominal tax rate for FDI invested firms has been 15 per cent and the real tax rate has been 11 per cent, while in contrast the rates for domestic firms are 33 per cent and 23 per cent respectively. Roughly speaking, the tax burden for domestic firms is twice that of FDI invested firms. Specifically, in respect of income tax, it was stipulated that productive FDI invested firms committed to operation over 10 years can be exempted from business income tax for two years starting from the year when the firm makes profit for first time, and then half of the tax rate will be applied for subsequent three years; the rate for FDI invested firms located in special economic regions and foreign enterprises that establish branches in special economic regions for production and operation is 15 per cent. In regard to (2), if domestic firms want to do business overseas they must apply for import and export licenses. FDI invested firms are entitled to this license automatically upon the establishment of the firm. In regard to (3), FDI invested firms have been able to have foreign exchange accounts and retain a certain amount of foreign income. But domestic firms cannot have foreign exchange accounts without special permission. In regard to (4), FDI invested firms have been able to borrow from overseas banks with little procedure, but domestic firms must undergo rigorous approval procedure. In regard to (5), FDI invested firms have been able to be established without the registered capital being fully paid. But domestic firms must pay up the registered capital fully to get the business license.

Less favourable than national treatment includes 1) the requirement that purchase of material needed by FDI invested firms, such as equipment and raw material, must be sourced as a priority in China if conditions between China and abroad are the same, 2) service fees to FDI invested firms is higher than that of domestic firms, 3) the requirement FDI invested firms must retain foreign exchange balances, 4) the restrictions on market access and business scope (Bu and Zhen, 2005).

Industrial composition

In 2002, Department of State released an amended *Regulation on Guiding Foreign Direct Investment Direction*, and a new *Industry Guiding Category for Foreign Direct Investment*. These documents govern the inflow of FDI by industrial category. The *Industry Category* classifies industries into 4 types: encouraged, permitted, restricted, and prohibited. The new Category enlarged the industrial categories open to foreign investment (Wang, 2004), as follows: 1) the number of encouraged industries was increased from 186 to 262, while the number of restricted industries was cut down from 112 to 75; 2) restrictions on the share of ownership held by foreign investors was relaxed. For example, the requirement that public wharfs should be controlled by Chinese investors was abolished; 3) more industries were opened to foreign direct investment, such as telecommunication, fuel gas, and water supply and sewage; 4) the services, such as banking, insurance, tourism, accounting, and law service, were further opened to FDI; 5) investment in western China was encouraged, and ownership and industry restrictions were loosened in western China; (6) the general manufacturing sector was classified as permitted category in order to boost market competition and optimize the industrial structure.

Regional distribution

As China launched its Strategy of Developing western China, the regional emphasis in FDI policy also shifted to western China by offering extended privileges to investors in western China. More investment was put into western China to build infrastructure; more transfer payments were made; more financial support and tax preference were offered; and openness was increased. In 2000 *Notification of Implementing 15 Per Cent of Preferential Business Income Tax*

Rate over FDI Invested Firms in Midwest China for Three Years was issued, which offers better conditions than in other regions in that there is no requirement that the firms must have be in operation for 10 years and the period of preferential tax rate is longer. In 2001 and 2002, *The Implementing Guidance of Some Policy Measures on Developing Western China and the Overall Planning of Developing Western China during 'Tenth Five' Period* were launched respectively, which give general guidance over investing in western China.

Evolution of FDI policy[4]

Yin and Lu (2005) characterize the evolution of FDI policy from the perspective of both its industrial and regional dimensions. FDI policy reveals a gradual opening process that was not planned on a defined schedule, but evolved as experience accumulated over in opening up to FDI (policy learning by doing). Restrictions on FDI by industry category are adjusting over time, while the openness to FDI by region continues to increase.

Table 1.1 shows the opening to FDI by region. We can see that the FDI inflow started from special economic regions (1979-1983), the open coastal belt (1984-1991), border cities and inland cities (1992-1999), and to midwest China (2000-2003) as is the emphasis of current FDI policy. Table 1.2 shows the opening to FDI by industry category. FDI policy proceeded from opening without industry guidance (1979-1982), priority on secondary industry (1983-1990), trial opening of tertiary industry (1991-2001), and overall opening (2002-2003).

[4] This section is based on Yin and Lu, 2005

Table 1.1 Gradual Pattern of Regional Aspect of China's FDI Policy

<table>
<tr><th>Year</th><th>Open Area</th><th colspan="2">Policy Experience</th><th>Laws and Statutes</th><th>Laws and Statutes of turning point</th></tr>
<tr><td rowspan="2">1979-
1983</td><td rowspan="2">Special Economic Regions</td><td>More economic power to local governments</td><td>Power of approval
Foreign capital
Fiscal credit</td><td rowspan="2">Two Reports on Foreign Economic Activities and Flexible Measures by Guangdong and Fujian Provincial Party Committees, 1979
Conference Minutes of Guangdong and Fujian, 1980
Working Conference Minutes of Guangdong and Fujian and Special Economic Regions, 1981
Minutes on Issues of Establishing Special Economic Regions, 1982</td><td rowspan="2">Directions on Strengthening the Utilization of Foreign Investment, 1983
(1) emancipate the mind;
(2) loosen the tax policy;
(3) offer part of domestic market.</td></tr>
<tr><td>Profit transfer to FDI firms</td><td>Tax preferences</td></tr>
<tr><td rowspan="3">1984-
1987</td><td rowspan="3">Coastal Open Belt (coastal open cities, and coastal economic open zones)</td><td colspan="2">Power of approving FDI lowered, foreign exchange quota and foreign exchange credit increased, tax preferences, technology development zones established</td><td>Minutes of Symposia of Coastal Cities, 1984
Minutes of Symposia of Yangtse River, Pearl River Delta and South Fujian- Xiamen Zhangzhou Quanzhou Delta, 1985</td><td rowspan="3"></td></tr>
<tr><td>Improve micro-environments of FDI firms</td><td>Materials supply
Financing
Foreign exchange revenue and expenditure</td><td rowspan="2">Stipulations on Encouraging Foreign Investment, 1986
Various policies of attracting FDI issued by local governments</td></tr>
<tr><td>Improve the efficiency of administration</td><td>Administrative management</td></tr>
<tr><td>1988-</td><td>Coastal</td><td colspan="2">Enlarge power of approving FDI,</td><td>Supplemental Provisions on Developing</td><td>Opinions on Speeding up</td></tr>
</table>

1991	Open Belt (coastal economic open zones)	manage the foreign exchange capital reasonably	*Export-oriented Economy in Coastal Area*, 1988	*Reform, Extending Opening, and Trying Better and More Quickly to Push Economy to a New Stage*, 1992 (1) The theoretical barriers to introducing FDI was resolved; (2) More domestic markets were opened
		Implement *Minutes of Symposia of Yangtse River, Pearl River Delta and South Fujian-Xiamen Zhangzhou Quanzhou Delta* (1985) and *Supplemental Provisions on Developing Export-oriented Economy in Coastal Area* (1988)	*Notification on Extending the Scope of Coastal Economic Open Zones*, 1988 *Reply on Extending the Scope of South Fujian Delta Economic Open Zone*, 1988 *Approval of Extending the Scope of Guangdong Coastal Economic Open Zone*, 1988 *Reply on Classifying Jinan City as Coastal Economic Open Zone*, 1990	
1992-1999	Cities along rivers and borders, and inland capital cities	Implement coastal open city policy	Notification on Further Opening Chongqing and Other Cities, 1992	*Notification on Policy Measures of Implementing Developing Western China Strategy*, 2000 (1) speed up to change idea; (2) increase opening
	Border cities and towns	Give certain power of approving license of foreign trade, tax preference, establish border economic cooperation zones, and arrange special-purpose loan etc.	*Notification on Further Opening Five Border Cities and Towns of Nanning, Kunming and Pinxiang etc.*, 1992 *Notification on Further Opening Four Border Cities of Heihe etc.*, 1992	
2000-2003	Midwest China	Increase the input of construction capital, the fiscal transfer payment, the financial credit support, the tax preference, and extend the opening etc.	*Notification on Implementing the 15% Preferential Business Income Tax Rate on FDI Firms ON Midwest Areas for Three Years*, 2000 *Opinions on Implementing Policy Measures of Developing Western China*, 2001	

			Overall Planning of Developing Western China during "Ten Fifth" Period, 2002	

Source: Yin and Lu, 2005

Table 1.2 Gradual Pattern of Industrial Aspect of China's FDI Policy

Year	Opening Industry	Policy Experience	Laws and Statutes	Laws and Statutes of turning point
1979-1990	Manufacture, Mining	Encouraging	*Rules for Implementing Business Income Tax on Chinese-foreign Joint Venture*, 1980	*Direction on Strengthening the Utilization of FDI*, 1983 (1) The joint venture should be productive
	Transportation, commerce, tourism, catering services, service	No restriction		
1983-1990	Second industry: "productive projects" and "two kinds of projects"	Encouraging	*Regulation for Implementing Law of Chinese-foreign Joint Venture*, 1983 *Stipulations on Encouraging Foreign Investment*, 1986 *Temporary Stipulations and Category for Guiding Direction of Foreign Investment*, 1987	*Notification on Approving National High-tech Industry Development Zone and Relevant Policies*, 1991 *Decision on Speeding Up the Development of Tertiary Industry*, 1992 (1) make various trial experiment
	Tertiary industry	Restriction		
1991-2001	Secondary industry: "3 types of projects"	Encouraging	*Temporary Stipulations and Category for Guiding Direction of Foreign Investment*, 1995, 1997 Various experimental laws	Accession to WTO (2001)
	Tertiary industry: experimental	Restriction reduced		
2002-2003	Secondary industry: "3 types of projects"	Encouraging	*Stipulations and Category for Guiding Direction of Foreign Investment*, 2002	
	Tertiary industry	Restriction cancelled gradually		

Source: Yin and Lu, 2005

Structure of the Thesis

The thesis is structured as follows.

In Chapter 2, there is a review of the literature of studies on technology and export spillovers of FDI. In Chapter 3, technology spillovers and their determinants are analysed at an industry level. We estimate an econometric model, in which industry value-added is a function of the interaction terms of the technology transfer of FDI with the technology gap, relative capital intensity and relative labour supply, over an eight-year panel data set from 1995 to 2003. This analysis suggests that on average there are negative technology spillovers from FDI. Yet domestic industries are doing better and better with FDI in the sense that from 1995 to 2003 more and more industries get positive technology spillovers and even for those industries that are negatively affected by FDI the magnitude of negative technology spillovers becomes smaller and smaller.

Chapter 4 further explores technology spillovers by digging into more disaggregate data at the firm level. A simultaneous equation model, in which domestic labour productivity and foreign presence (proxy for FDI) are a function of each other, is set up to accommodate for the potential endogeneity of FDI. The simultaneous equation model is then estimated over a comprehensive cross-sectional firm level micro-data set that covers over 180,000 firms in the manufacturing sector in China in 2003, and we find substantial technology spillovers from FDI.

Based on the same data set, Chapter 5 turns to the export spillovers of FDI. In Chapter 5, a partial equilibrium model is set up to illustrate that if the presence of FDI reduces domestic firms' export costs, for example by spillovers of knowledge about foreign markets and through labour movement, then domestic firms' export intensity, which is equal to the share of firms' exports in their total sales, will be unambiguously promoted. This hypothesis is then tested by a Heckman sample selection model estimated over the comprehensive cross-sectional micro-data. The estimation finds that FDI in the manufacturing sector does generate export spillovers, and furthermore the scale of the spillovers depends on firm characteristics.

Chapter 6 focuses on technology and export spillovers in the cultural, educational, and sporting product manufacturing industry, a two-digit industry where FDI presence and firms' export activities appear most significant, from 2000 to 2003. Focusing on an industry over time has three advantages. First, we do not need to worry about industry heterogeneity, which can be hard to capture. Secondly, endogeneity that occurs because of the possibility that FDI will tend to flow into industries with higher productivity or higher export intensity can be controlled for automatically. Thirdly, looking at technology and export spillovers over a period of time will also enable capture of the dynamic nature of spillovers. Following the specification in Chapters 4 and 5, we estimate a panel data model for technology spillovers and a Heckman sample selection model for export spillovers. We find no evidence of technology spillovers. However there exist export spillovers from FDI, with the scale depending on firm characteristics.

Chapter 7 turns to the regional dimension of FDI, by examining the technology spillovers in Gansu Province, one of the least developed regions in China. In this chapter, the stochastic frontier model is adopted to test whether the foreign presence has a positive impact on domestic firms' technical efficiency. Technology spillovers exist if the foreign presence positively affects domestic firms' technical efficiency. In this chapter, we find that if the FDI invested firms' activities are measured in terms of output share and employment share in the industry, FDI invested firms do have a positive impact on other firms' technical efficiency, and domestic firms' R&D spending plays a positive role in the scale of such technology spillovers. Based on findings of previous chapters, Chapter 8 discusses the policy implications of the analysis and offers some conclusions.

2. Review of Studies of the Spillover Effects of FDI

There are various studies of the impact of spillovers from FDI on domestic firms and industry, both theoretical and empirical. This chapter will review recent studies on the spillover effect of FDI, including technology spillovers and export spillovers. In the next section, we discuss the link between FDI and spillovers. Then we summarize the estimation approach and data set issues of estimating FDI spillovers in the following section. The last two sections, we present a survey on recent studies on FDI spillovers.

FDI and Spillovers

The presence of FDI invested firms in the domestic market will inevitably affect domestic firms. There are a number of channels through which such impacts are transmitted, namely the linkage between FDI invested firms and domestic firms, the movement of employees trained by FDI invested firms, and demonstration and competition effects (Blomstrom and Kokko, 1998).

The domestic firms are linked to FDI invested firms as either or both local suppliers and customers. If being local suppliers and customers helps domestic firms to increase the level of their technology and exports, then spillovers take place. The linkage as local suppliers is called a backward linkage while as customers is called a forward linkage. Lall (1980) suggests five ways FDI invested firms can affect domestic firms through backward linkages. FDI invested firms can help local suppliers to set up production facilities, provide technical assistance and information, help purchasing raw materials and intermediary inputs, provide training and help in management and organization, and assist suppliers to diversity by finding additional customers. On forward linkages, Blomstrom (1991) argues that growing technical complexity in many industries contributes to an increasing role of MNE customer contact, especially in smaller countries.

The second channel through which spillovers can happen is the movement of employees trained by FDI invested firms. MNEs usually have to provide training to local employees, through a range of activities such as on-the-job training and even overseas education and training at the parent company. These well trained employees can move to domestic firms or set up their own businesses. The skill they obtained in FDI invested firms will be naturally carried over to domestic firms. However, as FDI invested firms tend to offer higher wages, employee movement may not in reality have a significant effect.

The presence of FDI in host countries can also act as a learning model for domestic firms. By observing the business activities of FDI invested firms, domestic firms can learn from and imitate FDI invested firms to adopt similar production techniques and improve their own efficiency. The demonstration effect requires that the domestic firms must have capability to absorb the relevant know-how, that is, they cannot lag too far behind. Even if domestic firms are not inclined to imitate FDI invested firms, increased competition from FDI invested firms will force domestic firms to do so. As Jenkins (1990) observes, there is tendency for domestic firms to adopt similar production techniques to those of FDI invested firms if they are in competition with each other, produce similar products, have same scale and supply to the same market. In addition to forcing domestic firms to learn and imitate, the competition may have different effects in the short run and long run. It is argued that in the short run the competition will crowd some domestic firms out of the market and thus have a negative impact on domestic firms, but in the long run it will have a positive impact since firms that cannot adapt to the competition are forced out of the market and existing firms are forced to adopt more advanced technology to compete. The presence of FDI may also affect domestic industry structure, which will change the efficiency and resource allocation in the industry and hence affect the spillovers. Blomstrom and Kokko (1998), their survey of the empirical studies, conclude that FDI tends to flow into industries with high entry barriers and high levels of concentration, and thus in the short run increases the number of firms in the market, but in the long run may contribute to increases in concentration, although bringing with it efficiency benefits.

Not only can FDI spillovers be delivered through different channels, but also FDI can generate different types of spillovers. The FDI inflow into host countries affects host countries (host country spillovers) but the home country may also be affected (home country spillovers). For example MNEs may produce intermediate goods that are accessible to home country firms at a lower cost and thereby increase the international competitiveness of home country firms. In this thesis, we focus on the host country spillovers, namely the impact of FDI inflow in China.

FDI can affect other firms and industries in different ways, for example via its impact on technology or via its impact on exports. If FDI enhances the technology level of domestic firms or industries, then technology spillovers occur. Similarly, if FDI has a positive effect on the exports of domestic firms or industries, export spillovers take place. Export spillovers can happen if local firms expand their production and achieve economies of scale as a result of being suppliers and sub-contractors to FDI invested firms, or establish their own export channels through obtaining knowledge from FDI invested firms on foreign market conditions, such as foreign preferences on product design, packaging and quality. The thesis does not intend to cover all aspects of FDI spillovers, but instead I focus on technology and exports. Technology spillovers are most widely studied, while export spillovers are much less so, as will be shown in following sections.

FDI spillovers can also be classified into horizontal spillovers and vertical spillovers. The inflow of FDI that brings in better technology can encourage domestic firms within the same industry to improve their performance and competitiveness. In addition, domestic firms in the same industry may benefit from the presence of FDI via the channels discussed above. This kind of spillover takes place within the same industry, and is hence called a horizontal spillover, or equivalently an intra-industry spillover. Domestic firms in one industry can also be affected by FDI in other industries, if they are in business contact with FDI invested firms in other industries. These types of spillover are called vertical spillovers, or equivalently inter-industry spillovers, as they are spillovers generated by the FDI from other industries. Forward and backward linkages are important channels through which vertical spillovers can take place. In this thesis, we only cover the horizontal spillovers.

FDI spillovers are generally assumed to be positive. However, the impact of FDI is not necessarily always positive. Different domestic firms will respond differently to the FDI presence, and are then affected differently, depending on their own characteristics and the economic environment. For example, the market size, local content regulations, and size and technological capability of domestic firms will affect the extent of backward and forward linkages, all of which in turn affects the extent of spillovers (Blomstrom and Kokko, 1998). Hence it is not surprising to expect and observe that some domestic firms will suffer from the presence of FDI. Furthermore, it is more reasonable to expect that the magnitude of FDI spillovers will depend on the characteristics of domestic firms. Compared with previous studies, this thesis emphasizes the importance of domestic firm characteristics in FDI spillovers in the empirical exercises undertaken in subsequent chapters.

Estimation Approach and Data Sets

Hence, FDI is closely linked to spillovers conceptually. However is this necessarily the case in the real world? There have been a number of studies that test this link in reality. These empirical exercises can be summarized from three perspectives: the methodology, data set, and other issues in testing the spillover effect.

Firstly, in respect of the methodology, the commonly used method in testing FDI technology spillovers is to regress a proxy of technology, labour productivity or total factor productivity, against a proxy for FDI, usually called foreign presence, by controlling for the relevant factors that have a direct effect on the proxy of technology, such as the capital intensity and human capital. It is implicitly assumed that there exists a production function for the firm and or the industry and that its technology is a function of factors such as the FDI, market concentration, technology gap, and human resources, in which the FDI is the variable of interest. For FDI export spillovers, most empirical studies that directly target the issue at the firm level regress domestic firms' export intensity, measured as the share of domestic firms' exports in their total sales, against the foreign presence and other factors that affect firms' export activities, such as firms' capital intensity and size. The regression is completed using the Heckman sample selection model, accounting for a two-step decision procedure in firms' export activities: firms first decide whether to export and then decide how much to export if they have initially decided to export. In both the case of technology and export spillovers, the significance and magnitude of the coefficient of FDI is the focus of the studies. Thus it is important to choose an appropriate proxy for FDI.

Conventionally, there are three kinds of proxies for FDI, which are also called foreign presence, that is, the share of foreign owned firms' equity in the whole industry, the share of foreign owned firms' employment in the whole industry, and the share of foreign owned firms' production in the whole industry. Each of these three proxies has different deficiencies. The share of foreign owned firms' equity in the whole industry may be distorted by host country ownership restrictions (Kohpaiboon, 2006): for example the host country may impose a restriction that the share of foreign capital in total capital can not be higher than a fixed amount in some industries. FDI tends to invest in more capital-intensive industries compared with their counterparts and the share of foreign owned firms' employment in the whole industry will be lower because foreign firms are usually less labour intensive, so that this proxy will underestimate the presence of FDI (Kohpaiboon, 2006). The employment share is particularly problematic in China as China's state and collectively owned enterprises have to bear redundant employment because of their historical role in providing social services and security. As for the share of output of foreign owned firms in the whole industry, it is argued that since the dependent variable is productivity, which usually is calculated from the output, it is more appropriate to measure the foreign presence by inputs (Caves, 1974).

In summary, these three proxies may distort the true measurement of foreign investment presence. These distortions may contribute to the mixed empirical results, and make the estimation results sensitive to the choice of FDI proxy (Gorg and Strobl, 2001). In recognition of this, all three proxies are used in empirical exercises in subsequent chapters, with the interpretation based on one proxy and the other two serving as sensitivity analysis.

For productivity, a proxy for technology, it is well known that the conventional measure reflects not only technical efficiency, but also market power (for example, Bernard et al., 2003, Branstetter, 2006). To compute productivity, either labour productivity or total factor productivity, value added is needed, which in turn is calculated by assuming a competitive market and constant returns to scale. Hence the effect of market power and non-constant returns to scale affects the calculation of value added. For this reason, it is also argued that gross output data is preferable to the value-added data in empirical estimations (Basu and Fernald, 1995).

In addition to the widely used traditional approach, there are other approaches, such as those of Branstetter (2006) and Sadik and Bolbol (2001). The approach of Branstetter (2006) differs from the traditional approach in that different proxies for the technology of FDI are used. In Branstetter's analysis, patent citation is used as a proxy for technology. This excludes other technology such as technical know-how. Besides, one might argue that this definition of technology spillovers is too narrow in the sense that only spillovers that lead to innovations are treated as spillovers. Thus, Branstetter's approach very likely underestimates the true level of technology spillovers from FDI in a host country. Sadik and Bolbol (2001) adopted a growth accounting framework to study technology spillovers from incoming FDI. In their approach, FDI is treated as part of the domestic capital stock, and at the same time it also has an effect on the technology of the production function. A potential problem comes from the poor fit of the growth accounting method with reality, as is illustrated by the fact that the R^2 of Sadik and Bolbol's study is very low, which indicates that some important factors are left out.

For the studies of export spillovers of FDI, there are another two lines of approach, in addition to the approach that regresses export intensity against foreign presence. One is to examine the issue in the context of whether FDI positively affects aggregate exports in studying the determinants of exports, as in Lipsey and Weiss

(1981, 1984), Bento (2004), Hu and Ma (1999), Zhang et al. (2005), and Li et al. (2003). The other is to test whether FDI positively causes or predicts aggregate exports, as in, for example, Mello and Fukasaku (2000), Liu et al. (2001), Shan (2002), and Aizenman and Noy (2006). Compared with the first line of studies, the second focuses more on the dynamics of FDI's impact on exports, which is reasonable as it takes time for FDI to have an impact on exports. However, both lines of study are at an aggregate level, namely examining whether the aggregate FDI flow positively affects aggregate exports. If there are export spillovers from FDI, then we can observe that aggregate FDI flow positively affects aggregate exports. However, the observation that aggregate FDI flow positively affects aggregate exports does not necessarily imply that there are export spillovers from FDI, as the increase in aggregate exports may come from FDI invested firms themselves. Hence these two lines of study do not address the export spillovers directly.

Second, data sets, either cross-sectional or panel data sets are used in these studies, and these data sets are either on a firm level or on an industry level. So this is a two dimensional issue. The major problem for cross-sectional data is that they tend to overestimate the magnitude of technology spillovers. As found by Gorg and Strobl (2001), studies using cross-sectional data find systematically more technology spillovers from FDI than studies using panel data. One reason is that there is usually a reverse causality from productivity/export activities to FDI, that is, not only may the presence of FDI increase the productivity/export activities of domestic firms, but also FDI often tends to flow into industries with higher productivity/exports, or the FDI parent firm tends to enter a market by acquiring domestic firms with higher productivity/export activity. The solution to this reverse causality problem is either to find an instrumental variable, which is difficult in reality in that the variables that are correlated with FDI usually are also correlated with productivity/export activity, or to use a simultaneous equation system, which is not used by all previous studies that employ cross-sectional data sets. In contrast, in addition to the usual advantages, such as potentially increasing the degrees of freedom and reducing multi-collinearity problems (Hsiao, 2003), panel data can also accommodate the reverse causality problem easily, for example by using lagged FDI as the instrument. Besides, technology and export spillovers themselves have a dynamic nature, that is, they usually occur through time. This means that cross-sectional data sets may not be able to capture all relevant aspects of technology and export spillovers. In this sense, panel data is probably preferable to cross-sectional data.

The other dimension of data sets is the level of aggregation. As shown by Caballero and Lyons (1989), spillovers at a lower level of aggregation may be internalized at a higher level of aggregation, which means that if the lower level of aggregation gives a correct estimation of the magnitude of technology spillovers then the higher level will probably underestimate the magnitude, and vice versa. Thus, estimation by using firm-level (disaggregated) data and industry-level (aggregated) data will tend to present contrasting results. Compared with firm-level data, industry-level data is unable to control for differences in productivity across sectors which might be correlated with, but not caused by, foreign presence (Aitken and Harrison, 1999). However, from the researchers' point of view, industry level data are often much easier to obtain than firm level data, because industry level data are usually published officially while firm level data are often census data.

There are other issues about estimation that need attention. Gorg and Strobl (2001) argue that a proper definition of foreign presence, proxy for FDI, is important to capture technology spillover effects. The conventional measurements all have some deficiencies. Thus, while using these proxies, the specific situation from which the data come should be examined carefully. For example, in a country where ownership is restricted, measures of capital share should be used with caution.

One alternative is to construct a proxy for technology transfer of FDI, as is done in Chapter 3. Moreover the appropriate control variables should be selected carefully. Technology is transferred across country boundaries via several channels, namely international trade, particularly trade of capital goods, technology licensing, and FDI (Pack and Saggi, 1997). Technology spillovers may take place in all three channels. It is better to control for the other two channels while studying any one channel.

These can be called channel control variables. However, due to data constraints, we are not able to do so in this thesis. Factors that directly contribute to the development of technology, such as capital intensity, will be controlled. These factors can be called direct control variables. In export spillover studies, factors that contribute to firms' exports shall also be controlled, like firms' marketing expenses. However, the ensuing potential multicollinearity problem is a concern. In subsequent empirical exercises in this thesis, the potential multicollinearity is checked by examining whether individually insignificant variables are jointly significant.

Technology Spillovers from FDI

Testing the technology spillover effect of FDI has attracted a lot of attention[5], partly because economists think the foreign firms usually have some advantages (most often technological superiority) to offset their disadvantages compared with local firms. These advantages will inevitably benefit their local counterparts, and this implies that spillovers occur.

Theoretically, technology diffusion has been modelled through technology transfer and spillovers. There are two kinds of hypothesis regarding technology diffusion. One is that the larger the gap between domestic and foreign countries, the quicker the domestic country will be able to catch up internationally (because of relative backwardness), namely there exists technological convergence. This sort of idea comes from the observation that the less developed is a country compared with the industrialized countries, the quicker it will develop (Veblen, 1915, Gerschenkron, 1962). The other is that technology diffusion can be viewed like the spread of a contagious disease (that is, with a contagion effect). This idea emphasizes the importance of personal contacts in the process of technology diffusion. Technology is most effectively copied if there are inter-personal contacts between the actual users of technology and potential users of technology. Findlay (1978) captures these two hypothesises by proposing a function where the growth rate of domestic technology in a backward region is an increasing function of the technology gap

[5] A more complete survey of empirical studies on technology spillovers of FDI can be found in Gorg and Greenaway (2004).

between an advanced region and the backward region, and an increasing function of foreign presence (the ratio of the capital stock of FDI invested firms to that of domestic firms in the backward region). Then he shows that the technology gap and foreign presence converge to a steady state, which implies technology spillovers from FDI, as the increase of foreign presence leads to a reduction of technology gap.

Assuming a cost-reducing technology and costless spillovers, Das (1987) examines the technology spillovers of FDI in an oligopolistic market where the FDI invested firm is the leader and domestic firms constitute the fringe. Technology spillovers of FDI will reduce domestic firms' production costs and hence will hurt the profitability of FDI invested firms. In spite of this, Das shows that FDI invested firms still import better technology, in that the positive effect of cost saving of better technology outweighs the negative effect of reducing profitability due to spillovers to domestic firms. In contrast to Das' model, Wang and Blomstrom (1998) propose a model in which both the domestic firms' learning activities and the technology transferring process are costly. They show that the technology spillovers from FDI are positively related to the level of host country firms' learning investment.

Findlay's (1978) model emphasises the importance of the technology gap for spillovers. In Chapter 3, we test the role of the technology gap in spillovers using industry level panel data, and show that technology spillovers are negatively related to the technology gap. Das' (1987) model illustrates that indeed FDI invested firms have incentives to bring in technology from their parent firms continuously, even though the technology will spill over to domestic firms. Wang and Blomstrom's (1998) model emphasises the importance of one aspect of domestic firms, namely their investment in learning, in the process of spillovers. This thesis builds on this idea by incorporating numerous other firm characteristics in the empirical analysis, for example the firm size and age, which may also influence their ability to absorb spillovers.

Pioneered by Caves (1974), there are numerous empirical studies on testing technology spillovers from FDI. These empirical studies are often carried out by regressing the productivity of domestic firms or industries against a proxy of FDI, and then a significant and positive estimate of the coefficient implies positive spillovers from FDI. However the results are quite mixed in the sense that some found positive spillovers, while others found negative spillovers or the nonexistence of spillovers. Nevertheless, in regard to China, most studies find positive technology spillovers from FDI.

Li et al. (2001) examine two channels through which FDI spillovers occur, namely the demonstration effect and competition effect, in China's manufacturing sector, using the third industrial census data in 1995. They find positive spillovers, with the scale depending on the types of domestic firm ownership and different sources of FDI. For example, state-owned firms increase their technology level by competing with FDI invested firms. In addition, it is also found that the technology gap, which is measured as the difference in labour productivity between foreign owned firms and domestic firms, plays a negative role in technology spillovers, that is, a smaller technology gap implies larger spillovers. The findings of Li et al. (2001) are further explored by Buckley et al. (2002). Using the same data set, they confirm that collectively-owned firms are more capable of absorbing technology spillovers from FDI than state-owned firms, and that FDI from overseas Chinese multinational enterprises (MNEs) does not generate spillovers in terms of productivity gains, while FDI from non-overseas Chinese MNEs does generate spillovers, which can happen if non-overseas Chinese MNEs are technological superior to overseas Chinese MNEs. Again using the same data set, Chuang and Hsu (2004) find positive evidence of FDI technology spillovers. Like Li et al. (2001), they also examine the role of a technology gap in FDI technology spillovers, by splitting the data set into two subsets over which the regressions were run separately and compared, and found firms with a lower technology gap have bigger spillover benefits.

The studies of Li et al. (2001) and Buckley et al. (2002) show the importance of domestic firms' ownership and source of FDI in technology spillovers. In the subsequent chapters, the ownership of domestic firms is always incorporated into the empirical testing. For the source of FDI, as this thesis aims at exploring what domestic firm characteristics determine the extent of FDI spillovers, we do not distinguish between whether the FDI comes from overseas Chinese MNEs or non-overseas Chinese MNEs, but instead control for the potential effect of not distinguishing overseas and non-overseas Chinese MNEs by using the regional and industry dummies in subsequent empirical exercises. Overseas Chinese MNEs tend to distribute in coastal China and concentrate in certain industries, for example the textile industry. On the role of the technology gap in spillovers, in spite of the idea that bigger technology gap leads to quicker catch up (Findlay, 1978) the studies of both Li et al. (2001) and Chuang and Hsu (2004) yield the opposite finding, namely that the bigger the technology gap the smaller the technology spillovers. In Chapter 3 this study reports the same result.

Similar studies have also been carried out on regional China. Liu (2002) tests the intra-industry and inter-industry technology spillovers of FDI in the manufacturing sector of Shenzhen City, using a panel data from 1993 to 1998, and finds that the relationship between FDI in the manufacturing sector and the level and growth rate of productivity in component industries is significant and positive, and this is interpreted as positive FDI spillovers. Later, using firm level data in the Chinese manufacturing sector, Liu (2008) confirms that an increase in FDI lowers domestic firms' short-term productivity levels, but raises their long-term rates of productivity growth. Chuang and Lin (1999), using firm-level cross-sectional census data in 1991, examine the spillover effects of FDI in Taiwan's manufacturing sector, and find a significant positive effect of FDI on domestic firms' technology development with an elasticity ranging from 1.4 per cent to 1.88 per cent.

Outside China there are many more empirical studies on FDI technology spillovers, with mixed results. At both industry and firm levels, Caves (1974), Sinani and Meyer (2004), Branstetter (2006), and Kohpaiboon (2006) find positive technology spillovers, while, in contrast, Aitken and Harrison (1999), and Sadik and Bolbol (2001) find negative technology spillovers.

In his pioneering work, Caves (1974) uses data for Australia's manufacturing sector to test the effect of MNEs on technology spillovers on domestic firms, and finds a significantly positive relationship between foreign presence and domestic firms' labour productivity. Sinani and Meyer (2004) explore the FDI technology spillovers in Estonian manufacturing sector from 1994 to 1999. They examine the magnitude of intra-industry technology spillovers and how the magnitude varies with the domestic firm characteristics, finding evidence of considerable technology spillovers with the magnitude depending on the size, trade orientation and ownership structure of the recipient firms. Small firms, non-exporting firms, and outsider-owned firms benefit more from spillovers than other types of firms, suggesting that these firms are more capable of absorbing technology spillovers, possibly because of the competition effect. Branstetter (2006) tests the technology spillovers of FDI from Japan on domestic firms in the United States. In his study, patent citations are used to proxy technology, and technology spillovers are defined to exist when the number of patent citations is positively affected by FDI. His estimation shows that Japanese FDI in the U.S. has technology spillovers for domestic firms, and Japanese affiliates with higher technology levels have a stronger impact in terms of spillovers to domestic firms. Kohpaiboon (2006) examines the technology spillovers of FDI in Thailand by testing the Bhagwati (1973) hypothesis that the technology spillovers are conditioned by the nature of the trade policy regime, that is, the technology spillovers are more likely to happen under an export promotion policy regime than an import substitution policy regime. His study does not reject the Bhagwati hypothesis, and also confirms that trade barriers and domestic market size play important roles in determining FDI participation. In different industries FDI may have quite different effects in terms of the scale of technology spillovers. Alvarez and Molero (2005) examine whether FDI has a different degree of technology spillover in industries with different of technology intensity in Spain's manufacturing sector and find that in low-tech industries there exist significant technology spillovers but not in medium-tech and high-tech industries.

FDI may also have negative technology spillovers on domestic firms (that is, the presence of FDI may actually hurt domestic firms), as discussed in the previous section. Aitken and Harrison (1999) provide evidence of this from Venezuela. Using firm level panel data, they find foreign investment negatively affects the productivity of domestic firms, with the magnitude of negative spillovers ranging from -0.21 per cent to -0.32 per cent in different specifications. The explanation suggested is a market-stealing effect, that is, even though the presence of FDI may lower domestic firms' average costs (positive spillovers), it can also squeeze its domestic markets by drawing demand away from domestic firms if the market is imperfectly competitive, particularly in the short run. Sadik and Bolbol (2001) employ a growth accounting framework to study FDI technology spillovers in six Arab countries (Oman, Morocco, Saudi Arabia, Jordan, Tunisia, and Egypt) from 1978 to 1998. They find that for Oman, Morocco, and Jordan, there exist insignificant spillovers, but for the other three countries there exist negative and significant spillovers.

So we can see the empirical tests of technology spillovers from FDI give mixed results. What are the reasons behind this? Gorg and Strobl (2001) test whether the differences in research design, methodology, and data play a role, by conducting a meta-analysis of the literature on multinational companies and productivity spillovers over a sample consisting of 25 observations which are taken from 18 published papers and 3 unpublished papers. Their analysis finds that research design affects the results of studies. Specifically, cross-sectional studies usually find higher productivity spillovers than panel data studies, different definitions of foreign presence also tend to affect the results, and the studies with significant results are more likely to be published, namely there exists a 'publication bias'. Gorg and Strobl's study sheds light on the presence of mixed results in the empirical studies of FDI's technology spillovers. Based on their findings, we use both cross-sectional and panel data, and three measurements of foreign presence in the empirical exercises later, in order to ensure the robustness of the estimations.

Export Spillovers from FDI

In addition to technology spillovers, FDI also affects domestic firms' and industries' exports. Most studies of this issue focus on the impact of FDI on exports at an aggregate level, for which a positive impact from FDI on aggregate exports may imply export spillovers, and in contrast far fewer of them directly handle export spillovers at the firm level.

At an aggregate level, analysts usually examine whether the FDI determines or predicts exports. If FDI positively determines or predicts exports, then there may be export spillovers from FDI. In his review, Lipsey (2002) reveals that several country and industry studies (for example Rhee and Belot, 1990) show that FDI inflow positively affects exports by establishing new industries or sub-industries and transforming the host country from being an exporter of raw material and foods to being an exporter of manufacturing goods. In this process, presumably FDI positively affects domestic firms' exports, and there are export spillovers.

In addition to his review, Lipsey also investigates outward FDI's impact on aggregate exports in the US. Lipsey and Weiss (1981) examine the impact of direct investment by US firms (outward FDI) on exports to 44 foreign destinations by the US in 1970 at the three-digit level of manufacturing industries. Measuring outward direct investment by the output of US-owned affiliates and the number of foreign-owned manufacturing affiliates in each country, they find that there is a positive relationship between US affiliates' output and US exports. Later, Lipsey and Weiss (1984) use firm level cross sectional survey data to confirm the positive relationship between US firms' foreign affiliate activities and exports. Their estimation shows that the higher the level of output of a US firm in a foreign country (outward US FDI firm activities), the higher in general were that firm's exports from the US to that country. Outward FDI can bring home knowledge about the foreign market where its affiliates are located, and can spill over to other firms in home countries, boosting home country's exports to that market. The positive impact on exports by the outward FDI is also confirmed by Lin (1995). Lin (1995) looks at the trade effect of both the stock and flow of outward FDI in Taiwan from 1972 to 1992, and finds that the outward flow and stock of FDI have a significant and positive impact on the exports.

In assessing the general determinants of intra-EC (European Union) trade patterns, Fontagne et al. (1997) find that FDI has a significant and positive effect on both the intra-industry (vertical and horizontal) and inter-industry trade. Using a dataset of bilateral trade and FDI flows constructed by the OECD, Fontagne (1999) explores the relationship between inward/outward FDI and the export/import/trade balance in the UK, US, France, and the aggregation of 14 European countries at an industry level. The analysis shows that there exists a complementary relationship between both inward and outward FDI and exports and imports. Bento (2004) investigates the pattern and determinants of Portugal's trade in manufactured goods from 1971 to 1998. Using time series econometrics to capture dynamic nature of FDI's impact on exports, he examines the impact of manufacturing related FDI on the net exports, and finds that FDI inflows positively affect both the export and import.

In addition to studies that treat FDI as a determinant of exports, some studies focus on whether FDI positively predicts (causes) exports. If FDI positively predicts exports, then there are potentially export spillovers from FDI. Mello and Fukasaku (2000) examine the relationship between trade and inward FDI in selected Latin American and Southeast Asian economies, using time series covering the period 1970 to 1994. The results seem rather mixed in the sense that for some countries the causality, namely whether FDI positively predicts exports, exists but for other countries it does not. Liu et al. (2001) examine the causality between FDI and exports/imports in China, using a panel of annual bilateral data for China and 19 home countries/regions over the period 1984-1998. Granger causality tests show that the growth of China's imports Granger causes the growth of the FDI stock from a home country/region, which in turn Granger causes the growth of exports from China to this country/region. Shan (2002) adopts the impulse response function and variance decomposition technique to analyse the dynamic relationship between financial development and different economic variables within a framework of the vector autoregression model, in which FDI is one variable examined, and finds that the exports made a low contribution to the forecast error variance of FDI and FDI made a higher contribution to the forecast error variance of the exports, which implies a positive impact on exports by FDI. Aizenman and Noy (2006) investigate the inter-temporal link between FDI and trade using an annual panel data set of 81 countries from 1982 to 1998. Their empirical estimation confirms the existence of such linkages, and the feedback between FDI and manufacturing trade is the strongest linkage.

All these studies at the aggregate level are carried out in two frameworks[6]: one is whether FDI is a positive determinant of exports (that is, whether FDI of the current period positively affects exports of current period) and the other is whether FDI of previous periods positively Granger causes (predicts) exports of current period. Even though most of these studies find FDI positively affects aggregate exports, which implies potential export spillovers from FDI, these studies usually do not target the impact of the FDI on exports directly, and instead are by-products in addressing other issues. Nevertheless, they do reveal the possibility of export spillovers from FDI. Further studies that directly handle the impact of FDI on exports at the firm level are needed. This thesis will adopt an approach that directly addresses this issue.

Compared with studies that test the impact of FDI on aggregate exports as described above, there are far fewer studies that directly handle export spillovers of FDI at the firm level. Aitken et al. (1997) examine whether FDI firms' export activities reduce domestic firms' export costs in Mexico from 1986 to 1990. They find that the probability of a firm's exporting is positively correlated with the local concentration of multinational enterprises' activities, and uncorrelated with the local concentration of total export activities. In other words, domestic firms benefit from being near to multinational firms, even after accounting for the possibility that multinational firms

[6] Another line of study is made within the intra-industry trade framework, which tests whether FDI promotes intra-industry trade. For example, Hu and Ma (1999) study the determinants of intra-industry trade in China by using three-digit SITC cross-sectional data for 1995, and find that the FDI has a significant and positive impact on the vertical intra-industry trade. Similarly, using a panel data from 1992 to 2001, Zhang et al. (2005) find FDI exerts positive and significant effect on intra-industry trade, in exploring the determinants of the intra-industry trade in China. Li et al. (2003) test the determinants of intra-industry trade in the insurance service sector between the US and its 26 trading partners, using both cross-sectional and two year pooled data in 1995 and 1996. They find that FDI in the insurance service sector contributes significantly to the growth of trade in insurance services.

choose to invest where domestic firms are better. Extending Aitken et al.'s (1997) work, Greenaway et al. (2004) test export spillovers from FDI in the United Kingdom. They find that the intensity of foreign R&D expenditure, and the relative importance of multinational enterprises' production have positive impact on domestic firms' probability and propensity (which is equal to the share of firms' exports in their total sales) to export, while multinational enterprises' export activities promote domestic firms' probability to export, but not domestic firms' export propensity. Kneller and Pisu (2007) further examine export spillovers of FDI in the United Kingdom, by distinguishing horizontal export spillovers and vertical export spillovers. They confirm the existence of significant export spillovers from FDI in the UK. Furthermore, they find significant and positive horizontal and regional export spillovers from FDI on the probability of a firm's exporting, and significant backward vertical spillovers on firms' export intensity, which implies export spillovers are not homogenous; later we capture this by allowing export spillovers to vary across firms. Ruane and Sutherland (2005) test export spillovers from FDI in Ireland. Following Aitken et al. (1997) and Greenaway et al. (2004), they estimate export spillovers of FDI from firm level census data on the Irish manufacturing sector that covers 3,561 firms from 1991 to 1998. They find that domestic firms' decisions on whether to export are positively affected by the presence of FDI in the sector, while in contrast their export intensity is negatively associated with the export sales ratio of FDI firms.

Willmore (1992) examines the impact of firms' foreign ownership on domestic firms' exports and imports, using cross-sectional data that covers 17,053 firms in Brazil. Foreign ownership, which is a dummy variable that takes a value of one if the firm is foreign owned, has a large and independent effect on both export performance and import propensity. In studying the impact of FDI under different trade regimes in Uruguay, Kokko et al. (2001) find the presence of foreign affiliates established after 1973, when the Uruguayan trade regime changed from import substitution to export orientation, raises the likelihood that domestic firms participate in exporting, confirming the Bhagwati hypothesis. Barrios et al. (2003)

study the impact on domestic firms’ exports of FDI and R&D in Spain. After controlling for firm age, size, productivity, wage, and domestic firms’ R&D intensity, they find a positive spillover effect from multinational enterprises’ R&D activities, but not from their export activities. Swensen (2007) studies the relationship between FDI firms and private Chinese firms’ exports between 1997 and 2003, and finds that the FDI firms’ export activities are positively associated with the creation of trading relationships of private Chinese firms, and this effect is particularly large when the FDI firms are in the same industry.

This chapter has surveyed current studies of the spillover effects of FDI, including technology spillovers and export spillovers. Analysts find mixed results in respect of technology spillovers, as some studies reveal a positive impact from FDI while other studies show a negative impact. On export spillovers, studies of aggregated data find FDI causes trade, implying the presence of export spillovers. At the disaggregated firm level, there are fewer studies, but all of them find that FDI positively affects the probability of a domestic firm’s exporting and the intensity of its exporting. This review lays a foundation for the empirical analysis in subsequent chapters in which some of the findings of previous studies are incorporated. For example, we incorporate the ownership of domestic firms into empirical regressions as a control variable because some previous studies find firms’ ownership significantly affects their productivity and exports.

3. Testing Technology Spillovers at Industry Level

FDI not only adds to the accumulation of physical capital, it also has the potential to contribute to the productivity growth of the host economy through technology spillovers to domestic firms and industries. Are technology spillovers from FDI important in China? If so, what factors influence the scale of technology spillovers? This chapter examines these two issues, using industry level data.

In Chapter 2, we reviewed recent studies of technology spillover, and found that the results are quite mixed, in the sense that some find positive spillovers, while others find negative spillovers or no evidence of significant spillover effects. For example, Caves (1974), Chuang and Lin (1999), Sinani and Meyer (2004), Branstetter (2006), and Kohpaiboon (2006) find positive spillovers from FDI in Australia, Taiwan, Estonia, United States, and Thailand, while Aitken and Harrison (1999) and Sadik and Bolbol (2001) find negative evidence in Venezuela and five Arab countries (Morocco, Saudi Arabia, Jordan, Tunisia, and Egypt). One implication is that technology spillovers from FDI may indeed be different across time, industries, and countries. Hence in this chapter, we account for this possibility, by allowing for the technological impact of FDI to vary across time and industries. To the best of our knowledge, this study is the first to attempt this. In addition, our study is also different from previous research in that we use a proxy for technology transfer of FDI, instead of the commonly used proxy for FDI, foreign presence calculated as a share of the output, equity, or employment of FDI invested firms in the industry.

The chapter is organized as follows. The next section provides an overview of FDI inflow into China. Then we set out an analytical framework for assessing the effect of FDI spillovers. The econometric specification and hypothesis testing using the analytical framework follows. The data set and variables used in the estimation are then discussed. The estimation results are presented and reviewed. The conclusion follows.

Overview of FDI in China

In Chapter 1, we established the importance of FDI in Chinese economy. Here we provide a more detailed overview on FDI in China, with a focus on features that may affect empirical testing of FDI spillovers. The level of FDI inflow in China has been rapidly growing in the past three decades, as shown in Figure 1.1, even though the trend of its growth, after accounting for growth due to the scale of the economy, appears to be declining. Accompanying the overall increase in FDI inflow, there are two features that can potentially affect empirical testing of FDI spillovers. The first is the concentration of FDI in the manufacturing sector in terms of industry distribution. The second is so-called ‘round-tripping’ FDI, made by domestic investors in response to incentives such as lower tax rates for FDI invested firms.

FDI and GDP growth

From 1985 to 2004, the average annual growth rate of FDI inflow was as high as 15.2 per cent. In 2004, the inflow of FDI reached US $60.6 billion. Figure 3.1 presents a picture of the annual growth rate of GDP and FDI inflow in China since 1985. We can see that there are similar trends in GDP and FDI. The correlation between the annual growth rates of GDP and FDI inflow is as high as 0.7. This suggests that FDI inflow in China may have contributed substantially to economic development[7]. The curve in the figure shows the trend in FDI growth, and indicates that, except in 1998-99, FDI inflow in China maintained a rising trend. The decline of FDI inflow in 1998-99 was a result of the Asian financial crisis that undermined foreign investors’ confidence in Chinese economy.

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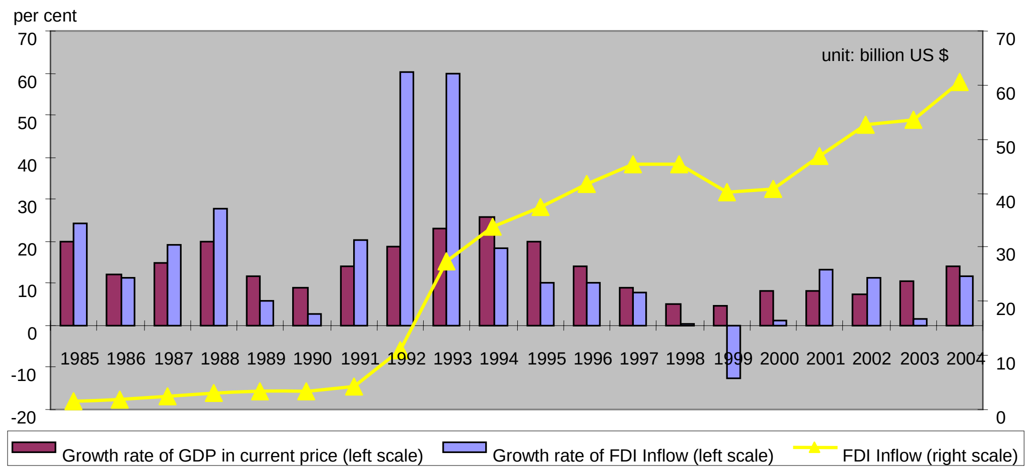
[7] However it is also possible that that higher economic growth rate and bigger economy will attract more FDI inflow. Hence this tells nothing about the direction of causality.

Figure 3.1 China's FDI Inflow and GDP Growth Since 1985

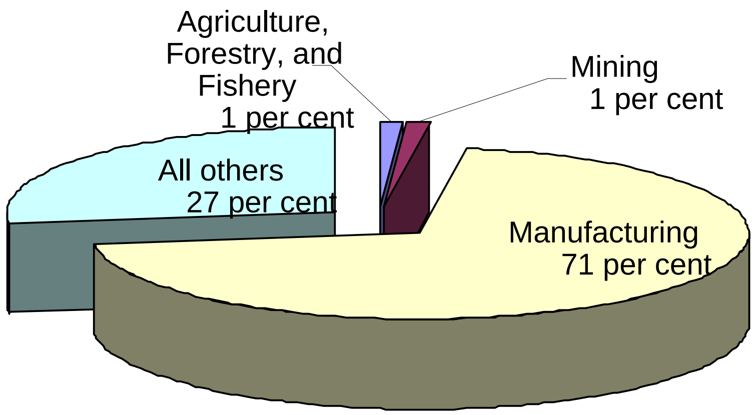


Source: *China Statistical Yearbook*, 2005

Industry distribution

FDI in China is concentrated in the manufacturing sector, which has continually ranked number one as the destination for FDI inflow. Measured in terms of the stock of FDI, the manufacturing sector is the biggest recipient of FDI in China, and roughly takes account of two thirds of China's total FDI stock. The real estate industry accounts for about 21 per cent of total FDI stock, and other industries account for about eight per cent of total FDI stock (MOFCOM, 2005). In contrast, FDI inflow into the service industries has been slower. FDI inflow in all sectors in 2004, except in the service industries, grew positively, while FDI inflow in the service industries declined. Figure 3.2 shows the industry distribution of FDI in China in 2004. The manufacturing sector alone accounted for 71 per cent of actually-utilized FDI in the year.

Figure 3.2 Industry Distribution of FDI in 2004



Source: MOFCOM website, 2005, http://www.mofcom.gov.cn

One reason for the focus of FDI inflow into the manufacturing sector may be the emphasis in government policy. In order to optimize its industry structure, the central government launched the *Catalogue for the Guidance of Foreign Investment Industries* in 1995, which classified all industries into four categories: investments that were encouraged, investments that were allowed, restricted investments, and prohibited investments. Many sub-industries within the manufacturing sector fall into the category of investment that is encouraged.

This kind of classification creates a potential problem for empirical FDI studies in China, namely the endogeneity problem. If the classification is made according to the growth prospects of industries, for example high-growth industries are ‘encouraged’, then FDI inflow will self-select into high growth industries. It is also possible that the standard happens to be correlated with the growth prospect of industries. For example high-tech industries are usually encouraged, but high-tech industries also usually grow more quickly than other industries. However, as will be discussed later, the endogeneity test by using instrumental variables fails to reject the null hypothesis of no evidence of the endogeneity problem.

Problem of round-tripping FDI

Another issue in empirical study of FDI in China is the round-tripping problem. China offers many policy privileges to FDI invested firms, including low tax rates, favourable land use rights, administrative support, and favourable financial services from domestic and foreign financial institutions (Xiao, 2004). This gives domestic capital a large incentive to go offshore and return, in the guise of FDI, in order to make use of various privileges offered by both central and local governments. According to a World Bank estimation (2002, cited in Xiao 2004), round-tripping FDI inflow could be as high as one quarter of total FDI inflow. The estimate of Xiao (2004) is even higher, at 40 per cent of total FDI inflow.

Like normal FDI, round-tripping FDI inflow also serves capital accumulation. It is doubtful, however, that it will have the same technology effect as normal FDI inflow. Hence, in measuring the technology effect, it is better to distinguish round-tripping FDI from regular FDI. Yet it is very difficult to distinguish the two in practice due to lack of information and data. One simple approach is to look at the source country of FDI inflow since domestic capital usually flows out to countries and regions that have less control on capital movements. If FDI inflow comes from developed countries, it is more likely that it is regular FDI. If the FDI inflow comes from offshore financial centres or countries and regions that enjoy a reputation of less capital movement control, then it is more likely that it is round-tripping FDI. Table 3.1 shows the top ten countries and regions that were sources of FDI in 2001, 2002, and 2003. We can see that FDI inflow from the Virgin Islands ranked in the top two consecutively in 2001, 2002 and 2003; FDI from Cayman Islands ranked in the top nine in 2001 and top eight in 2002 and 2003; and FDI from Samoa which is not reported in the table ranked in the top 11 in 2002 and top ten in 2002 and 2003. Altogether, FDI from these three regions accounted for 14.2 per cent, 15.5 per cent, and 15.3 per cent of FDI in 2001, 2002 and 2003 respectively. Considering that these regions have less control over capital movement than many other countries and regions, it is reasonable to suspect that FDI from these regions is more likely to have been round-tripping investment. This problem is handled by excluding these countries and regions in constructing the proxy for technology transfer in the following section.

Table 3.1 Source of FDI Inflow

Rank	2001	2002	2003
1	Hong Kong	Hong Kong	Hong Kong
2	Virgin Islands	Virgin Islands	Virgin Islands
3	U.S.	U.S.	U.S.
4	Japan	Japan	Japan
5	Taiwan	Taiwan	Taiwan
6	Korea	Korea	Korea
7	Singapore	Singapore	Singapore
8	Germany	Cayman Islands	Cayman Islands
9	Cayman Islands	Germany	Germany
10	Britain	Britain	Britain

Source: MOFCOM, 2005

FDI inflow is concentrated in the manufacturing sector, and round-tripping FDI accounts for a significant proportion of FDI inflow and both features can create problems of the endogeneity and over-estimation in analysing FDI inflows. The endogeneity problem is dealt with by the instrumental variable estimation, and the round-tripping FDI problem is accommodated by excluding potential sources of round-tripping FDI in constructing the proxy of technology transfer.

Analytical Framework

In an industry composed of domestic firms and MNE affiliates, the output of the industry is described by an aggregate Cobb-Douglas production function, as:

$$Y = AK^{\alpha}L^{\beta} \tag{3.1}$$

where Y is the output; K is the stock of domestic physical capital and FDI; A is the technology level; and L is the labour supply. In addition to the direct contribution of FDI as a part of the capital stock, it also exerts an indirect impact on the output through the technology A, that is, technology transfer and subsequent potential technology spillovers, which can happen through several channels as discussed in Chapter 2. Hence the technology A in the industry depends on the technology brought by FDI, and is assumed as:

$$A = (A_f)^B E \tag{3.2}$$

where E denotes the exogenous technical factors, which captures all the other factors that contribute to technology formation, and A_f denotes the technology transfer from FDI. A_f is subject to an efficiency parameter *B*, which can be used to measure the existence of spillovers.

Technology spillovers exist if the technology transfer of FDI triggers a positive domestic technology formation. Hence technology spillovers can be measured by the elasticity of domestic technology with respect to the technology brought by FDI ($\frac{\dot{A}/A}{\dot{A}_f/A_f}$, where A denotes technology stock and the subscript f denotes the technology brought by FDI). If the elasticity is positive, then the technology transfer of FDI generates positive domestic technology accumulation, and thus there exist technology spillovers from FDI. From equation (3.2), $\frac{\dot{A}/A}{\dot{A}_f/A_f} = B$.

Therefore, spillovers exist if and only if $B > 0$. In addition, a bigger value of parameter *B* implies a bigger domestic technology formation, for a given one per cent increase of technology transfer by FDI. That is, the domestic industry can utilize the technology brought by FDI more efficiently.

Since the parameter *B* denotes the efficiency with which the domestic industry can utilize the technology brought by FDI, and can measure the existence of technology spillovers, *B* will be assumed to be endogenously determined by the interaction of research efforts, captured by firms' R&D expenditure, of representative domestic firms and FDI invested firms, as:

$$B = f(x_1, x_2) = \log\left(x_2 / x_1 \right)$$

s.t.

$f_1^{'} < 0 \quad f_{11}^{''} \geq 0$ (assumption1)

$f_2^{'} > 0 \quad f_{22}^{''} \leq 0$ (assumption2)

$f_{12}^{''} \leq 0$ (assumption3)

where x_1 is the research effort of FDI invested firm, which is carried out in its parent firm and thus exogenous, and x_2 is the research effort of domestic firm.

The research effort of a FDI invested firm captures its investment in technological development. The higher the FDI invested firm's research effort, the more superior its technology level is likely to be, and the larger the technology gap will be[8]. Thus it is then more difficult for a domestic firm to learn from a FDI invested firm and in turn the less the spillover effect. Furthermore, as the FDI invested firm increases its research effort, not only does it become more difficult for a domestic firm to learn, but also the marginal difficulty of learning becomes larger and larger. This idea is captured by Assumption 1, in which the negative first partial derivative ($f_1^{'} < 0$) implies that it is more difficult for a domestic firm to learn if FDI invested firm exerts more research effort and the positive second partial derivative ($f_{11}^{''} \geq 0$) implies the increasing marginal difficulty of learning.

The research effort of domestic firm captures its investment in learning, one important aspect of domestic firms in the process of technological spillovers as

[8] In regard to the role of a technology gap in spillovers, as discovered above, there is one idea that the bigger the technology gap, the quicker the catch-up, that is a sort of convergence, for example Findlay (1978). However, there are some empirical studies supporting the idea that smaller technology gap makes larger technology spillovers, for example Chuang and Hsu (2004) and Li et al. (2001).

emphasised by Wang and Blomstrom (1998). The more effort a domestic firm exerts, the bigger technology spillovers are likely to be. However, due to the decreasing marginal productivity of investment in learning, the increase of technology spillovers is subject to decreasing pace. This idea is captured by Assumption 2, in which the positive first partial derivative ($f_2^{'} > 0$) implies the positive role of domestic firm's investment in learning and the negative second partial derivative ($f_{22}^{''} \leq 0$) implies the diminishing marginal productivity of investment in learning.

Assumption 3 ensures that the increase in a FDI invested firm's research effort will lower the marginal productivity of domestic research effort and hence to keep the efficiency parameter (*B*) unchanged, more domestic research efforts are needed. From the assumption of firm's profit maximization, we can derive the optimal behaviour of domestic firm's research efforts.

To do so, suppose firms are endowed with fixed resources, capital *K* and labour *L*, for simplicity[9]. The firm's problem is to decide the allocation of the endowment between R&D and production, in order to maximize its profit. The role of R&D is to increase firms' technology level, which in turn improves efficiency in the production process. The firm is faced with linear market demand, $p = a - bQ$, and exogenous factor prices, *w* (labour wage) and *r* (real interest rate). The firm's production function is $Q = Q(k_1, l_1, X)$; the R&D function is $X = X(k_2, l_2, FDI)$; the firm's total cost is $TC = Kr + Lw$; the resource constraints are: $k_1 + k_2 = K$ and $l_1 + l_2 = L$, where the subscript 1 denotes resources used in production, and 2 denotes resources used in R&D, and *FDI* denotes the presence of FDI, which

[9] To maximize profit, the firm is faced with a two-stage problem. At stage 1, it decides how many resources (capital and labour) to buy in the factor market. Then at stage 2 it decides the allocation of resources between R&D and production. However, here the stage 1 problem is abstracted away.

positively affect domestic firm's R&D, reflecting the firm level externality from FDI.

Then the firm's problem[10] is to:

$$\max_{\{k_1,l_1,k_2,l_2\}} \pi = [a - bQ(k_1, l_1, X(k_2, l_2.FDI))]Q(k_1, l_1, X(k_2, l_2, FDI)) - TC$$

s.t. $k_1 + k_2 = K$, and $l_1 + l_2 = L$.

Solving the problem, we can obtain:

$$Q'_{k_1} = Q'_x X'_{k_2}$$

$$Q'_{l_1} = Q'_x X'_{l_2}$$

which says the marginal product of each resource (capital and labour) used in production should be equal to the marginal product of each resource used in R&D.

Then in order to solve for k_2 and l_2 explicitly, functional forms of production and R&D are specified. We assume the most commonly used Cobb-Douglas functional form, as follows:

$$Q = k_1^{\alpha} l_1^{\beta} x$$

$$x = A^{\lambda} k_2^{\gamma} l_2^{\eta}$$

where A denotes the industry technology stock and is an implicit increasing function of FDI.

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[10] Here the firm is monopolist. However, if the firm is a price taker, the solution to the profit maximization problem obtains same results.

Hence, we can solve for k_2 and l_2 as:

$$k_2 = \frac{\gamma}{\alpha+\gamma}K\,,\; l_2 = \frac{\eta}{\beta+\eta}L$$

Then the optimal research effort of domestic firms is:

$$x = CA^{\lambda}K^{\gamma}L^{\eta}$$

where $C \equiv \left(\frac{\gamma}{\alpha+\gamma}\right)^{\gamma}\left(\frac{\eta}{\beta+\eta}\right)^{\eta}$.

Similar reasoning can be applied to determine the optimal level of research effort of FDI invested firms. We can find $x_w = CA_w^{\lambda}K_w^{\gamma}L_w^{\eta}$, where the subscript *w* denotes 'world'. Thus plugging domestic firm's research effort ($x = CA^{\lambda}K^{\gamma}L^{\eta}$) and FDI invested firm's research effort ($x_w = CA_w^{\lambda}K_w^{\gamma}L_w^{\eta}$) into $B = \log\left({x_2}/{x_1}\right)$, we obtain

$$B = -\lambda\log\left(\frac{A_w}{A}\right) + \gamma\log\left(\frac{K/L}{K_w/L_w}\right) + (\eta-\gamma)\log\left(\frac{L}{L_w}\right) \qquad (3.3)$$

Equation (3.3) says the efficiency parameter B is determined by three components: the technology gap, the relative capital-labour ratio (relative factor intensity), and relative labour supply[11]. The technology gap A_w/A has a negative impact on *B*. The larger the technology gap, the less capability the domestic industry has to absorb technology transferred. From equation (3.3),

[11] It should be noted that equation (3.3) implicitly assumes the domestic and foreign R&D functions have same parameters.

$\frac{\partial B}{\partial \log(A)} = \lambda > 0$, which says that if a country has a larger technology stock, it will be easier to use the foreign technology. The relative capital-labour ratio, $\frac{K/L}{K_w/L_w}$, characterizes the comparison of capital-labour ratios between the foreign country and host industry. As both the investment in learning by domestic industry and investment in technological development by foreign industry are capital intensive activities, a ratio higher than 1 implies that the domestic industry can afford to allocate more capital resources in learning than capital resources allocated by the foreign industry in technological development, and hence the domestic industry will be more capable of making use of technology introduced through FDI. If this ratio is less than 1, it implies that the domestic industry is not able to make full use of the technology brought in through FDI. Relative labour supply[12], L/L_w, may have a positive/negative/zero impact on *B*, which depends on the parameters of the R&D function. A higher value of relative labour supply implies that there is relatively more labour in the domestic industry than the foreign industry, and hence it is more likely that technology spillovers will occur due to the contagious effect. Meanwhile the supply of labour is closely correlated with the factor intensity of the industry, namely a higher relative labour supply indicates that the domestic industry is relatively more labour intensive than the foreign industry, which is not good for such capital intensive activity as investment in learning.

Econometric Specification and Hypothesis Testing

By inserting equations (3.2) and (3.3) into equation (3.1), and taking logs of both sides, we can get:

[12] It would be more reasonable to think that human capital will also play a part in the R&D, which can be easily incorporated by adding human capital into the R&D function. However, due to the data constraint in the subsequent empirical testing, we do not incorporate the human capital here.

$$\log Y = -\lambda \log \frac{A_w}{A} \log A_f + \gamma \log \frac{K/L}{K_w/L_w} \log A_f + (\eta - \gamma) \log \frac{L}{L_w} \log A_f$$
$$+ \alpha \log K + \beta \log L + \log E$$

Hence, the econometric specification can be written as:

$$\begin{aligned} \log(Y_{it}) &= \beta_0 + \delta_1 \log A_{fit} \times \log rA_{it} + \delta_2 \log A_{fit} \times \log rK_{it} \\ &+ \delta_3 \log A_{fit} \times \log rL_{it} + \beta_1 \log K_{it} + \beta_2 \log L_{it} + v_{it} \\ v_{it} &= \alpha_i + \lambda t + \gamma t^2 + u_{it} \end{aligned} \qquad (3.4)$$

where i denotes the industry, t denotes time, rA denotes the technology gap, $\frac{A_w}{A}$, rK denotes the relative factor intensity, $\frac{K/L}{K_w/L_w}$, and rL denotes the relative labour supply, $\frac{L}{L_w}$. In the composite error term v_{it}, we allow for the industry fixed effect (α_i), which controls for the industry heterogeneity in production and technology accumulation, and potential time constant omitted variables, a nonlinear time trend ($\lambda t + \gamma t^2$) which can control for other potential time varying omitted variables[13], and i.i.d. normal idiosyncratic error terms (u_{it}). The exogenous technical factors in equation (3.2) are captured by the industry fixed effect and quadratic time trend.

In equation (3.4), testing the existence of technology spillovers from FDI follows two steps: first test the joint significance of δ_1, δ_2, and δ_3. If these are jointly insignificant, then the technology spillovers do not exist. Second, differentiate equation (3.4) with respect to $\log A_{fit}$, to obtain the technology transfer elasticity:

[13] See Chow and Lin (2002)

$$\varepsilon = \delta_1 \log rA_{it} + \delta_2 \log rK_{it} + \delta_3 \log rL_{it} \tag{3.5}$$

where ε denotes the technology transfer elasticity, namely the percentage that domestic technology will grow for one per cent increase in technology transfer by FDI. We then insert the estimated δ_1, δ_2, and δ_3 into equation (3.5), and evaluate it at the industry's technology gap (in log form), relative factor intensity (in log form), and relative labour supply (in log form). If the evaluated elasticity is positive, we can then conclude there exist technology spillovers from FDI as the technology transfer of FDI generates positive impact on domestic technology formation. The elasticity depends on three factors: the technology gap, relative factor intensity, and relative labour supply, which can be different across industries. Hence the specification in equation (3.4) actually allows for the possibility that FDI may have different impacts on different domestic industries. This possibility is not accommodated for by previous studies.

In equation (3.4), we can also examine the role of the technology gap, relative factor intensity, and relative labour supply in the industry's utilization efficiency of the technology transfer by FDI[14]. Differentiating equation (3.5) with respect to $\log rA_{it}$, $\log rK_{it}$, and $\log rL_{it}$ respectively, we obtain $\frac{\partial \varepsilon}{\partial \log rA_{it}} = \delta_1$, $\frac{\partial \varepsilon}{\partial \log rK_{it}} = \delta_2$, and $\frac{\partial \varepsilon}{\partial \log rL_{it}} = \delta_3$. Hence the sign and significance of the estimated δ_1, δ_2, and δ_3 will show the impact of the technology gap, relative factor intensity, and relative labour supply. As shown in the above, we expect the technology gap plays a negative role, that is, δ_1 is negative, and the relative factor intensity plays a positive role, i.e. δ_2 is positive. No prior expectation can be made in regard to the role of the relative labour supply.

[14] In the case where the technology spillovers do happen ($\varepsilon > 0$), then we are actually examining the determinants of technology spillovers.

The Data

Summary of the original data set

The data set used in the analysis here is an eight-year panel from 1995 to 2003, which comes from *China Statistical Yearbooks* 1996-2004, and UNIDO INTSTAT3 database, 2004. It covers 23 industries in the manufacturing sector. The 1998 data are not included due to lack of FDI data.

The data from *China Statistical Yearbook* contain the gross value of output in current prices, value added in current prices, number of employees, original value of fixed assets, annual balance of net value of fixed assets, and working capital. The data from UNIDO INTSTAT3 database, 2004, contain the output value and value added in nominal US dollars, number of employees, and gross fixed capital formation in nominal US dollars. These four variables are used to construct the proxy for technology transfer by FDI (A_f), technology gap ($\frac{A_w}{A}$), relative factor intensity ($\frac{K/L}{K_w/L_w}$), and relative labour supply ($\frac{L}{L_w}$).

Construction of variables

There are nine variables included in the econometric analysis: the real value added, real capital stock, number of employees, proxy for technology transfer, technology gap, relative factor intensity, relative labour supply, time (equal to the year), and time squared.

The dependent variable used in the econometric analysis is the real value added, obtained by deflating the value added in current price using implicit deflators, which are the ratios of the gross output in current prices and in constant 1990 prices that are obtained from *China Industrial Economy Statistical Yearbook* various issues. The number of employees is used to proxy for labour supply, which even though is not the best measurement [15] is the only available information.

The real capital stock is constructed following Liu (2002), in which Chow's method (1993) is employed to construct the real fixed capital stock that is then added to real working capital to form real capital stock. In constructing the measure of real fixed capital stock, nominal newly added fixed assets in each year are calculated[16], which is then deflated by the price index of investment in fixed assets to 1991 prices. Then the initial real capital stock is assumed to be the deflated annual balance of the net value of fixed assets in 1995. The annual real fixed capital stock is the sum of the previous year's fixed capital stock and the annual increment. As argued by Liu (2002), it is not reasonable to exclude working capital from the real capital stock as the size of working capital is substantial relative to that of fixed capital. Hence, nominal working capital is then deflated to 1991 prices using the ex-factory price index of industrial products. Deflated working capital is then added to the fixed capital stock to form the real capital stock.

In constructing the proxy for technology transfer by FDI, the technology gap, relative factor intensity, and relative labour supply, the data from the UNIDO INTSTAT3 database, 2004, is applied. As China uses its own national economy industry classification method and UNIDO uses ISIC, we must first reconcile these two industry classifications. Table 3.2 presents the match between China's industry classification and the ISIC 3 digit classification. All data that come from the UNIDO INTSTAT3 database, such as the value of output, value added, and gross fixed capital formation, are deflated to the 1995 price before using them to construct the above four variables, by using the producer price index obtained from the International Financial Statistics, 2004. The data from the UNIDO

[15] The number of working hours better captures the labour inputs.
[16] Even though the 1998 FDI series is not available, other series such as the original value of fixed assets and working capital in 1998 are still available. Hence the construction of real capital stock is not affected by the unavailability of 1998 FDI series.

INSTAT3 database are two-year lagged, reflecting the possibility that technology brought by FDI is lagged, and are summed over 13 countries and regions, namely Hong Kong, the United States, Japan, South Korea, Singapore, Germany, the United Kingdom, Canada, France, Australia, Malaysia, Italy, and Indonesia. This summation is able to represent the FDI inflow in China as the inflow from these 13 countries and regions accounts for over 70 per cent of total FDI inflow into China since 1995. This helps us ameliorate the impact of 'round-tripping' FDI, as discussed above.

The proxy for technology transfer by FDI is computed according to the formula $A_f = \frac{D}{K^w} A^w$, where A_f denotes technology transfer by FDI, D denotes the total assets of FDI invested enterprises, K^w denotes the world gross fixed capital formation, and A^w is the world labour productivity. This formula relates the FDI technology transfer with the world labour productivity, which is scaled down by the ratio of total assets of FDI invested enterprises to world gross fixed capital formation. The advantage of using this proxy is that it alleviates the impact of 'round-tripping' FDI by excluding regions that are potential destination of 'round-tripping' FDI in calculating the world labour productivity.

The technology gap is proxied by the ratio of world labour productivity to labour productivity in China. The relative factor intensity is the ratio of the fixed capital stock per worker in China to the world fixed capital stock per worker. The UNIDO INTSTAT3 database provides the data of gross fixed capital formation, which is deflated and summed to compute the fixed capital stock, assuming the deflated value of gross fixed capital formation in the initial period to be the fixed capital stock in that period. The relative labour supply is the ratio of the number of employees in China to that of the world.

Table 3.2 Match of Industries

	China Classification	ISIC Code	UNIDO Classification
1	Food Processing, and Food Manufacturing	311	Food products
2	Beverage Manufacturing	313	Beverages
3	Tobacco Processing	314	Tobacco
4	Textile Industry	321	Textiles
5	Garments and Other Fiber Products	322	Wearing apparel, except footwear
6	Leather, Furs, Down and Related Products	323	Leather products
7	Timber Processing, Bamboo, Cane, Palm Fiber and Straw Products	331	Wood products, except furniture
8	Furniture Manufacturing	332	Furniture, except metal
9	Papermaking and Paper Products	341	Paper and products
10	Printing and Record Medium Reproduction	342	Printing and publishing
11	Stationery, Educational and Sports Goods	390	Other Manufacturing, including manufacturing of musical instruments, sporting and athletic goods
12	Petroleum Processing and Coking	353	Petroleum refineries
13	Raw Chemical Materials and Chemical Products, Chemical Fibers, and Medical and Pharmaceutical Products	351 352	Industrial chemicals Other chemicals
14	Rubber Products	355	Rubber products
15	Plastic Products	356	Plastic products
16	Nonmetal Mineral Products	369	Other non-metallic mineral products
17	Smelting and Pressing of Ferrous Metals	371	Iron and steel
18	Smelting and Pressing of Nonferrous Metals	372	Non-ferrous metals
19	Metal Products	381	Fabricated metal products
20	Ordinary Machinery, and Instruments, Meters, Cultural and Official Machinery	382	Machinery, except electrical
21	Special Purpose Equipment	385	Professional & scientific equipment
22	Transport Equipment	384	Transport equipment
23	Electric Equipment and Machinery, and Electronic and Telecommunications	383	Machinery, electric

Source: Author's match based on China national industry classification and the International Standard Industrial Classification.

Descriptive statistics

Table 3.3 presents the descriptive statistics for variables used in the regression analysis. We can see that the sample mean for the log value of technology gap, relative factor intensity, and relative labour supply are all positive, indicating that the world has a higher technology level, proxied by labour productivity, and a higher capital labour ratio and labour supply, which satisfied the test of reasonableness.

Table 3.3 Descriptive Statistics

Variables	Obs	Mean	Std.Dev.	Min	Max
ln(value added)	184	6.05	1.19	3.15	9.17
ln(capital)	184	7.10	0.99	4.84	9.26
ln(labour)	184	4.78	0.92	2.73	6.51
ln(technology transfer)	184	3.28	1.07	1.13	6.85
ln(technology gap)	184	0.66	1.03	-4.34	2.56
ln(relative factor intensity)	184	0.21	1.06	-2.90	2.58
ln(relative labour supply)	184	0.17	1.15	-2.29	3.79

Source: constructed from *China Statistical Yearbook*, various issues, and UNIDO INDSTAT Database 2004

Empirical Results and Discussion

Estimation Strategy

To estimate equation (3.4), we first assume FDI inflow in China is exogenous, and then apply the fixed effect and random effect estimators. However, it is likely that the idiosyncratic error terms in equation (3.4) are serially correlated. To check this, the Wooldridge (2002) test for AR(1) autocorrelation is adopted. The Wooldridge test regresses the residuals, obtained from the regression of the first-differenced variables, against their one-period lag, and under the null hypothesis of no serial correlation in the idiosyncratic error terms the coefficient estimated is -0.5. The test statistic is the usual *t* statistic on the estimated coefficient. Drukker (2003) shows that this test has good size and power properties in reasonable sample sizes. In our test, the test statistic is 0.008 with a p-value of 0.93, and hence we conclude that there is no first order autocorrelation at the 5 per cent significance level.

The dependent variable in equation (3.4) is the value added in the industry, which is very different across industries in the manufacturing sector. Hence it appears that there is a potential heteroskedasticity problem. To test for this, a procedure suggested by Wiggins and Poi (2003) is adopted. First, the equation (3.4) is estimated using an iterated GLS estimator by allowing for panel-level heteroskedasticity and by assuming homoskedasticity respectively. Then these two estimations are compared with each other to see whether there is a significant difference. The likelihood ratio test can be adopted to test this as the estimation assuming homoskedasticity is nested within the estimation allowing for panel-level heteroskedasticity. The test statistic we obtained, which is chi-square distributed with degree of freedom of 22, is 115.73 with a p-value of 0. Hence we reject the null hypothesis of homoskedasticity at the 5 per cent significance level. In the fixed effect estimation, we also conduct a modified Wald test for groupwise heteroskedasticity, and obtained a test statistic of 5601.92 with a p-value of 0. Hence at the 5 per cent significance level we reject the null hypothesis of homoskedasticity.

Assuming the exogeneity of FDI, equation (3.4) is estimated using the fixed effect estimator and random effect estimator separately, with robust standard errors computed to account for heteroskedasticity of arbitrary form. In the fixed effect estimation, the F test statistic for the significance of fixed effect, namely the joint significance of industry dummies, is 6.72 with a p-value of 0, which rejects the null hypothesis of no fixed effects. For the fixed effect and random effect estimator, if the fixed effects (or the unobserved industry heterogeneity) are uncorrelated with the regressors, then the random effect estimator is more efficient than the fixed effect estimator, however if they are correlated the random effect estimator will be inconsistent. Under the assumption of conditional homoskedasticity and no autocorrelation, this can be tested by carrying out the Hausman test. Due to the presence of heteroskedasticity which is accommodated by computing the robust standard errors, the Hausman test is invalid. To determine whether the fixed effect estimator or the random effect estimator is appropriate, we conduct an 'omitted variables' version of the Hausman test, which is asymptotically equivalent to the Hausman test. We first compute the time demeaned explanatory variables, the quasi-time demeaned explanatory variables and dependent variable, and then regress the quasi-time demeaned dependent variable against both the time demeaned and quasi-time demeaned explanatory variables. Under the null hypothesis that the fixed effects are uncorrelated with the explanatory variables, namely the random effect estimator is appropriate, the coefficients of time demeaned explanatory variables shall be jointly insignificant, that is, if the random effect estimator is appropriate, the time de-meaned explanatory variables shall have no explanatory power. Hence a joint significance of the coefficients will reject the random effect estimator in favour of the fixed effect estimator. The F statistic for the joint significance of the time demeaned explanatory variables in our test is 13.12 with a p-value of 0. Hence we conclude that the fixed effect estimator is appropriate at the 5 per cent significance level.

Up to this point, FDI is assumed to be exogenous. However, it is possible that FDI is endogenous in equation (3.4), which will make the fixed effect (FE) estimation inconsistent and biased. The endogeneity problem can occur if there is reverse causality, for example FDI tends to flow into industries that are growing more quickly, or FDI is correlated with some unobserved and uncontrolled factors that also have impact on the industry's output, for example the Chinese government's industrial policy may cause FDI to self-select into faster growing industries. This kind of endogeneity of FDI will make the three terms, $\log A_{fit} \times \log rA_{it}$, $\log A_{fit} \times \log rK_{it}$, and $\log A_{fit} \times \log rL_{it}$, correlate with the idiosyncratic error term in equation (3.4), which can not be eliminated by the panel data estimation technique. Hence, with the endogeneity of FDI, our estimation using FE estimator will be biased and inconsistent. To resolve the endogeneity problem of FDI, we employ the instrumental variable (IV) estimator.

The key point of an IV estimator is to identify the instrument of FDI that is correlated with FDI (the relevance of instruments) and uncorrelated with the error term (the validity of instruments). Conventionally, the lagged endogenous variable is a good instrument. So in our IV estimation, we use the one-period lagged $\log A_{fit}$, which is interacted with $\log rA_{it}$ (the log of technology gap), $\log rK_{it}$ (the log of relative factor intensity), and $\log rL_{it}$ (the log of relative labour supply), and the number of firms in the industry as the instruments.

The IV estimation is carried out using Schaffer's (2007) procedure. In the estimation, we first test the relevance and validity of instruments. As discussed in Baum et al. (2003), the relevance of instruments can be tested by examining the fit of the first stage regressions, for which there are three statistics, namely the Bound et al. (1995) partial R^2, the Shea (1997) partial R^2, and the F statistic for joint significance of the lagged variables and the number of firms. Table 3.4 presents the test statistics, which confirms that the instruments are all relevant as both the R^2 are high and the F statistics are significant. For the validity of instruments (overidentifying restriction), as we have more excluded instruments than endogenous variables, we are able to test it using Hansen's (1982) J statistic, which is asymptotically chi-square distributed with degrees of freedom equal to the number of overidentifying restrictions. The J statistic is 1.441 with a p-value of 0.2299. Hence we conclude the instruments are valid at the 5 per cent significance level.

Table 3.4 Test for Relevance of Instruments

Endogenous Variables	Shea Partial R^2	Bound et. al. Partial R^2	F(4, 107)	P-value
ln(technology transfer) ×ln(technology gap)	0.81	0.8133	30.19	0
ln(technology transfer) ×ln(relative labour supply)	0.5208	0.8108	33.3	0
ln(technology transfer) ×ln(relative factor intensity)	0.5071	0.7858	34.69	0

Source: Author's calculation.

As we find evidence of heteroskedasticity in the estimations that assume FDI to be exogenous, it is reasonable to suspect the existence of heteroskedasticity in the IV estimation. The Pagan and Hall (1983) statistic is thus computed to test the heteroskedasticity. The statistic obtained is 60.6 with a p-value of 0.0005, and hence we reject the null hypothesis of homoskedasticity at the 5 per cent significance level. Thus, the robust standard errors are computed in the IV estimator and the feasible efficient two-step GMM estimator which is more efficient than the IV estimator if there is heteroskedasticity (Baum et al., 2003).

The last step in our estimation process is to determine whether the IV/GMM estimators or the FE estimator is more appropriate, which is done by an endogeneity test. The endogeneity test is carried out using the *C* statistic (Hayashi, 2000, Eichenbaum et al., 1988, discussed in Baum et al., 2003), which tests the orthogonality of endogenous variables and is chi-square distributed. The *C* statistic we obtain is 2.951 with a p-value of 0.3992, and hence we fail to reject the null hypothesis of orthogonality of endogenous variables at the 5 per cent significance level, namely there is no endogeneity problem, which is consistent with the finding of Liu (2002). So we conclude the FE estimator is most appropriate to estimate equation (3.4).

Testing for Existence of Technology Spillovers

Table 3.5 presents the estimation results. Columns one to five are the coefficient estimations using the fixed effect (FE) estimator, feasible efficient two-step generalized method of moments (GMM) without instruments, instrumental variable (IV) estimator, feasible efficient two-step GMM estimator with instruments, FE estimator with the dependent variable (value added), the capital and labour being the industry average respectively. In general, the estimated coefficients are robust in the sense that most of the estimate is generally within one or two standard deviations of another estimate. Compared with the FE/IV/GMM estimations, the IV/GMM with instruments estimations get bigger point estimate of coefficients of the relative labour supply and relative factor intensity terms and smaller point estimate of the coefficient of the technology gap terms. As explained in the above estimation strategy, we conclude that the FE estimation in the column one presents the most appropriate estimation of equation (3.4). Hence, the following test for existence of technology spillovers are based on the FE estimation in column one[17].

The estimated coefficients for the capital and labour inputs are both statistically significant (0.4164 for the capital input with *t* statistic of 2.58, 0.4818 for the labour input with *t* statistic of 2.85), and the magnitude is consistent with the findings of Chow (1993), Liu (2002), and Chow and Lin (2002). The coefficients for the nonlinear time trend are both individually significant (*t* statistics for the *t* and t^2 are 6.03 and -6.03 respectively) and jointly significant (*F* statistic is 18.25 with a p-value of 0). The negative coefficient for t^2 and positive coefficient for *t* show an inverse U-shaped time trend, which implies that the manufacturing sector as a whole has experienced positive productivity growth after the capital, labour and FDI factors are conditioned out, but this exogenous productivity growth is subject to a decreasing pace.

As described above, testing for the existence of technology spillovers from FDI follows two steps. First, test the joint significance of coefficients δ_1, δ_2, and δ_3. The *F* statistic obtained is 61.33 with a p-value of 0, which indicates the three coefficients are jointly significant at 5 per cent significance level. Second, plug the estimated coefficients δ_1, δ_2, and δ_3 in to equation (3.5), the technology transfer elasticity, and evaluate it at different industries' value of technology gap, relative factor intensity, and relative labour supply in different periods. If this evaluated elasticity is positive, then the technology transfer by FDI has positive

[17] In addition, compare the FE and GMM without instruments estimations, there is only a negligible difference.

impact on domestic productivity growth, namely there exist technology spillovers from FDI. Table 3.6 presents the obtained technology transfer elasticity across time and industries.

In Table 3.6, a positive figure indicates the FDI has positive impact on domestic industry’s productivity, and hence there exists technology spillovers. In contrast, a negative figure shows the domestic industry actually suffers from the presence of FDI. Table 3.6 shows that most industries actually suffer from the presence of FDI. On average, the elasticity is -0.1114, which indicates that 1 per cent increase in the technology transfer by FDI will decrease domestic productivity by 0.1114 per cent. Nevertheless, Table 3.6 also presents several interesting dynamic patterns on the impact of technology transfer by FDI. First, there are more and more industries that have a positive elasticity over time. In 1995, only one industry, namely the tobacco processing industry, has a positive elasticity. In 1996, 1997, 1999, 2000, 2001, 2002, and 2003, the number of industries with positive elasticities increases to 3, 3, 3, 4, 4, 7, and 20 respectively. Second, most industries’ elasticity is increasing over time (see Figure 3.3 for detail), which reflects the learning effect of domestic industries. Third, from 1999 to 2000, most industries’ elasticity decreases, except for the tobacco processing industry, the smelting and pressing of ferrous metals industry, the electric equipment, machinery, electronic and telecommunications industry, and the petroleum processing and coking industry. The decrease of elasticity in this year may come from the adverse impact of 1997-8 Asian financial crisis when the FDI inflow declined.

The driving forces for our different estimates of technology transfer elasticity across different industries in different time periods are the technology gap, relative factor intensity, and relative labour supply. Our estimation confirms prior expectation. For the technology gap, the coefficient estimated is -0.2027 with a *t* statistic of -13.43, which is significant at the 5 per cent level and indicates that for a 1 per cent increase in the technology gap the technology transfer elasticity will decrease by 0.2027 per cent. For relative factor intensity, the coefficient is 0.052 with a *t* statistic of 1.7, which is significant at the 10 per cent level and indicates that a 1 per cent increase in the relative factor intensity will promote the elasticity by 0.052 per cent. For the relative labour supply, our estimation shows it has positive and significant impact on the elasticity, with 1 per cent increase in the relative labour supply promoting the elasticity by 0.0681 per cent.

Discussion

We test empirically for the technology spillovers of FDI and their determinants in China's 23 industries from 1995 to 2003. As distinct from previous studies, we allow for the FDI's impact on domestic industries to vary across time and industries. We find that for most of the time FDI inflow in China has a negative impact on domestic industries' productivity, which may be caused by the competition effect from FDI. However as time goes by domestic industries benefit more and more from the presence of FDI. In 2003, 20 out of all the 23 industries benefit from the presence of FDI. We also confirm that the technology gap and relative factor intensity play a negative/positive role in the happening of spillovers respectively.

Is this result driven by the aggregation of industry level data? To find out whether our result is sensitive to aggregation problems, we re-estimate equation (3.4) by FE estimator using a dependent variable of log of average industrial value added which is equal to value added divided by the number of firms in the industry, the log of average industrial capital and labour inputs which are equal to the capital and labour inputs divided by the number of firms in the industry respectively. Column (5) of Table 3.5 presents the estimation results. Compared with column (1), the capital and labour coefficients are smaller, but are still within a reasonable range. For the three interaction terms of technology transfer, the estimated coefficients display no significant difference in the sense that they are within one standard deviation of each other. The evaluated elasticity is presented in Table 3.7 and Figure 3.4, which shows no difference compared with Table 3.6 and Figure 3.3. Hence we conclude our estimation result is robust to the data aggregation.

In equation (3.2), domestic technology accumulation in the industry is only affected by FDI flowing into the industry, not by FDI that flows into the other industries. This means that we are only testing intra-industry technology spillovers of FDI, not inter-industry technology spillovers. Besides, we are also not able to distinguish horizontal FDI and vertical FDI. For these two types of FDI, the FDI invested firms will have different power of technology control and in turn will generate different magnitude of spillovers.

Conclusions

In this chapter, we have tried to estimate the technology spillover effect of FDI in China and its determinants with an eight-year balanced industry level panel data set. To do so, we first proposed an analytical framework from which the empirical model is derived and estimated. Unlike previous studies, our study allows for the impact of FDI to vary across time and industries, and moreover we are able to empirically test the determinants by further decomposing the spillover parameter in equation (2) into three general factors: the technology gap, relative factor intensity, and relative labour supply.

Our empirical estimations find that the FDI inflow in China in different industries generates different effects on domestic industries' productivity. On average FDI exerts a negative impact on domestic industry, and for a 1 per cent increase in the technology transfer by FDI, domestic industries' productivity will decrease by 0.1114 per cent. However, domestic industries are doing better and better over time, either because domestic industries learn to handle the challenge of FDI or because the competition effect from FDI lessens as industries consolidate. In 1995 only one industry benefits from the presence of FDI, while in 2003 there are 20 industries that benefit from the presence of FDI. Moreover even for industries that never benefit from the presence of FDI over the sample periods, the negative impact from FDI gets smaller and smaller. The finding that different industries benefit differently from the presence of FDI hints at the possibility of designing specific industrial policy for attracting FDI that suits the specific requirements of different industries in China. We also test the determinants of technology spillovers of FDI, and find the technology gap plays a negative role in the occurrence of technology spillovers, relative factor intensity plays a positive role, which is consistent with the theoretical expectation, and the relative labour supply plays a positive role.

Table 3.5 Estimation Results

Variables		(1)FE	(2)GMM	(3)IV	(4)GMM	(5)FE
ln(technology transfer) ×ln(technology gap)	δ_1	-0.2027 (0.0151)	-0.2027 (0.0148)	-0.2337 (0.0322)	-0.2271 (0.0318)	-0.2018 (0.0133)
ln(technology transfer) ×ln(relative factor intensity)	δ_2	0.052* (0.0305)	0.052* (0.0299)	0.1353* (0.0708)	0.1337* (0.0708)	0.0436** (0.0296)
ln(technology transfer) ×ln(relative labour supply)	δ_3	0.0681 (0.03)	0.0681 (0.0293)	0.1389 (0.06)	0.1429 (0.0599)	0.0626 (0.0273)
ln(capital)	β_1	0.4164 (0.1614)	0.4164 (0.1578)	0.3768 (0.1749)	0.4056 (0.1732)	0.3696 (0.1235)
ln(labour)	β_2	0.4818 (0.1688)	0.4818 (0.1651)	0.5063 (0.235)	0.5122 (0.2349)	0.3324 (0.1461)
t	λ	114.3869 (18.9828)	114.3871 (18.5516)	144.0401 (35.9258)	153.2507 (35.0973)	136.812 (19.2635)
t^2	γ	-0.0286 (0.0047)	-0.0286 (0.0046)	-0.036 (0.009)	-0.0383 (0.0088)	-0.0342 (0.0048)
constant		-114295.2 (18987.07)	no	no	no	-136746.4 (19265.13)
Wooldridge Test for AR(1) Autocorrelation		0.008 [0.9312]	0.008 [0.9312]	n.a.	n.a.	0.010 [0.9232]
Test for Instrument Validity (Hansen's *J* statistic)		n.a.	n.a.	1.441 [0.2299]	1.441 [0.2299]	n.a.
Endogeneity Test (*C* statistic)		n.a.	n.a.	2.951 [0.3992]	2.951 [0.3992]	n.a.
R-square		0.84	0.813	0.78	0.784	0.87
Sample Size		184	184	138	138	184

Note: The dependent variable is ln(value added in the industry); the proxy for technology transfer enters the estimation only through its interaction terms with the technology gap, relative factor intensity, and relative labour supply. However if the proxy itself is included in the estimation, the estimated coefficients do not change significantly and the coefficient for the proxy itself is insignificant; all figures are rounded at 4-digit level; figures in the bracket are the robust standard errors; figures in the square bracket are the p-values; * denotes significance at 10 per cent level; ** denotes the p-value being 0.143; Column (1) is the fixed effect estimator; Column (2) is the feasible efficient two-step GMM estimator which is estimated with no instruments used and is more efficient in the presence of heteroskedasticity; Column (3) and (4) are the instrument variable estimator and GMM estimator respectively, which uses one-period lagged proxy of technology transfer and number of firms in the industry as instruments; Column (5) is the fixed effect estimator in which the dependent variable is ln(average value added in the industry) and the capital and labour are also the industry average.

Table 3.6 Technology Transfer Elasticity of FDI

ID	Industry	1995	1996	1997	1999	2000	2001	2002	2003
1	Food Processing, and Food Manufacturing	-0.2651	-0.2162	-0.2019	-0.1392	-0.2502	-0.1983	-0.0326	0.1906
2	Beverage Manufacturing	-0.2747	-0.2787	-0.2650	-0.1968	-0.2449	-0.2210	-0.1326	0.0575
3	Tobacco Processing	0.1168	0.1680	0.2246	-0.0421	0.5810	0.6124	0.9662	0.6997
4	Textile Industry	-0.1309	-0.0937	-0.0938	-0.0470	-0.1214	-0.1042	-0.0156	0.2081
5	Garments and Other Fiber Products	-0.0339	0.0506	0.0423	0.0382	-0.1172	-0.0915	-0.0396	0.2657
6	Leather, Furs, Down and Related Products	-0.0004	0.0468	0.0316	0.0806	-0.0706	-0.0390	0.0079	0.0800
7	Timber Processing, Bamboo, Cane, Palm Fiber and Straw Products	-0.2561	-0.1677	-0.1373	-0.1161	-0.2906	-0.2320	-0.1507	0.2011
8	Furniture Manufacturing	-0.2265	-0.1385	-0.1287	-0.1214	-0.3117	-0.2475	-0.1410	0.1678
9	Papermaking and Paper Products	-0.3647	-0.2881	-0.3158	-0.1784	-0.3137	-0.2686	-0.1258	0.1401
10	Printing and Record Medium Reproduction	-0.4510	-0.3731	-0.3624	-0.2540	-0.5819	-0.4952	-0.4321	0.0185
11	Stationery, Educational and Sports Goods	-0.1992	-0.1314	-0.1306	-0.1023	-0.2846	-0.2339	-0.1862	0.1206
12	Petroleum Processing and Coking	-0.3095	-0.4383	-0.4630	-0.3087	0.2340	0.2088	0.3120	-0.1302
13	Raw Chemical Materials and Chemical Products, Chemical Fibers, and Medical and Pharmaceutical Products	-0.3757	-0.3030	-0.3078	-0.2065	-0.2369	-0.2359	-0.1009	0.2284
14	Rubber Products	-0.2677	-0.1494	-0.1288	-0.0836	-0.2029	-0.1342	-0.0084	0.3350
15	Plastic Products	-0.2774	-0.1617	-0.1496	-0.0468	-0.2421	-0.1930	-0.1130	0.1998
16	Nonmetal Mineral Products	-0.1901	-0.1569	-0.1633	-0.1147	-0.3354	-0.3023	-0.2210	-0.0492
17	Smelting and Pressing of Ferrous Metals	-0.2004	-0.2459	-0.2693	-0.1744	0.0521	0.1223	0.2009	0.0949
18	Smelting and Pressing of Nonferrous Metals	-0.1987	-0.1974	-0.2145	-0.0860	-0.0460	-0.0242	0.0558	0.1930
19	Metal Products	-0.2979	-0.2094	-0.2124	-0.1068	-0.3027	-0.2637	-0.1833	0.0968
20	Ordinary Machinery, and Instruments, Meters, Cultural and Official Machinery	-0.4081	-0.3524	-0.3242	-0.2105	-0.3671	-0.3238	-0.2463	-0.0241
21	Special Purpose Equipment	-0.3249	-0.2704	-0.2730	-0.2049	-0.3804	-0.3420	-0.1709	0.0727
22	Transport Equipment	-0.3419	-0.2684	-0.2704	-0.1705	-0.1793	-0.1117	0.0596	0.2109
23	Electric Equipment and Machinery, and Electronic and Telecommunications	-0.2798	-0.1698	-0.1347	0.0508	0.1225	0.1779	0.2404	0.1988

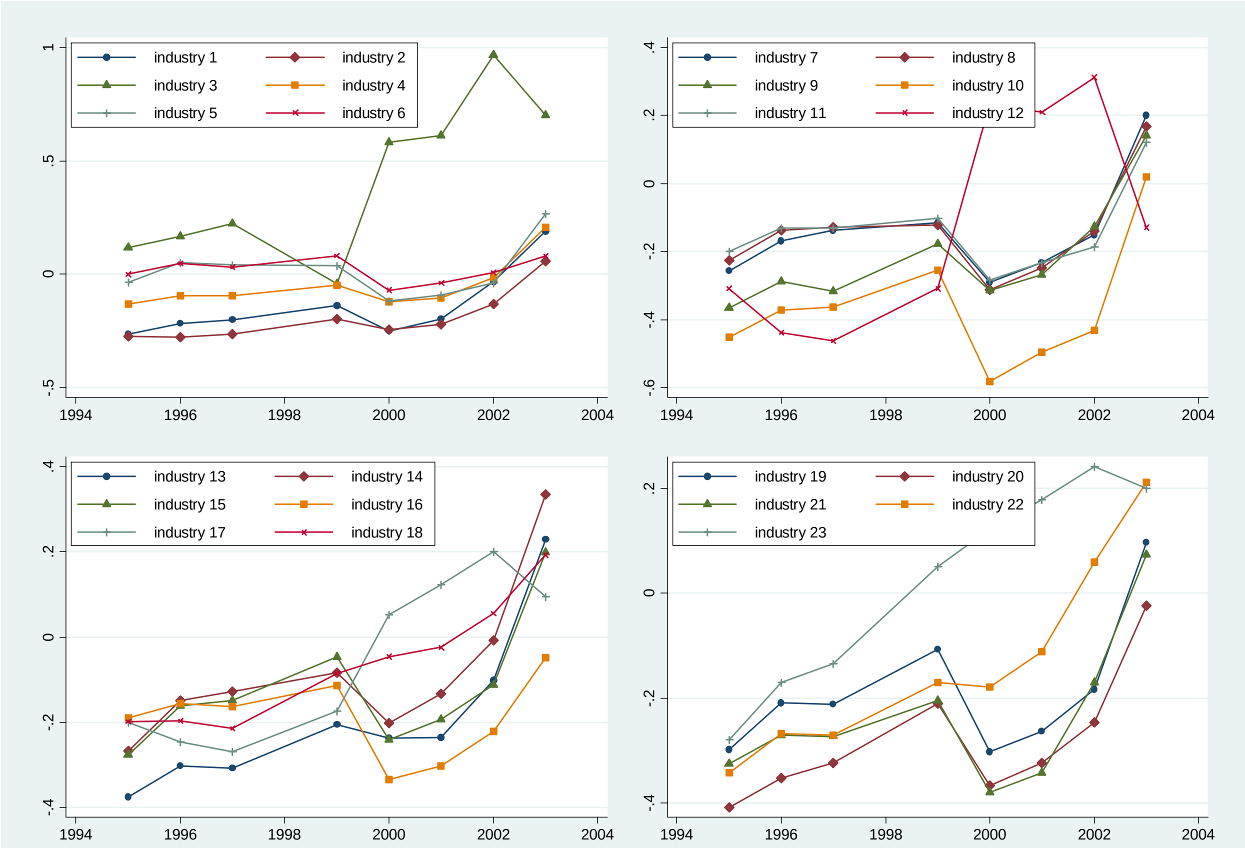
Table 3.7 Technology Transfer Elasticity of FDI for Sensitivity Analysis

ID	Industry	1995	1996	1997	1999	2000	2001	2002	2003
1	Food Processing, and Food Manufacturing	-0.2651	-0.2162	-0.2019	-0.1392	-0.2502	-0.1983	-0.0326	0.1906
2	Beverage Manufacturing	-0.2747	-0.2787	-0.2650	-0.1968	-0.2449	-0.2210	-0.1326	0.0575
3	Tobacco Processing	0.1168	0.1680	0.2246	-0.0421	0.5810	0.6124	0.9662	0.6997
4	Textile Industry	-0.1309	-0.0937	-0.0938	-0.0470	-0.1214	-0.1042	-0.0156	0.2081
5	Garments and Other Fiber Products	-0.0339	0.0506	0.0423	0.0382	-0.1172	-0.0915	-0.0396	0.2657
6	Leather, Furs, Down and Related Products	-0.0004	0.0468	0.0316	0.0806	-0.0706	-0.0390	0.0079	0.0800
7	Timber Processing, Bamboo, Cane, Palm Fiber and Straw Products	-0.2561	-0.1677	-0.1373	-0.1161	-0.2906	-0.2320	-0.1507	0.2011
8	Furniture Manufacturing	-0.2265	-0.1385	-0.1287	-0.1214	-0.3117	-0.2475	-0.1410	0.1678
9	Papermaking and Paper Products	-0.3647	-0.2881	-0.3158	-0.1784	-0.3137	-0.2686	-0.1258	0.1401
10	Printing and Record Medium Reproduction	-0.4510	-0.3731	-0.3624	-0.2540	-0.5819	-0.4952	-0.4321	0.0185
11	Stationery, Educational and Sports Goods	-0.1992	-0.1314	-0.1306	-0.1023	-0.2846	-0.2339	-0.1862	0.1206
12	Petroleum Processing and Coking	-0.3095	-0.4383	-0.4630	-0.3087	0.2340	0.2088	0.3120	-0.1302
13	Raw Chemical Materials and Chemical Products, Chemical Fibers, and Medical and Pharmaceutical Products	-0.3757	-0.3030	-0.3078	-0.2065	-0.2369	-0.2359	-0.1009	0.2284
14	Rubber Products	-0.2677	-0.1494	-0.1288	-0.0836	-0.2029	-0.1342	-0.0084	0.3350
15	Plastic Products	-0.2774	-0.1617	-0.1496	-0.0468	-0.2421	-0.1930	-0.1130	0.1998
16	Nonmetal Mineral Products	-0.1901	-0.1569	-0.1633	-0.1147	-0.3354	-0.3023	-0.2210	-0.0492
17	Smelting and Pressing of Ferrous Metals	-0.2004	-0.2459	-0.2693	-0.1744	0.0521	0.1223	0.2009	0.0949
18	Smelting and Pressing of Nonferrous Metals	-0.1987	-0.1974	-0.2145	-0.0860	-0.0460	-0.0242	0.0558	0.1930
19	Metal Products	-0.2979	-0.2094	-0.2124	-0.1068	-0.3027	-0.2637	-0.1833	0.0968
20	Ordinary Machinery, and Instruments, Meters, Cultural and Official Machinery	-0.4081	-0.3524	-0.3242	-0.2105	-0.3671	-0.3238	-0.2463	-0.0241
21	Special Purpose Equipment	-0.3249	-0.2704	-0.2730	-0.2049	-0.3804	-0.3420	-0.1709	0.0727

22	Transport Equipment	-0.3419	-0.2684	-0.2704	-0.1705	-0.1793	-0.1117	0.0596	0.2109
23	Electric Equipment and Machinery, and Electronic and Telecommunications	-0.2798	-0.1698	-0.1347	0.0508	0.1225	0.1779	0.2404	0.1988

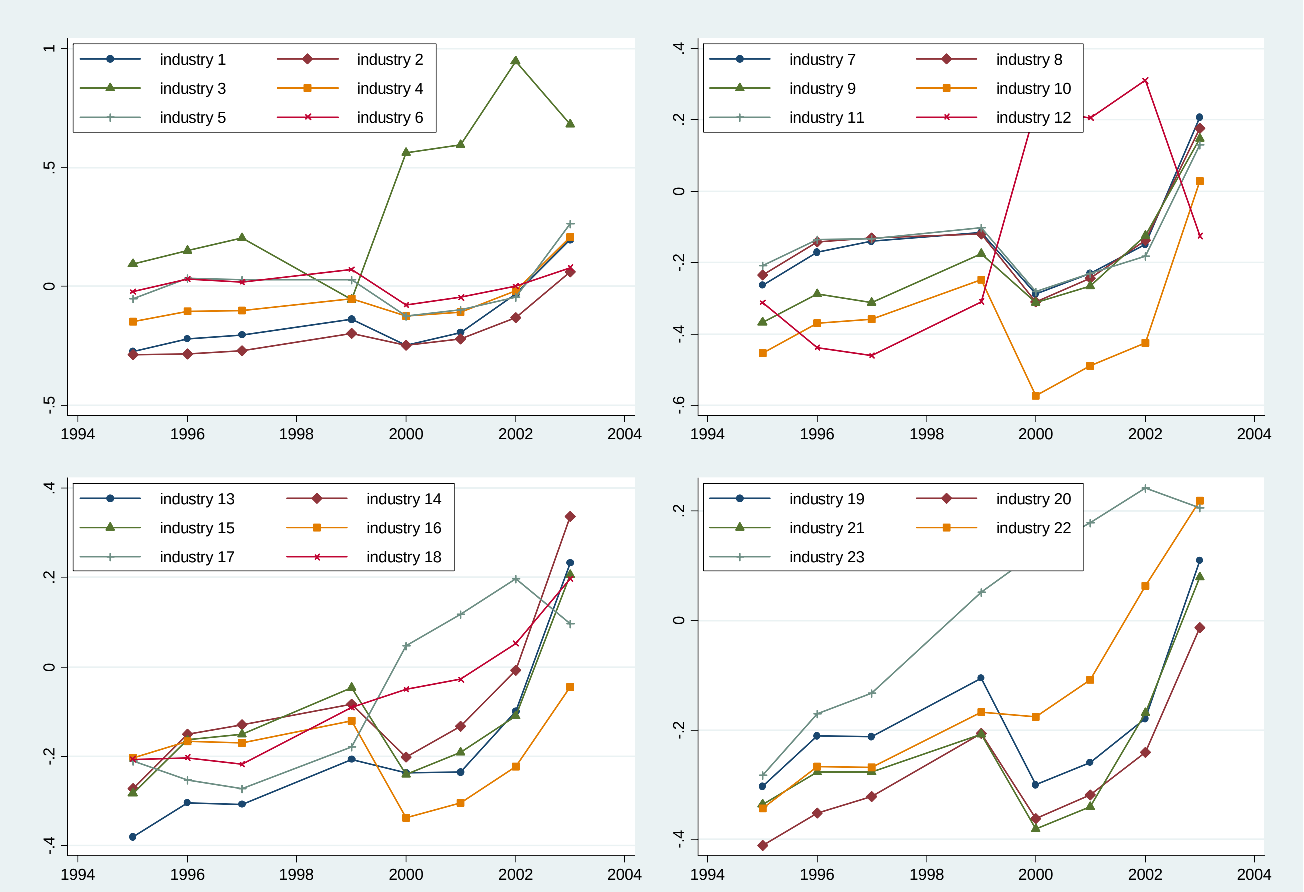
Note: Elasticity computed from the regression where the average value added, average capital stock, and average labour.

Figure 3.3 Evaluated Technology Transfer Elasticity



Note: the corresponding name of industry 1-23 shall be referred to Table 3.2

Figure 3.4 Evaluated Technology Transfer Elasticity for Sensitivity Analysis



Note: the corresponding name of industry 1-23 shall be referred to Table 3.2

4. Technology Spillovers: Firm Level Evidence

Over the period from 1995 to 2003, Chinese domestic industries appear to have become better and better at benefiting from the presence of FDI. In 2003, 20 out of the 23 industrial sectors identified in this study benefited from FDI, that is, they experienced positive technology spillovers from FDI. In Chapter 3, the tests for technology spillovers of FDI were undertaken at an aggregate industry level, using an eight year balanced panel data, and it was found that the marginal impact from FDI on domestic industry's productivity varies across both time and industries. But the analysis in Chapter 3 is highly aggregated. What happens if we analyse the relationship between FDI and spillovers at a more disaggregated level? As shown by Caballero and Lyons (1989), spillovers at a lower level of aggregation can be internalised at a higher level of aggregation. Hence we will expect to find more evidence of spillovers at lower level of aggregation. This chapter thus aims at testing technology spillovers from FDI at a firm level, using a comprehensive firm level micro-data set in the Chinese manufacturing sector for 2003.

The chapter is composed of five sections. The following section discusses the presence of FDI in the manufacturing sector and the distribution of firm productivity, which gives background knowledge for the subsequent empirical modelling. Then we present the empirical model, in which a simultaneous equation model is set up, to accommodate for the potential endogeneity of FDI, and construct variables used in the estimation. The last two sections present the findings from empirical modelling, and conclude the chapter.

FDI and Firm Productivity in the Manufacturing Sector

The data set used in this chapter is a cross-sectional firm level micro-data from the *Enterprise Data*, National Bureau of Statistics, Beijing, which covers 181,188 firms in the manufacturing sector in China in 2003. From this data set, we construct the FDI measurement and calculate firm productivity.

FDI measured in terms of foreign presence

Conventionally, as discussed earlier, there are three proxies for measuring the activities of FDI in domestic industries, namely the share of FDI invested firms' output/employees/assets in the domestic industry, as follows:

$$fp = \frac{\sum_{i \in I} x_i}{\sum_{j \in J} x_j}$$

where *fp* denotes foreign presence, *x* denotes a firm's output/employees/assets, *I* denotes the set of FDI invested firms in the industry, *J* denotes the set of all firms in the industry, and $I \subset J$. In the following, we use *fpe*/*fpa*/*fpo* to denote the employment/assets/output share foreign presence respectively. Each of these three measurements has its own pitfalls. It is argued that FDI invested firms are usually more capital intensive than their domestic counterparts and hence that the employment share will under-represent the true scale of FDI activity. The assets share is sensitive to host country's ownership restrictions (Kohpaiboon, 2006). Since the output share is an output measurement of FDI, it is thought to be more appropriate to use the input measurements of FDI, such as the employment share, in testing the technology spillovers (Caves, 1974). In recognition of these pitfalls, all three measurements are used in this chapter, the interpretation in which is based on the employment share with the other two measurements serving as sensitivity comparisons[18].

Table 4.1 presents FDI in the manufacturing sector measured by the three proxies of foreign presence we have identified at the two-digit industry level. Several observations can be made from the results in the table. FDI has a significant presence in the manufacturing sector in China. On average, FDI invested firms account for 28 per cent of total employment, 36 per cent of total assets, and 34 per cent of total output in the industry. However, the distribution of FDI across

[18] In the subsequent empirical exercise, we find that estimations using the three measurements of FDI respectively exhibit little variation and hence the interpretation based on the employment share will be the same as those based on the other two measurements.

industries is uneven. Some industries have very high foreign presence. For example, the nuclear radiation processing industry in the two-digit ‘crafts and other products manufacturing industry’ has a foreign presence of 100 per cent as the industry only has one FDI invested firm and the container manufacturing industry in the two-digit ‘fabricated metal products industry’ has a foreign presence higher than over 90 per cent, and is an industry in which there are 55 firms. In contrast, some industries have rather low foreign presence. For example, in the two-digit tobacco industry, which has 255 firms, foreign presence is lower than 4 per cent. The uneven distribution of FDI in different industries comes from two sources. First, the government’s industry policy, which classifies industries into those which are encouraged, allowed, restricted, and prohibited, making in likely that FDI will self-select industries that are encouraged and allowed. Second, in addition to the self-selection caused by government industry policy, it is also possible that FDI itself will tend to flow into industries with some characteristics, such as industries with higher productivity. These two factors may raise a potential endogeneity problem in testing the technology spillover effects of FDI[19].

Comparing the three proxies, we find that there are some industries where all three proxies give very similar measurements. For example, in the textile garments, shoes and hats manufacturing industry the average foreign presence is 52/52/53 per cent respectively. However, there are also industries in which the three proxies are quite different. For example, in the waste resources and recycling materials processing industry, *fpa* is over three times the value of *fpe*. In addition, quite often the proxy measured in terms of employee share is lower than the other two proxies, which reflects the fact that FDI invested firms are usually more capital intensive than their purely domestic counterparts.

Ideally, we would expect all these three proxies to rank the industries consistently. For example, if one industry is ranked third in terms of output share, then it will be also ranked third in terms of both employee share and assets share. If this kind of

[19] Edogeneity caused by the self-selection of FDI only occurs when the government’s industry policy is set according to the standard that industries with higher productivity are more likely to be classified as encouraged or allowed categories.

consistency is satisfied, then these would appear to be a reasonable set of proxies for foreign presence. From Table 4.1, it can be seen that the three proxies give similar measurement of foreign presence in that their mean and standard deviation are quite close to each other. In terms of ranking of average level of foreign presence, the ranking of *fpo* is consistent with that of *fpa*. However, the ranking of *fpe* is different (see Table 4.2).

Distribution of firm productivity

We use labour productivity to proxy for firm productivity. Conventionally, labour productivity is equal to value added divided by the number of employees. However, as there is a large stock of inventories, and hence the construction of value added will be distorted upwards (as the output that is stored as inventories will be taken into account in constructing value added and hence value added is exaggerated), sales per employee is used as a measurement of labour productivity (Chuang and Hsu, 2004). In 2003, the average inventory output ratio was as high as 77.2 per cent in the manufacturing sector.

There is considerable variation in labour productivity across different firms. Average labour productivity is 280 thousand RMB/employee with a standard deviation of 917 thousand RMB/employee. The highest labour productivity is 209,775 thousand RMB/employee, in the four-digit camera and equipment manufacturing industry (4153), and in contrast the lowest labour productivity is 0, which occurs either because of data collection error or indeed these firms are so weak to compete in the market that they simply cannot sell anything. Nevertheless even though there are 1,696 such firms, they account for only a very small proportion of total firms (0.94 per cent). Table 4.3 sets out productivity distribution across two-digit industries. It confirms that there is a big variation in firms' labour productivity, and the big variation does not come from the fact that firms belong to different industries. Even in the same two-digit industry, some firms have much higher labour productivity than others. For example, in the food processing industry (13), the average labour productivity is 430 thousand RMB/employee with a standard deviation of 899 thousand RMB/employee. The highest labour productivity is 66,883 thousand

RMB/employee, over 150 times that of average value, and in contrast the lowest labour productivity is 0.

Figure 4.1 presents the density of the log of labour productivity, which is approximately symmetric around 5. Figure 4.2 presents a breakdown of the labour productivity distribution by firm ownership structure. It appears that the productivity distribution of privately owned firms is biased more to the right, compared with that of state and collectively owned firms, indicating that privately owned firms have higher labour productivity. The Kolmogorov-Smirnov test for equality of two distributions also rejects the null of equal distribution with a test statistic of 0.1208 and p-value of 0. In terms of regional difference, the distribution of labour productivity of firms located in coastal China is also different from those of firms in central and western China, indicating that firms located in coastal China are more likely to have higher labour productivity than their counterparts in central and western China. If we compare the productivity distribution of domestic firms with that of FDI invested firms, they appear to be similar to each other (Figure 4.4). However, the Kolmogorov-Smirnov test rejects the null hypothesis that they are equal with a test statistic of 0.0329 and p-value of 0.

In summary, we observe that there exists significant variation in firm labour productivity, and in addition firm labour productivity exhibits a significant difference by ownership structure and regions, which are two sets of control variables incorporated in the following empirical modelling.

The Empirical Model

We aim at testing whether FDI in China has a positive impact on domestic firms productivity. However, it is possible that FDI tends to flow into industries with higher productivity, and in the case of China the government's FDI industry policy may also make FDI self-select into industries that happen to have higher productivity. In both cases FDI will be endogenous. Hence, in empirically testing technology spillovers of FDI, we need to account for the endogeneity of FDI. To address this issue, we set up a simple simultaneous equation model, as follows:

$$
\begin{aligned}
&\ln lp = \alpha_0 + \alpha_1 \ln kl + \alpha_2 \ln ml + \alpha_3 \ln lq + \alpha_4 age + \alpha_5 age^2 \\
&+ \alpha_6 fp + \alpha_7 scale + \alpha_8 herfindahl + \alpha_9 ownership + \alpha_{10} middle \\
&+ \alpha_{11} western + \alpha_{12} idummies + \varepsilon_1
\end{aligned}
\tag{4.1}
$$

$$
\begin{aligned}
&fp = \beta_0 + \beta_1 \ln dmkts + \beta_2 ie + \beta_3 iaveragewage + \beta_4 iuprodcst \\
&+ \beta_5 \ln lp + \beta_6 middle + \beta_7 western + \beta_8 idummies + \varepsilon_2
\end{aligned}
\tag{4.2}
$$

where *lp* denotes the labour productivity, proxied by sales per employee, *kl* denotes domestic firms' capital intensity, *ml* denotes firms' intermediate inputs per employee, *lq* denotes the labour quality, proxied by firms' average wage, *age* is firms' age, *fp* denotes foreign presence, *scale* is the industry's scale economies, *herfindahl* is the Herfindahl index that captures domestic market structure, *ownership* is a dummy that takes a value of 1 if the firm is privately owned firm, *middle* and *western* are regional dummies that capture firms' regional heterogeneity and take a value of 1 if the firm is located in central or western China respectively, *idummies* is a vector of 29 two-digit industry dummies that capture firms' industry heterogeneity and other possible omitted variables, *dmkts* denotes the domestic market size which is equal to the sum of firms' domestic sale in the four-digit industries, *ie* is the industry export intensity which is equal to the four-digit industry 's total exports divided by its total sales, and *iuprodcst* denotes the industry unit production cost which is equal to the four-digit industry's total production cost divided by its total outputs. We intend to test the significance and sign of the coefficient of *fp* in equation (4.1). A significantly positive coefficient implies the FDI does have positive impact on domestic firms' productivity.

Equation (4.1) hypothesises that domestic firms' labour productivity depends on their capital intensity, intermediate inputs per employee, labour quality, age, FDI, the scale of economies in the industry, domestic market structure, ownership structure, regional location, and industry heterogeneity. For capital intensity, we expect it to have a positive impact on domestic firms' labour productivity. A firm with higher capital intensity is more capable of conducting R&D, an important factor that positively affects firms' productivity but is not available in our data set.

The variable intermediate inputs per employee is expected to exert positive impact, as the higher the intermediate inputs per employee, the more output the firm will produce and hence the more sales the firm will make. Labour quality is expected to have a positive impact. Labour quality, measured by a firm's average wage, is a proxy for a firms' human capital, which should positively affect firm productivity.

For firm age, the impact on firm labour productivity may be nonlinear. At an early age, the firm may be too young to be efficient and may remain inefficient until it learns to improve its efficiency. Then eventually the firm will become efficient as it gains enough experience. Hence the impact of firm age on efficiency may exhibit a U shape. This nonlinearity is captured by the square term of *age*. Regarding foreign presence, which is the focus of the study, we expect it to affect a domestic firm's labour productivity positively, as FDI invested firms' technology transfer will possibly benefit domestic firms by imitation, labour mobility, and competition. In addition, most previous studies in China obtained positive technology spillovers from FDI.

In regard to scale economies, as the scale of production increases, firms are usually more capable of reducing their cost and promoting their efficiency. Hence a positive impact is expected. For market structure, proxied by the Herfindahl index, there is no prior expectation about the sign of its coefficient. On the one hand, firms in a more concentrated market have less incentive to upgrade their technology and improve their efficiency, as they are not confronted with fierce market competition. But on the other hand, firms that have market power are usually bigger and hence more able to overcome the usually big fixed cost in R&D activities and adopt measures that will improve their efficiency, and can possibly enjoy a scale of economy, which may be not captured fully by the industry's scale economies.

For ownership structure, as discussed in previous section, the distribution of privately owned firm labour productivity is biased to the right compared with that of state and collectively owned firms (see Figure 4.2), and hence we expect the coefficient of *ownership* to be positive. For the regional dummies, *middle* and *western*, the discussion in the previous section also shows that firms located in coastal China are more efficient than their counterparts in the central and western China (see Figure 4.3), and thus their coefficients are expected to be negative.

In addition, the two regional dummies, together with the set of industry dummies, control different roles of export-oriented and market-oriented FDI in generating technology spillovers. FDI inflow in a host country can be broadly classified into two categories according to its objectives or motivation, namely export-oriented and market-oriented FDI, with the former targeting exports while the latter focuses on the domestic market in the host country. Hence these two types of FDI may generate quite different technology spillovers, and need to be differentiated in testing for spillovers. In China, export-oriented FDI is concentrated in certain industries (processing industries) and most of them are located in coastal China due to its proximity to international markets and the lower transportation costs involved in delivering output. The regional and industry dummies are intended to control for this.

Equation (4.2) hypothesises that foreign presence depends on the domestic market size, industry's export intensity, industry unit production cost, domestic firms' labour productivity, regional dummies and a set of industry dummies. For export-oriented FDI, the domestic industry's export prospect is clearly an important factor that foreign firms consider in their decision on whether to enter the market. Better export prospects will attract more FDI inflow. The industry's export prospects are captured by the industry export intensity, for which higher industry export intensity means better export prospects. Hence we expect the industry export intensity to have a positive impact on the foreign presence. Unlike export-oriented FDI, market-oriented FDI aims at penetrating the domestic market, and hence in deciding whether to enter the market, domestic market size will be an important factor, and the bigger the domestic market is the more likely the FDI will flow in. We measure domestic market size as the sum of all firms' domestic sales in the four-digit industry, and its coefficient is expected to be positive.

In addition to the domestic market size and industry export intensity, the domestic industry's cost of production is another important factor that affects foreign firms' entry decision. Particularly for China, which enjoys a name of 'World Factory', the low cost of production is one factor that attracts so many multinational enterprises, no matter whether they are export-oriented or market-oriented. An industry's labour quality is another factor that affects the foreign presence. Compared with domestic counterparts, FDI invested firms are usually more capital intensive, and are likely to have higher skill requirements for their employees, for example they may require their employees to be able to speak English, and hence may flow into industries with better labour quality. So we expect labour quality, proxied by the industry's average wage, to have a positive impact on the foreign presence.

Domestic firms' labour productivity will have a positive impact on foreign presence if the FDI tends to flow into industries with higher productivity. Besides, it is also reasonable to assume that the foreign presence will display regional and industry heterogeneity, which is captured by the two regional dummies and 29 industry dummies. For the regional difference, we expect FDI will flow more into coastal China than central and western China, as coastal China is more developed. For industry heterogeneity, we expect they will be jointly significant, due to government industry policy that regulates the FDI inflow.

Equations (4.1) and (4.2) can be estimated by a three stage least square estimator (3SLS), which uses the instrumental variable approach and generalized least squares to obtain consistent estimation. At stage one, the reduced form of equations (4.1) and (4.2) is estimated, namely each endogenous variable (*lnlp* and *fp* here) is regressed against all exogenous variables, from which the predicted *lnlp* and *fp* are obtained. The predicted values of *lnlp* and *fp* are then used as instruments in estimating equation (4.1) and (4.2). Then at stage two, based on the residuals from estimating equations (4.1) and (4.2), a consistent estimate for the covariance matrix of the error terms in equations (4.1) and (4.2) is obtained. At stage three, a generalized least squares estimation is made, using the estimated covariance matrix in stage two and the instruments obtained in stage one (Stata Corp., 2005)

Variable Construction

Of the over 180,000 firms in the data set, there are 143,161 domestic firms, which are used in the estimation. Here we describe how we construct the variables used in equations (4.1) and (4.2).

Capital intensity is equal to domestic firm assets divided by the number of employees; the intermediate inputs per employee is equal to total intermediate inputs divided by the number of employees; labour quality is equal to total salaries payable divided by the number of employees; scale economies are defined as average of firm sales revenue relative to the minimum efficient scale of the industry, which in turn is equal to average sales revenue of firms with a market share bigger than 50 per cent (see Cory, 1981, Chuang and Hsu, 2004); the Herfindahl index, which captures the domestic market structure, is calculated at the four-digit industry level and equal to the sum of firms' shares in the industry total sales squared; domestic market size is equal to sum of domestic firm sales in the four-digit industry; industry export intensity is equal to total industry exports divided by total industry sales; the industry average wage is calculated as the industry's total salaries payable divided by total number of employees; and industry unit production cost is equal to total industry production cost divided by total industry output.

The ownership structure is a dummy variable, which is constructed from the type of firm registration, and takes a value of 1 if the firm is privately owned firm. Regional heterogeneity consists of two regional dummies, the variable *western* which takes a value of 1 if the firm is located in western China, and the variable *middle* which takes value of 1 if the firm is located in central China. Western China includes Chongqing City, Sichuan Province, Guizhou Province, Yunnan Province, Tibet Autonomous Zone, Shannxi Province, Gansu Province, Qinghai Province, Ningxia Autonomous Zone, Inner Mongolia Autonomous Zone, Xinjiang Autonomous Zone, and Guangxi Autonomous Zone. Central China includes Shanxi Province, Henan Province, Anhui Province, Jiangxi Province, Hunan Province, Hubei Province, Jilin Province, and Heilongjiang Province. The rest of China is classified as coastal region, including Beijing City, Tianjin City, Shanghai City, Liaoning Province, Hebei Province, Shandong Province, Jiangsu Province, Zhejiang Province, Fujian Province, Guangdong Province, and Hainan Province. The industry dummies are constructed at two digit level (see Table 4.4).

Table 4.5 presents the descriptive statistics of variables used in the estimation, and Table 4.6 reports the correlation among key variables. The top panel of Table 4.5 reports the summary statistics for continuous variables, from which we can see that there are missing variables. The missing values come from two sources. One is that some firms report zero employment, which makes variables constructed by dividing the number of employees meaningless, and the second source is taking natural logarithm, which results in missing values if the natural logarithm is taken over zero. However, compared with the total sample size, the number of missing values is relatively small, and a further examination of observations in the sample shows that the missing values appear to be randomly distributed across industries. The bottom panel of Table 4.5 shows a summary of dummy variables, with the number indicating the percentage that the dummy variable takes a value of 1. For example, 51.9 per cent of domestic firms are privately owned, 12 per cent of domestic firms are located in western China, and 19 per cent of domestic firms are located in central China. From Table 4.6, we can see the correlations among key variables are relatively small, indicating that the multicollinearity issue may not be a problem in our estimation[20].

Empirical Results

Equations (4.1) and (4.2) are set up to capture the potential simultaneity between domestic firm labour productivity and FDI. However this simultaneity may not exist. Hence before estimating the model by 3SLS, we need to test whether the simultaneous equation model is appropriate or not. Following Geroski (1982), and also Li et al. (2001), we first estimate the reduced form equations in which the labour productivity and foreign presence, measured by the FDI invested firms' employment share in the industry, are regressed against all exogenous variables respectively, and then plug the predicted residuals from the labour

[20] Due to the large sample size, the estimation is very robust to the possible multicollinearity problem.

productivity/foreign presence estimation into the estimation of the foreign presence/labour productivity structural equation. If the residuals have significant impact, then it indicates that equations (4.1) and (4.2) are simultaneously determined. In the Geroski test, the coefficient of the residuals, predicted from the reduced form foreign presence equation estimation, is estimated to be -4.9432 with t-statistic of -2.35 and p-value of 0.019 in the foreign presence structural equation estimation, and the coefficient of the residuals, predicted from the reduced form labour productivity equation estimation, is estimated to be -0.0105 with t-statistic of -15.73 and p-value of 0 in the labour productivity structural equation, which indicates that equations (4.1) and (4.2) are simultaneously determined and the simultaneous equation model is appropriate.

For equations (4.1) and (4.2) to be estimated simultaneously, they need to be identifiable. One rule of thumb is that there need to be some exogenous variables that appear in equation (4.1) but not in equation (4.2) and vice versa. This condition is clearly satisfied in both equations. In addition, we also check whether the rank condition is satisfied for each equation in the two equation system, using a procedure proposed by Baum (2007). Baum’s procedure checks whether the rank condition is satisfied for each of equations (4.1) and (4.2) and confirms that the two equation system is identified. Then equations (4.1) and (4.2) are estimated using 3SLS procedure, and Table 4.7 presents the estimation results, in which employment share is used as a proxy for foreign presence.

The labour productivity equation

In the labour productivity equation estimates shown in Table 4.7, the sign and significance of most estimated coefficients are consistent with prior expectation. For capital intensity, we find it positively affects domestic firms’ labour productivity, with a 1 per cent increase in capital intensity leading to a 0.3901 per cent increase in labour productivity, confirming that firms that are more capital intensive are usually more efficient. For the intermediate inputs per employee, a 1 per cent increase in intermediate inputs results in a 0.0083 per cent increase in labour productivity, refecting the fact that more intermediate inputs usually mean more output and sales.

Labour quality also has a significantly positive impact on labour productivity, and a 1 per cent increase in labour quality leads to a 0.3325 per cent increase in the labour productivity.

Firms' age has a nonlinear impact on the labour productivity. With the coefficient for age being significantly negative and the coefficient for squared age being significantly positive, the nonlinear impact exhibits a U shape. However the coefficient for squared age is much smaller than the absolute value of the coefficient of age, resulting in the turning point of the U shape being 283 years old, much older than the firm age in the sample. So for the firms in the data set, after controlling other factors that affect productivity, the older the firm is, the less efficient it is, possibly due to the fact that older firms are less willing to upgrade their technology and improve the efficiency than younger firms.

For economies of scale and domestic market structure, both appear to affect domestic firms' labour productivity positively, indicating that domestic firms enjoy economies of scale, even though the coefficient of scale economy is only significant at the 10 per cent level. For the ownership structure, the coefficient is significantly positive, indicating that privately owned firms are more efficient than state and collectively owned firms, confirming the finding of the previous section that productivity distribution of privately owned firms is biased to the right compared with that of state and collectively owned firms, even after controlling for other factors. For the two regional dummies, the coefficient of *middle* is insignificant, while in contrast the coefficient of *western* is significantly negative, which implies that firms located in western China are less efficient than their counterparts in central and coastal China. The industry dummies are jointly significant at the 1 per cent level, which controls the industry heterogeneity and other omitted variables.

For the foreign presence -- the focus of our study, measured here by the FDI invested firms' employment share in the four-digit industry -- the coefficient is significant and positive (5.7707 with a *t* statistic of 2.24 and p-value of 0.025), confirming that FDI in China does generate significantly positive technology spillovers to domestic firms. A 1 per cent increase in the presence of FDI in the domestic industry will promote domestic firms' labour productivity by 5.7707 per cent, an impressively substantial magnitude.

The foreign presence equation

The right-hand panel of Table 4.7 presents the estimation of the foreign presence equation (equation 4.2). For domestic market size, the coefficient is insignificant at the 10 per cent level, indicating that the domestic market size appears not to play a role in attracting the FDI inflow. However, the domestic industry's export prospects do positively affect the entry decision of FDI. The estimated coefficient is 0.0045 with a *t* statistic of 2.95 and p-value of 0.003, indicating that a 1 per cent increase in industry export intensity will lead to a 0.0045 per cent increase in the foreign presence. The coefficient for the industry average wage is significantly negative, surprisingly contradicting our prior expectation. However this may be explained by higher average wages being more likely to be offered in industries where the FDI entry is more difficult because of the government industry policy. For example, the average wage in the petroleum industry is high, but FDI is discouraged in this industry by government policy.

The coefficient for industry unit production cost is positive and significant at the 10 per cent level, again contradicting our prior expectation. This may be a consequence of MNE production costs being lowered through investing in China compared with costs at home, even when Chinese costs are driven up by the FDI. For the regional dummies, the coefficients for both *middle* and *western* are significantly negative. FDI tends to flow into Coastal China where the economy is more developed and the infrastructure is better than central and western China. The 29 industry dummies are jointly significant at the 1 per cent level, confirming the existence of industry heterogeneity and other potential omitted variables. Domestic firm labour productivity does positively affect foreign presence, indicating that FDI does tend to flow into industries with higher levels of labour productivity, which makes FDI endogenous. The estimated coefficient is 0.0104 with a *t*-statistic of 19.89 and p-value of 0.000, implying that a 1 per cent increase in domestic firms' labour productivity will promote foreign presence by 0.0104 per cent.

Sensitivity analysis

Using the FDI invested firms' employment share in the industry as the proxy for foreign presence, we have found that the FDI in domestic industry does generate positive technology spillovers to domestic firms, and that FDI also tends to flow into industries with higher domestic labour productivity. However, is the result sensitive to how we measure the foreign presence? To examine the robustness of the result, we re-estimated equations (4.1) and (4.2) using the assets and output share respectively as the measurement of foreign presence.

In the two estimations, we first test the appropriateness of the simultaneous equation model, following the Geroski (1982) approach, and find that the residuals predicted from the reduced form equation estimations are significant when they are augmented into the structural equation estimation, indicating that the simultaneous equation model is appropriate. Then we test whether the system is fully identified by using Baum's (2007) procedure, and find in both estimations that the system is fully identified. Then the 3SLS is applied to estimate the model. Tables 4.8 and 4.9 present the estimation outputs, using the assets and output share as foreign presence respectively. Comparing the three estimations (in Tables 4.7, 4.8, and 4.9), we can see that they are quite consistent with each other in the sense that the sign of estimated coefficients does not change and the magnitude of the coefficients are within one or two standard deviations of each other. For foreign presence in the labour productivity equation, the coefficient estimated in the three estimations is 5.77, 5.98, and 6.3 respectively, which are all significant, positive, and within one standard deviation of each other. For domestic labour productivity in the foreign presence equation, the coefficient estimated in the three estimations is 0.01, 0.02, and 0.02 respectively, which are all significant and positive but there is more variation among them compared with the estimated coefficient of foreign presence in the labour productivity equation. Hence, we can conclude that the result is robust to different measurements of foreign presence[21].

Conclusions

In this chapter, we used a simultaneous equation model, which captures the potential endogeneity of the FDI inflow, to test the existence of technology spillovers from FDI. The simultaneous equation model was estimated over a comprehensive cross-sectional firm level micro-data set that covers 181,188 firms in the manufacturing sector in China in 2003. The results suggest that FDI inflow into the manufacturing sector generates positive technology spillovers to domestic firms, with a 1 per cent increase in the presence of FDI in the domestic industry promoting domestic firms' labour productivity by 5.7707 per cent. It is also found that FDI tends to flow into industries with higher labour productivity. In Chapter 3, we tested FDI's technology spillovers at an industry level, and found that more and more domestic industries benefited from the presence of FDI from 1995 to 2003. In 2003, 20 out of all the 23 industries benefited from the presence of FDI. This chapter confirms the importance of spillovers and we find substantial technology spillovers from the FDI at the firm level in 2003.

[21] So fortunately the ranking issue of the three measurements of foreign presence in the previous section is not problematic.

Table 4.1 Foreign Presence by Industries

	Obs	Mean	Std.Dev.	Min	Max
13 Food processing industry					
fpo	11193	0.26	0.16	0.07	0.82
fpe	11193	0.20	0.15	0.04	0.60
fpa	11193	0.30	0.15	0.10	0.80
14 Food manufacturing industry					
fpo	4636	0.40	0.16	0.10	0.76
fpe	4636	0.29	0.12	0.13	0.53
fpa	4636	0.40	0.16	0.17	0.71
15 Beverage manufacturing industry					
fpo	3194	0.39	0.23	0.09	0.89
fpe	3194	0.27	0.19	0.07	0.76
fpa	3194	0.38	0.23	0.12	0.87
16 Tobacco industry					
fpo	255	0.02	0.02	0.00	0.05
fpe	255	0.04	0.04	0.01	0.10
fpa	255	0.03	0.04	0.00	0.08
17 Textile industry					
fpo	14863	0.32	0.14	0.10	0.56
fpe	14863	0.27	0.15	0.03	0.54
fpa	14863	0.35	0.15	0.12	0.65
18 Textile garments, shoes and hats manufacturing					
fpo	9717	0.52	0.01	0.52	0.57
fpe	9717	0.52	0.03	0.51	0.62
fpa	9717	0.53	0.02	0.53	0.63
19 Leather, fur, feathers (cashmere) and the apparel industry					
fpo	4518	0.54	0.10	0.32	0.71
fpe	4518	0.57	0.15	0.25	0.73
fpa	4518	0.58	0.10	0.37	0.75
20 Timber processing and wood, bamboo, vines and brown grass-products industry					
fpo	3501	0.28	0.13	0.07	0.44
fpe	3501	0.23	0.11	0.02	0.43
fpa	3501	0.36	0.14	0.09	0.64
21 Furniture manufacturing					
fpo	2046	0.50	0.05	0.13	0.57
fpe	2046	0.51	0.04	0.21	0.56
fpa	2046	0.53	0.06	0.23	0.60
22 Paper and paper products industry					
fpo	5570	0.35	0.06	0.12	0.54
fpe	5570	0.23	0.08	0.10	0.39
fpa	5570	0.41	0.08	0.08	0.58
23 Printing and reproduction of recorded media					
fpo	4084	0.35	0.09	0.23	0.49

fpe	4084	0.27	0.10	0.13	0.46
fpa	4084	0.35	0.10	0.21	0.43
24 Cultural, educational, sporting products manufacturing					
fpo	2516	0.59	0.14	0.01	0.91
fpe	2516	0.61	0.16	0.00	0.92
fpa	2516	0.65	0.15	0.01	0.80
25 Oil processing, coking and nuclear fuel processing industry					
fpo	1323	0.13	0.07	0.00	0.20
fpe	1323	0.10	0.05	0.00	0.14
fpa	1323	0.17	0.10	0.00	0.26
26 Chemical materials and chemical products industry					
fpo	13803	0.28	0.17	0.00	0.70
fpe	13803	0.16	0.10	0.01	0.52
fpa	13803	0.28	0.16	0.00	0.66
27 Pharmaceutical industry					
fpo	4063	0.27	0.06	0.15	0.36
fpe	4063	0.20	0.04	0.10	0.26
fpa	4063	0.26	0.06	0.15	0.36
28 Chemical fiber industry					
fpo	937	0.33	0.06	0.07	0.37
fpe	937	0.25	0.06	0.05	0.30
fpa	937	0.38	0.12	0.02	0.48
29 Rubber products industry					
fpo	2016	0.37	0.10	0.09	0.47
fpe	2016	0.32	0.14	0.08	0.56
fpa	2016	0.42	0.12	0.12	0.56
30 Plastic products industry					
fpo	8382	0.45	0.13	0.22	0.61
fpe	8382	0.41	0.17	0.15	0.62
fpa	8382	0.50	0.15	0.25	0.67
31 Non-metallic mineral products industry					
fpo	16245	0.18	0.09	0.03	0.51
fpe	16245	0.11	0.08	0.01	0.45
fpa	16245	0.22	0.10	0.07	0.60
32 Smelting and rolling of ferrous metals industry					
fpo	4119	0.17	0.03	0.11	0.23
fpe	4119	0.09	0.02	0.07	0.15
fpa	4119	0.15	0.01	0.13	0.19
33 Smelting and rolling of non-ferrous metals industry					
fpo	3367	0.18	0.09	0.00	0.29
fpe	3367	0.12	0.07	0.00	0.26
fpa	3367	0.20	0.12	0.00	0.39
34 Fabricated metal products					
fpo	9746	0.33	0.12	0.01	0.92
fpe	9746	0.27	0.13	0.04	0.93

fpa	9746	0.36	0.13	0.01	0.94
35 General equipment manufacturing industry					
fpo	12546	0.26	0.13	0.06	0.67
fpe	12546	0.18	0.09	0.04	0.48
fpa	12546	0.29	0.12	0.05	0.69
36 Specialized equipment manufacturing					
fpo	7129	0.24	0.17	0.01	0.75
fpe	7129	0.16	0.14	0.00	0.48
fpa	7129	0.23	0.18	0.00	0.76
37 Transportation equipment manufacturing					
fpo	8281	0.33	0.17	0.00	0.83
fpe	8281	0.19	0.11	0.00	0.87
fpa	8281	0.32	0.16	0.00	0.89
39 Electrical machinery and equipment manufacturing industry					
fpo	10400	0.40	0.14	0.22	0.74
fpe	10400	0.36	0.14	0.13	0.74
fpa	10400	0.40	0.16	0.16	0.70
40 Communication equipment, computer and other electronic equipment manufacturing					
fpo	5857	0.75	0.17	0.20	0.92
fpe	5857	0.66	0.15	0.07	0.87
fpa	5857	0.66	0.17	0.06	0.92
41 Instrumentation and cultural, office machinery manufacturing					
fpo	2515	0.50	0.22	0.00	0.97
fpe	2515	0.39	0.23	0.00	0.88
fpa	2515	0.42	0.24	0.00	0.91
42 Crafts and other products manufacturing industries					
fpo	4259	0.42	0.11	0.20	1.00
fpe	4259	0.46	0.14	0.14	1.00
fpa	4259	0.46	0.12	0.23	1.00
43 Waste resources and recycling materials processing industry					
fpo	107	0.20	0.02	0.17	0.21
fpe	107	0.08	0.02	0.07	0.12
fpa	107	0.31	0.07	0.22	0.36

Note: fpo/fpe/fpa denotes foreign presence measured in terms of output/employee/assets share.
Source: Author’s calculation based on Enterprise Data, NBS, Beijing, 2003

Table 4.2 Ranking Consistency of Three FDI Proxies

Industry Code	fpo	rank (fpo)	fpe	Rank (fpe)	fpa	Rank (fpa)
40	0.75	1	0.66	1	0.66	1
24	0.59	2	0.61	2	0.65	2
19	0.54	3	0.57	3	0.58	3
21	0.50	4	0.51	5	0.53	4
18	0.52	5	0.52	4	0.53	5
30	0.45	6	0.41	7	0.50	6
42	0.42	7	0.46	6	0.46	7
41	0.50	8	0.39	8	0.42	8
29	0.37	9	0.32	10	0.42	9
22	0.35	10	0.23	18	0.41	10
14	0.40	11	0.29	11	0.40	11
39	0.40	12	0.36	9	0.40	12
15	0.39	13	0.27	14	0.38	13
28	0.33	14	0.25	16	0.38	14
34	0.33	15	0.27	12	0.36	15
20	0.28	16	0.23	17	0.36	16
23	0.35	17	0.27	13	0.35	17
17	0.32	18	0.27	15	0.35	18
37	0.33	19	0.19	21	0.32	19
43	0.20	20	0.08	29	0.31	20
13	0.26	21	0.20	19	0.30	21
35	0.26	22	0.18	22	0.29	22
26	0.28	23	0.16	24	0.28	23
27	0.27	24	0.20	20	0.26	24
36	0.24	25	0.16	23	0.23	25
31	0.18	26	0.11	26	0.22	26
33	0.18	27	0.12	25	0.20	27
25	0.13	28	0.10	27	0.17	28
32	0.17	29	0.09	28	0.15	29
16	0.02	30	0.04	30	0.03	30

Source: Author’s calculation based on Enterprise Data, NBS, Beijing, 2003

Table 4.3 Firm Labour Productivity by Industries

(Unit: thousand RMB/employee)

	Obs	Mean	Std.Dev.	Min	Max
13 Food processing industry	11080	429.58	898.82	0	66883.00
14 Food manufacturing industry	4574	246.76	356.58	0	7669.55
15 Beverage manufacturing industry	3167	254.58	483.65	0	12491.43
16 Tobacco industry	251	616.20	849.69	0	6038.04
17 Textile industry	14813	220.67	420.02	0	27370.00
18 Textile garments, shoes and hats manufacturing	9692	141.68	218.13	0	10937.50
19 Leather, fur, feathers (cashmere) and the apparel industry	4510	208.11	343.28	0	6215.86
20 Timber processing and wood, bamboo, vines and brown grass-products industry	3480	200.33	249.37	0	6028.07
21 Furniture manufacturing	2040	209.08	273.85	0	6422.00
22 Paper and paper products industry	5537	236.51	293.24	0	6729.53
23 Printing and reproduction of recorded media	4052	194.44	751.76	0	45220.00
24 Cultural, educational, sporting products manufacturing	2510	154.96	217.62	0	5111.67
25 Oil processing, coking and nuclear fuel processing industry	1306	740.11	1321.09	0	14392.31
26 Chemical materials and chemical products industry	13708	385.91	850.68	0	44287.96
27 Pharmaceutical industry	4031	254.41	352.64	0	8132.70
28 Chemical fiber industry	936	439.03	432.20	0	3600.00
29 Rubber products industry	2010	209.24	385.29	0	10904.13
30 Plastic products industry	8360	270.83	402.24	0	17978.96
31 Non-metallic mineral products industry	16132	190.51	425.69	0	29915.71
32 Smelting and rolling of ferrous metals industry	4085	465.97	1409.28	0	78858.00
33 Smelting and rolling of non-ferrous metals industry	3352	542.01	899.68	0	16488.91
34 Fabricated metal products	9714	293.64	841.84	0	51506.67
35 General equipment manufacturing industry	12496	230.37	380.52	0	21617.50
36 Specialized equipment manufacturing	7087	234.65	464.82	0	25240.00
37 Transportation equipment manufacturing	8239	261.98	491.05	0	9313.50
39 Electrical machinery and equipment manufacturing industry	10367	308.35	501.09	0	18493.13
40 Communication equipment, computer and other electronic equipment manufacturing	5843	479.23	2700.76	0	152445.90
41 Instrumentation and cultural, office machinery manufacturing	2510	333.70	4208.82	0	209774.80
42 Crafts and other products industries	4250	207.52	654.48	0	33803.60
43 Waste resources and recycling materials processing industry	106	907.64	1760.79	6.47	10996.92

Note: the number of firms here is different from that of Table 4.1, due to missing value.

Source: Enterprise Data, NBS, Beijing, 2003

Table 4.4 Coverage of Manufacturing Sector

Code	Industry Name
13	Food processing industry
14	Food manufacturing industry
15	Beverage manufacturing industry
16	Tobacco industry
17	Textile industry
18	Textile garments, shoes and hats manufacturing
19	Leather, fur, feathers (cashmere) and the apparel industry
20	Timber processing and wood, bamboo, vines and brown grass-products industry
21	Furniture manufacturing
22	Paper and paper products industry
23	Printing and reproduction of recorded media
24	Cultural, educational, sporting products manufacturing
25	Oil processing, coking and nuclear fuel processing industry
26	Chemical materials and chemical products industry
27	Pharmaceutical industry
28	Chemical fibre industry
29	Rubber products industry
30	Plastic products industry
31	Non-metallic mineral products industry
32	Smelting and rolling of ferrous metals industry
33	Smelting and rolling of non-ferrous metals industry
34	Fabricated metal products
35	General equipment manufacturing industry
36	Specialized equipment manufacturing
37	Transportation equipment manufacturing
39	Electrical machinery and equipment manufacturing industry
40	Communication equipment, computer and other electronic equipment manufacturing
41	Instrumentation and cultural, office machinery manufacturing
42	Crafts and other products industries
43	Waste resources and recycling materials processing industry

Note: 29 industry dummies are constructed from this classification

Table 4.5 Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
ln(labour productivity)	140805	4.9918	1.1472	-8.1198	12.2538
fpe	143161	0.2635	0.1842	0	0.9333
fpa	143161	0.3478	0.1796	0	0.9379
fpo	143161	0.3305	0.1811	0	0.9744
ln(capital intensity)	141942	-2.0867	1.0879	-13.3047	6.7739
ln(intermediate inputs per employee)	140627	4.6098	1.2285	-8.8130	11.3739
ln(labour quality)	141952	2.1162	0.7584	-6.9985	6.6493
age	143161	11.5010	12.9647	0	403
scale economy	143161	0.1617	0.0810	0.0113	1
Herfindahl	143161	0.0002	0.0059	0	1
ln(domestic market size)	143161	17.1874	1.3764	8.8223	20.1563
industry export intensity	143161	0.1858	0.1919	0	0.9798
industry average wage	143161	11.5896	3.8558	5.2282	78.6448
industry unit production cost	143161	0.6457	0.9047	0.0492	9.1009

Dummy variables	per cent	Dummy variables	per cent	Dummy variables	per cent
Ownership	0.5187	d21	0.0109	d32	0.0237
Western	0.1201	d22	0.0315	d33	0.0193
Middle	0.1895	d23	0.0235	d34	0.0534
Past exporting experience	0.1926	d24	0.0117	d35	0.0734
d14	0.0255	d25	0.0076	d36	0.0415
d15	0.0182	d26	0.0792	d37	0.048
d16	0.0016	d27	0.0235	d39	0.0575
d17	0.0801	d28	0.005	d40	0.0288
d18	0.0472	d29	0.0113	d41	0.0133
d19	0.0219	d30	0.0437	d42	0.021
d20	0.0191	d31	0.0942	d43	0.0006

Note: (1) fpo/fpe/fpa is the foreign presence measured in terms of output/employee/assets share in the industry; (2) Variables starting with letter *d* are the industry dummies, for example *d14* denotes whether the firm is in Industry 14; (3) Percentage for dummy variables denotes the proportion of firms that take value 1, for example for dummy *Western*, 12.01 per cent of domestic firms are located in western China.

Source: Enterprise Data, NBS, Beijing, 2003

Table 4.6 Correlation Matrix among Key Variables

	lnspe	*fpe*	*fpa*	*fpo*	*lnkl*	*lnml*	*lnlq*	*age*	*scale*	*herfindahl*	*lndmkts*	*ieintensity*	*iaveragewage*	*iuprodct*
lnspe	1													
fpe	-0.011	1												
fpa	0.0151	0.918	1											
fpo	0.017	0.9185	0.9532	1										
lnkl	0.4879	-0.0899	-0.056	-0.0185	1									
lnml	0.0258	0.0234	0.0261	0.0218	-0.0107	1								
lnlq	0.3905	0.1125	0.1067	0.1293	0.3563	0.0014	1							
age	-0.2363	-0.1487	-0.1526	-0.1289	0.0293	-0.0723	-0.0501	1						
scale	0.0124	0.011	0.0107	0.0102	-0.0033	0.0084	0.0072	-0.0214	1					
herfindahl	0.0284	0.0009	-0.0045	0.0007	0.0309	0.0007	0.0266	0.0202	-0.0036	1				
lndmkts	-0.0073	-0.0115	-0.0121	-0.0105	-0.0046	0.0437	-0.0157	0.01	-0.4992	0.006	1			
ieintensity	0.0257	0.0256	0.0234	0.0206	0.0055	-0.0045	0.0215	-0.0626	0.357	-0.0022	-0.3031	1		
iaveragewage	0.0008	0.0037	0.0045	0.0061	0.0192	0.0666	0.0217	0.0169	-0.3268	0.0022	0.2048	-0.1356	1	
iuprodct	-0.0113	-0.0122	-0.0113	-0.0074	0.0145	-0.1919	-0.0002	0.0454	-0.2826	0.0044	0.2064	-0.2962	0.2828	1

Source: Author’s calculation based on Enterprise Data, NBS, Beijing, 2003

Table 4.7 Estimation Results Using Employment Share as Proxy for FDI

labour productivity equation			foreign presence equation		
Variables	Coef.	Std. Err.	Variables	Coef.	Std. Err.
ln(capital intensity)	0.3901	0.0098	ln(domestic market size)	0.0002**	0.0002
ln(intermediate inputs per employee)	0.0083	0.0026	industry export intensity	0.0045	0.0015
ln(labour quality)	0.3325	0.0222	industry average wage	-0.0002	0.0001
age	-0.0170	0.0018	industry unit production cost	0.0006*	0.0004
age2	0.00003	0.0000	ln(labour productivity)	0.0104	0.0005
fpe	5.7707	2.5738			
scale	0.0524*	0.0298			
herfindahl	2.9730	0.3935			
ownership	0.1520	0.0480			
middle	0.1409**	0.0980	middle	-0.0406	0.0009
western	-0.2127	0.1063	western	-0.0420	0.0011
d14	-1.0862	0.2222	d14	0.0925	0.0024
d15	-1.0692	0.1754	d15	0.0713	0.0027
d16	0.6139*	0.3666	d16	-0.1558	0.0081
d17	-0.8591	0.1091	d17	0.0534	0.0017
d18	-2.5399	0.7554	d18	0.3141	0.0020
d19	-2.6026	0.8793	d19	0.3582	0.0025
d20	-0.6727	0.0583	d20	0.0352	0.0026
d21	-2.3670	0.7616	d21	0.3096	0.0033
d22	-0.6006	0.0686	d22	0.0314	0.0022
d23	-1.1913	0.1789	d23	0.0735	0.0025
d24	-3.0263	0.9749	d24	0.3985	0.0032
d25	0.5529	0.2414	d25	-0.0954	0.0039
d26	-0.0795**	0.1094	d26	-0.0397	0.0017
d27	-0.7170	0.0326	d27	0.0118	0.0024
d28	-0.5152	0.0954	d28	0.0370	0.0046
d29	-1.3102	0.2797	d29	0.1169	0.0033
d30	-1.6460	0.4912	d30	0.1999	0.0020
d31	-0.1803**	0.2246	d31	-0.0788	0.0017
d32	0.5384*	0.2762	d32	-0.1049	0.0024
d33	0.4174*	0.2142	d33	-0.0823	0.0026
d34	-0.8387	0.1371	d34	0.0616	0.0019
d35	-0.4477	0.0849	d35	-0.0258	0.0018
d36	-0.4550	0.1139	d36	-0.0388	0.0020
d37	-0.5847	0.0328	d37	-0.0047	0.0019
d39	-1.3457	0.3719	d39	0.1501	0.0018
d40	-3.2436	1.1072	d40	0.4403	0.0023
d41	-1.7720	0.3957	d41	0.1627	0.0031
d42	-2.0342	0.5931	d42	0.2458	0.0026

d43	0.6948	0.3433	d43	-0.1241	0.0127
constant	4.5193	0.4814	constant	0.1573	0.0048
R-square	0.0177		R-square	0.5923	

Note: * denotes insignificant at 5 per cent level but significant at 10 per cent level; ** denotes insignificant at 10 per cent level.

Table 4.8 Estimation Results Using Assets Share as Proxy for FDI

labour productivity equation			foreign presence equation		
Variables	Coef.	Std. Err.	Variables	Coef.	Std. Err.
ln(capital intensity)	0.3853	0.0027	ln(domestic market size)	0.0002**	0.0002
ln(intermediate inputs per employee)	0.0062*	0.0034	industry exports intensity	0.0036	0.0017
ln(labour quality)	0.3156	0.0202	industry average wage	-0.0002	0.0001
age	-0.0155	0.0021	industry unit production cost	0.0005**	0.0004
age2	0.0000	0.0000	ln(labour productivity)	0.0163	0.0006
fpa	5.9832	2.4376			
scale	0.0557*	0.0292			
herfindahl	3.1186	0.4654			
ownership	0.1180	0.0508			
middle	0.1618**	0.1007	middle	-0.0429	0.0010
western	-0.1856*	0.1115	western	-0.0434	0.0013
d14	-1.2110	0.2546	d14	0.1138	0.0028
d15	-1.2111	0.2162	d15	0.0959	0.0031
d16	1.2080	0.5794	d16	-0.2535	0.0093
d17	-0.7803	0.0718	d17	0.0432	0.0020
d18	-2.1022	0.5206	d18	0.2377	0.0023
d19	-2.1973	0.6452	d19	0.2840	0.0029
d20	-0.8306	0.1204	d20	0.0658	0.0030
d21	-1.9892	0.5471	d21	0.2412	0.0038
d22	-1.1269	0.2766	d22	0.1213	0.0025
d23	-1.1188	0.1349	d23	0.0624	0.0029
d24	-2.7255	0.7764	d24	0.3417	0.0037
d25	0.7653	0.3074	d25	-0.1284	0.0045
d26	-0.2010	0.0509	d26	-0.0164	0.0020
d27	-0.5257	0.0610	d27	-0.0176	0.0028
d28	-0.7537	0.1807	d28	0.0776	0.0053
d29	-1.3343	0.2677	d29	0.1214	0.0038
d30	-1.6607	0.4577	d30	0.1994	0.0023
d31	-0.215**	0.1889	d31	-0.0658	0.0019
d32	0.8030	0.3586	d32	-0.1448	0.0028
d33	0.5075	0.2315	d33	-0.0942	0.0030
d34	-0.8357	0.1274	d34	0.0628	0.0022
d35	-0.5501	0.0355	d35	-0.0041	0.0020

d36	-0.2929*	0.1687	d36	-0.0611	0.0023
d37	-0.7560	0.0494	d37	0.0276	0.0022
d39	-1.0229	0.2103	d39	0.0939	0.0021
d40	-2.7751	0.8238	d40	0.3514	0.0026
d41	-1.4376	0.2291	d41	0.1062	0.0035
d42	-1.5321	0.3438	d42	0.1593	0.0030
d43	-0.12**	0.1158	d43	0.0166**	0.0145
constant	3.9297	0.7054	constant	0.2215	0.0056
R-square	-0.1122		R-square	0.4344	

Note: * denotes insignificant at 5 per cent level but significant at 10 per cent level; ** denotes insignificant at 10 per cent level.

Table 4.9 Estimation Results Using Output Share as Proxy for FDI

labour productivity equation			foreign presence equation		
Variables	Coef.	Std. Err.	Variables	Coef.	Std. Err.
ln(capital intensity)	0.3736	0.0060	ln(domestic market size)	0.0002**	0.0002
ln(intermediate inputs per employee)	0.0066	0.0030	industry exports intensity	0.0026*	0.0016
ln(labour quality)	0.3102	0.0183	industry average wage	-0.0002	0.0001
age	-0.0155	0.0016	industry unit production cost	0.0007*	0.0004
age2	0.0000	0.0000	ln(labour productivity)	0.0185	0.0006
fpo	6.2990	2.1743			
scale	0.0596	0.0295			
herfindahl	2.9856	0.4020			
ownership	0.1228	0.0388			
middle	0.1363**	0.0774	middle	-0.0361	0.0010
western	-0.2053	0.0891	western	-0.0362	0.0012
d14	-1.4415	0.2953	d14	0.1464	0.0027
d15	-1.4639	0.2693	d15	0.1336	0.0030
d16	1.2029	0.4971	d16	-0.2371	0.0090
d17	-0.8199	0.0759	d17	0.0487	0.0019
d18	-2.3284	0.5222	d18	0.2630	0.0023
d19	-2.2537	0.5688	d19	0.2796	0.0028
d20	-0.6113	0.0353	d20	0.0285	0.0029
d21	-2.0959	0.5022	d21	0.2473	0.0037
d22	-1.0052	0.1931	d22	0.0972	0.0025
d23	-1.3426	0.1897	d23	0.0978	0.0028
d24	-2.7254	0.6606	d24	0.3260	0.0036
d25	0.8168	0.2794	d25	-0.1299	0.0043
d26	-0.3541	0.0186	d26	0.0099	0.0019
d27	-0.7498	0.0347	d27	0.0213	0.0027
d28	-0.6381	0.1167	d28	0.0563	0.0052
d29	-1.2979	0.2151	d29	0.1114	0.0036
d30	-1.5896	0.3642	d30	0.1794	0.0022

d31	-0.1529**	0.1815	d31	-0.0704	0.0019
d32	0.5171	0.2054	d32	-0.0920	0.0027
d33	0.4917	0.1911	d33	-0.0868	0.0029
d34	-0.8567	0.1162	d34	0.0643	0.0021
d35	-0.5964	0.0192	d35	0.0055	0.0020
d36	-0.5255	0.0655	d36	-0.0186	0.0023
d37	-1.0597	0.1446	d37	0.0766	0.0022
d39	-1.2977	0.2729	d39	0.1344	0.0021
d40	-3.6362	0.9955	d40	0.4726	0.0025
d41	-2.1934	0.4541	d41	0.2236	0.0034
d42	-1.5825	0.3110	d42	0.1607	0.0029
d43	0.4383	0.1942	d43	-0.0728	0.0141
constant	4.0369	0.5642	constant	0.1734	0.0053
R-square	-0.1393		R-square	0.4761	

Note: * denotes insignificant at 5 per cent level but significant at 10 per cent level; ** denotes insignificant at 10 per cent level.

Figure 4.1 Distribution of Labour Productivity

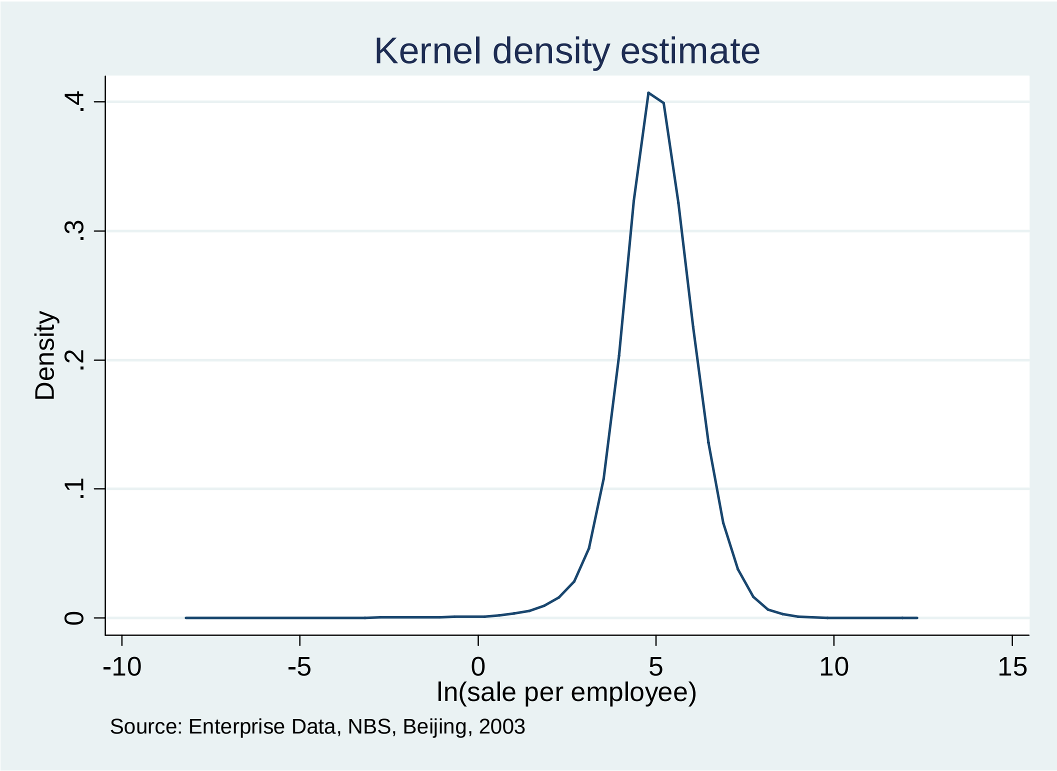


Figure 4.2 Distribution of Labour Productivity by Ownership

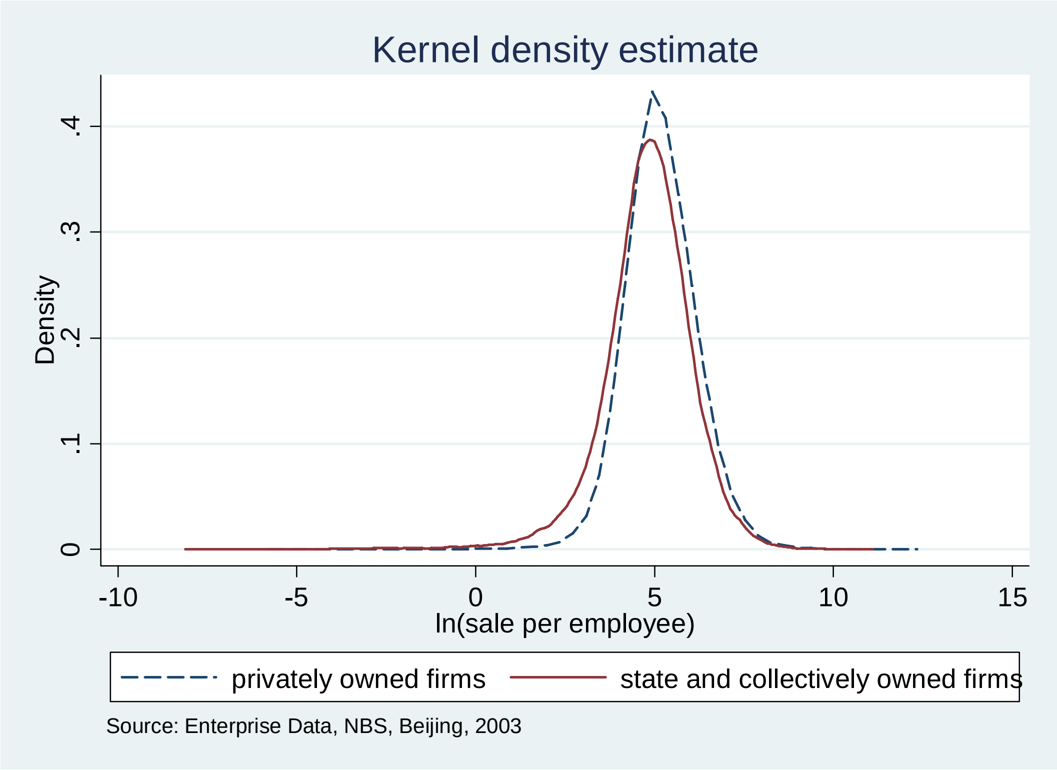


Figure 4.3 Distribution of Labour Productivity by Regions

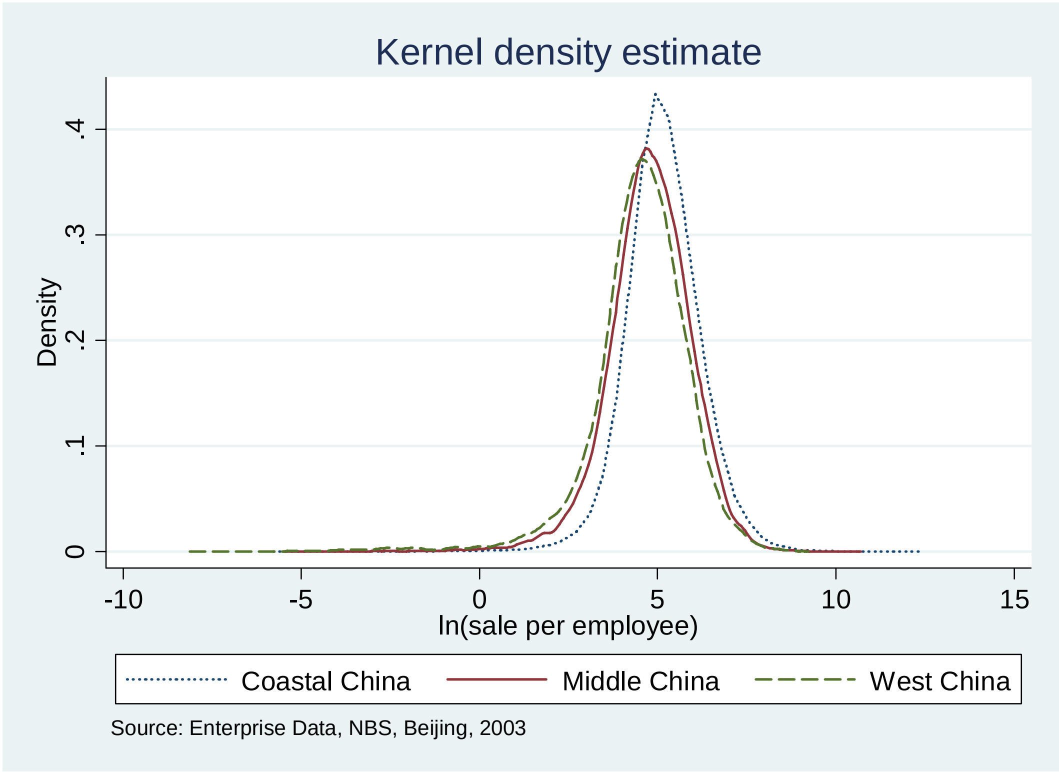
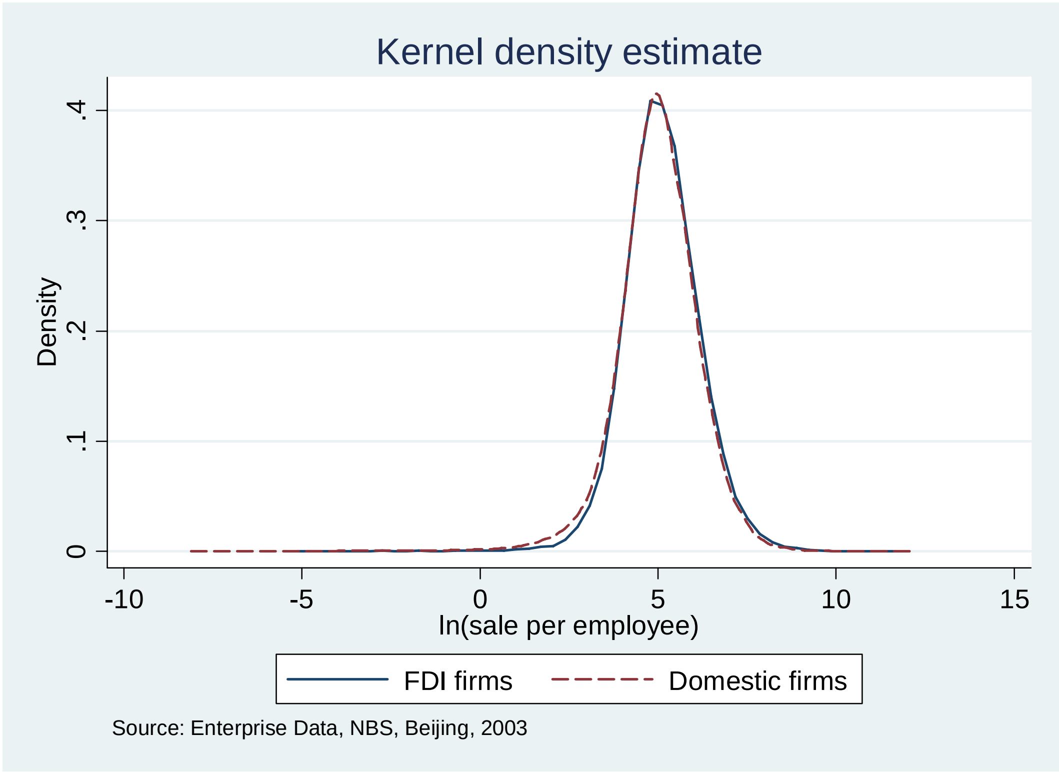


Figure 4.4 Distribution of Labour Productivity of Domestic and FDI Invested Firms



5. Export Spillovers of FDI in the Manufacturing Sector

FDI in manufacturing has been welcomed in China for the contribution that it could make to generating exports and foreign exchange earnings. Foreign invested firms are indeed associated with a very large proportion of China's exports. In Chapters 3 and 4, we tested technology spillovers of FDI at both the industry and firm levels. In this chapter, we turn to export spillovers of FDI in the manufacturing sector in China.

The chapter is organized into six sections. The following section makes a survey on determinants of firms' exports. In the subsequent two sections, we lay out a theoretical model to show that if the presence of FDI reduces domestic firms' export costs, for example by knowledge spillovers, domestic firms' export intensity will be promoted unambiguously. We deploy the econometric specification and estimation strategy used, namely the Heckman sample selection model, to test export spillovers. Then we describe the data set used, construct variables, present and discuss empirical results. The last section concludes the chapter.

Determinants of Firm Exports

A firm's export behaviour is affected by a variety of factors, which can be classified into three categories: the firm's characteristics, industry characteristics, and institutional factors. Different firms will take different values for firm characteristics. For industry-level characteristics, firms located in the same industry will take the same values, while firms located in different industries will have different values. Institutional factors are policy instruments, such as the tariff rate and export tax refund. In our subsequent empirical analysis, these three categories of factors serve as control variables.

Firm characteristics

A firm's characteristics indicate the firm's competitiveness in the market, and include size, capital intensity, production cost, composition of employment, innovation activity, marketing expense, past exporting experience, ownership structure, and regional heterogeneity.

Firm size is expected to have a positive relationship with firm exports, at least for the following two reasons. First, international trade allows for the exploitation of internal economies of scale as international trade can be viewed as a way of extending the market (for example, Krugman, 1979), and firm size is a good indicator of such scale economies (Hirsch and Adlar, 1974, Glejser et al. 1990, Lall and Kumar, 1981). In a bigger firm, particularly in a big business group, its subsidiaries are more able to exploit export channels of other subsidiaries within the same group, and obtain necessary export resources, such as finance, marketing, physical and human capital. Second, bigger firms usually have more resources to support entering the world market, and this can be particularly important if there exist fixed costs of exporting, such as gathering information and covering the uncertainty of a foreign market (Wakelin, 1998). Hence a bigger firm is more likely to export. However, the relationship between firm size and exports may not necessarily be linear. Firm size may be important for firms to overcome initial cost barriers in establishing their export channels. With the establishment of export channels, the initial investment is regarded as a sunk cost and firm size may be less important in determining export intensity, that is, the relationship between firm size and exports is likely to be an inverted U shape. In empirical studies, this kind of inverted U shaped relationship is found by Willmore (1992), Kumar and Siddharthan (1994), Wagner (1995), Wakelin (1998), Bernard and Jensen (1999), Sterlacchini (1999), and Roper and Love (2002).

Capital intensity, which is measured by the capital-labour ratio, captures a fundamental aspect of firm’s production technology, and can also be an important factor in determining firm’s exports. In the context of the factor endowment theory of trade, relative factor intensity directly determines trade pattern. Hence a firm’s capital intensity shall play a role in its exports. In addition, a firm’s capital intensity can also proxy for its innovation activities, for which a few empirical studies , for example Wakelin (1998) and Roper and Love (2002), have found positive impact on exports as innovation activities such as R&D are usually quite capital intensive. Hence higher capital intensity is positively related to more active innovation, which predicts a positive relationship between capital intensity and exports, as the innovation leads to either production of new products or reduction of production costs which enhances the firm's competitiveness in the world market. In empirical studies, Athukorala et al. (1995) find that capital intensity has a positive and significant impact on a firm's export participation decision, but an insignificant impact on firm's export level. In the meantime, the impact of capital-labour ratio on firm exports will depend on a country's factor endowment. In a country with rich capital endowment, a firm with high capital-labour ratio will have comparative advantage compared with a firm with low capital-labour ratio, which makes it easier to export and be more competitive in the world market. In a country with rich labour endowment, the situation will be the opposite.

The production cost can be expected to play an important role in firm's exports. Firms with lower production costs are more likely to export as they have comparative advantages over other firms. In reality, firm's production costs are not easily observed, particularly capital costs. Thus in empirical studies, production costs are proxied by different variables. Wakelin (1998) uses two labour cost variables to proxy for production costs: the unit labour cost and the average wage. Unit labour cost is the total remuneration of employees divided by total sales, and will be negatively related to exports. The average wage, which is equal to the total remuneration of employees divided by the total number of employees, on the one hand indicates a firm's skill level and hence can have a positive effect on exports, and on the other hand proxies for costs and can have a negative effect on exports. Wakelin's (1998) empirical results confirm that the average wage has positive impact on exports in the UK, and unit labour cost is negatively correlated with exports for non-innovating firms. Another proxy for production costs is total factor productivity (TFP). A higher TFP implies a lower production cost for a given output level, and hence should have a positive impact on exports. Alvarez (2006) uses TFP, the logarithmic difference between value-added and weighted inputs with the weight obtained from a semi-parametric estimation of firms' production function, in testing the determinants of export performance in Chilean manufacturing plants, and finds a significant and positive impact.

The composition of a firm's employment can also affect export behaviour. Some empirical studies find that the quality of a firm's employees is positively related to its exports (Roberts and Tybout, 1997, Alvarez, 2006). There are different proxies for this factor. For example, Alvarez (2006) uses the fraction of white-collar wages in the total wage bill to capture labour quality. The average wage can also proxy for labour quality. If the labour market is competitive, then the average difference in wages across firms reflects the differences in skill level. Some empirical studies find a significant and positive impact of firm innovation on their exports (e.g. Roper and Love, 2002, Basile, 2001, Wakelin, 1998). Intuitively, innovation can be important in determining exports, as innovation leads to either the production of new products or lowering the production costs of current products. In both cases firms' exports may be promoted. There are also different variables used in empirical studies to capture different aspects of innovation, for example R&D expenditure which is an indicator of investment in the resource base of the firm, the number of innovations used, and the number of innovations produced.

Other factors include a firm's marketing expenses, past exporting experience, ownership structure, and regional heterogeneity. A firm's marketing expenses clearly reflect its sales strategy. If firms put lots of money into successful marketing, then it is likely that they will export more. Past exporting experience is also important in that it indicates the entry costs to exporting have been paid and hence exporting is more likely. Firm ownership structure may also play a role, as privately-owned firms and state and collectively-owned firms may behave differently in exporting. However, the sign of the impact of ownership structure on exports cannot be pre-determined, as on the one hand privately-owned firms may have more incentive to export than state and collectively-owned firms, while on the other hand state and collectively-owned firms have more resources to help them to export, for example by being more capable in obtaining bank loans. Hence, there is no reason a priori to expect private firms to export more than state and collectively-owned firms or vice versa. Regional heterogeneity is also an important factor to consider. Firms located in different regions tend to behave systematically differently, owing to region-specific factors such as regional corporate culture and transportation costs. In China, the coastal region has been more open to the world market than the western and central regions. Hence it is reasonable to expect firms located in the coastal region to be more likely to export than firms located in western and central regions.

Industry characteristics

Different from firm characteristics, industry characteristics are those that are the same across firms in the same industry[22], but different across industries. By definition, industry characteristics have the same impact on exports for firms in the same industry. Industry characteristics include the penetration of FDI in the industry, the degree of competition or concentration in an industry, and industry heterogeneity in export behaviour.

In respect of the impact of FDI on exports of domestic firms, it is generally argued that the presence of FDI in the industry usually promotes domestic firm's exports (Alvarez, 2006), that is, there exist positive export spillovers. Compared with domestic firms, FDI invested firms usually possess some advantages (Dunning et al., 1990); for example, they are technologically superior and have expertise in international business and knowledge about foreign market. These advantages to some extent can spill over to domestic firms via the mobility of labour or domestic firm's learning. Hence the export costs, particularly the entry costs, of domestic firms can be lowered by the presence of FDI, and subsequently their exports are promoted. However, whether these export spillovers will occur and to what extent these spillovers occur will also depend on a domestic firm's absorptive capacity. In empirical studies, Alvarez (2006) finds a positive and significant impact of foreign capital on firms' exports in Chilean manufacturing industry, and Athukorala et al. (1995) find a positive impact of 'third-world' multinationals on firms' export decisions in Sri Lankan manufacturing industry.

[22] In this chapter, the industry is at the two-digit aggregation level.

Another industry characteristic is the extent of competition or concentration in the market. In an industry where the market is competitive, domestic competition may force firms to explore the international market. In contrast, in an industry where some firms have market power, then the profit maximization incentive urges these firms to exploit market power in the domestic market, and hence they are less willing to export. So firms' exports may be negatively correlated with domestic market concentration. A proxy for the market structure of an industry market can be either the n-firm concentration ratio or the Herfindahl Index. Firms' export behaviour, namely the way they export their products, can be systematically different across industries, that is, there exists industry heterogeneity. This is intuitive, for example a firm's export behaviour in an industry that exports heavy machinery must be significantly different from an industry that exports software services.

Institutional factors

Institutional factors that affect a firm's export behaviour include the export promotion or import substitution policy, tariff and non-tariff trade barriers, exchange rate policies, and domestic tax refund schemes for exports.

In countries that adopt export promotion policies, policies commonly directed at promoting exports in certain industries, particularly in some high value-added manufacturing industries such as the electronics industry. This will obviously encourage firms in those industries to export, although there is no guarantee that such policies will work. In contrast, import substitution policies will discourage firms from exporting in certain industries. The tariff rate and non-tariff barriers, such as some technological standards, aim to discourage imports and thus protect domestic markets from foreign competition. These protective measures reduce domestic competition and hence reduce domestic firms' incentive to export. The exchange rate, including both its mean level and its volatility, will have an immediate and direct effect on firm's exports, as changes in the exchange rate will directly affect firm's export revenue in domestic currency. High volatility of the exchange rate will increase a firm's export risk and thus make firms less willing to export, while a stable exchange rate system is likely decrease this uncertainty. Even though this exchange rate risk can be covered to a significant extent, covering such risk increases a firm's export costs. In addition, domestic tax refunds for exports, a common practice in many countries, will also positively affect firm's exports. The rate and coverage of domestic tax refunds will directly affect firm's export costs. Higher rates of refund reduce export costs. The procedure of tax refund also plays a role, for example whether the tax refund is paid back before exports or after exports has different implication for firm export costs.

A Simple Model of Firm Export Behaviour

In order to capture the impact of FDI on domestic firm's export activity, namely the export spillovers of FDI, a simple model of firm export behaviour is developed in this section. In an industry that contains N firms, which include $N(1-\gamma)$ domestic firms and $N\gamma$ FDI invested firms, where γ denotes the foreign presence in the industry. The FDI invested firms are able to choose their output quantity and export intensity independently from their parent firm[23]; that is, they can act like a domestic firm. All firms are homogenous and can sell their products in both the domestic market and foreign market. In the domestic market, firms play a Cournot, and have inverse demand functions as follows:

$$p = p(Q),\ p' < 0$$

where Q is the domestic demand and $Q = \sum_{i=1}^{N}(1-s_i)q_i$, s_i is firm i's export intensity, namely the share of exports in total output, and q_i denotes firms i's output. The world market is a competitive market, and firms are faced with world price P.

Costs are incurred in the course of production and exporting. For the production process, firm i's cost function is $C(q_i)$ with $C'(q_i) > 0$. For the export process, firm

[23] By this, we can abstract away from the parent firm's decision. However this is not a strong assumption, as the world market is competitive and the FDI parent firms earn zero profit there and hence the FDI parent firm's global profit maximization is equivalent to the domestic market profit maximization.

i's export cost function is $E = E\left(s_i q_i, \sum_{j=1}^{N\gamma} q_j\right)$ with $E_1^{'} > 0$, $E_{11}^{''} > 0$, $E_2^{'} < 0$, $E_{22}^{''} < 0$, and $E_{12}^{''} < 0$. $E_1^{'} > 0$, $E_{11}^{''} > 0$ shows that the cost of a firm's exports is rising in its export quantity, and the speed is increasing. $E_2^{'} < 0$, $E_{22}^{''} < 0$ shows that for a given firm's export quantity, the cost of its exports is decreasing in FDI invested firms' activities in the industry, but the speed of the fall in cost is also decreasing. $E_{12}^{''} < 0$ states that if FDI invested firms' activities in the industry increase, then $E_1^{'}$ decreases, which means that for a given fixed increase in export quantity, the increase in export costs will be smaller due to the increased activities of FDI invested firms. Increased activities by FDI invested firms make it more likely that their export knowledge is passed on to domestic firms and hence reduce the marginal cost of exports for domestic firms. If firm *i* is a domestic firm, then it enjoys export spillovers from FDI invested firms as its export cost is reduced by the presence of FDI invested firms. The channels of such benefits can vary; for example domestic firms can learn from FDI invested firms' export behaviour and subsequently reduce the transaction costs in exporting and other input costs. These channels for domestic firms' learning to export are assumed to be exogenous and hence are not modelled here.

Firm *i*'s problem is to choose its output quantity and export intensity to maximize its profit, given all the other firms' output quantities and export intensities, as follows:

$$\max_{\{q_i, s_i\}} \Pi_i = (1 - s_i) q_i p\left(\sum_{i=1}^{N} (1 - s_i) q_i\right) + s_i q_i P - C(q_i) - E\left(s_i q_i, \sum_{j=1}^{N\gamma} q_j\right)$$

Then a domestic firm's FOCs are:

$$(1 - s_i) p + (1 - s_i)^2 q_i p^{'} + s_i P - C^{'}(q_i) - s_i E_1^{'} = 0$$

$$- q_i p - (1 - s_i) q_i^2 p^{'} + q_i P - q_i E_1^{'} = 0$$

An FDI invested firm's FOCs are:

$$(1-s_i)p+(1-s_i)^2 q_i p' + s_i P - C'(q_i) - s_i E_1' - E_2' = 0$$

$$-q_i p - (1-s_i) q_i^2 p' + q_i P - q_i E_1' = 0$$

By symmetry, all domestic firms choose the same output quantity and export intensity, and all FDI invested firms choose the same output quantity and export intensity. But FDI invested firms' choices of output quantity and export intensity are different from domestic firms' choices. Let a domestic firm's choice be (q_d, s_d) and an FDI invested firm's choice be (q_f, s_f). The FOCs become:

$$(1-s_d)p+(1-s_d)^2 q_d p' + s_d P - C'(q_d) - s_d E_{1,d}' = 0 \qquad (5.1)$$

$$-q_d p - (1-s_d) q_d^2 p' + q_d P - q_d E_{1,d}' = 0 \qquad (5.2)$$

$$(1-s_f)p+(1-s_f)^2 q_f p' + s_f P - C'(q_f) - s_f E_{1,f}' - E_{2,f}' = 0 \qquad (5.3)$$

$$-q_f p - (1-s_f) q_f^2 p' + q_f P - q_f E_{1,f}' = 0 \qquad (5.4)$$

where $E_{1,d}'$ is the first derivative of the export cost function with respect to its first argument, evaluated at domestic firms' output quantity and export intensity, and $E_{1,f}'$ and $E_{2,f}'$ are those evaluated at FDI invested firms' choice.

Multiplying equation (5.2) by $\frac{1-s_d}{q_d}$ and add to equation (5.1), we obtain:

$$P - C'(q_d) - E_{1,d}' = 0 \qquad (5.5)$$

Multiplying equation (5.4) by $\frac{1-s_f}{q_f}$ and add to equation (5.3), we obtain:

$$P - C^{'}\left(q_f\right) - E^{'}_{1,f} - E^{'}_{2,f} = 0 \qquad (5.6)$$

The first observation about equations (5.5) and (5.6) is that $\left(q_d, s_d\right) \neq \left(q_f, s_f\right)$, that is, domestic firms and FDI invested firms have different equilibrium choices of output quantity and export intensity, which occurs due to the asymmetric impact of foreign presence on firms' export costs. Furthermore, if FDI invested firms have same production capacity as domestic firms, namely $q_f = q_d$, then FDI invested firms will always export more than their counterparts. This point can be showed by plugging $q_d = q_f$ into equations (5.5) and (5.6):

$$E^{'}_{1,d} - E^{'}_{1,f} - E^{'}_{2,f} = 0$$

which implies $E^{'}_{1,d} < E^{'}_{1,f}$ as $E^{'}_{2,f} < 0$. Since $E^{''}_{11} > 0$, $s_d < s_f$.

Totally differentiate equation (5.5) and (5.6), holding *N*, q_d, and q_f constant, we obtain:

$$\frac{ds_d}{d\gamma} = -\frac{E^{''}_{12,d}}{E^{''}_{11,d}} \times \frac{Nq_f}{q_d} > 0$$

$$\frac{ds_f}{d\gamma} = -\frac{E^{''}_{12,f} + E^{''}_{22,f}}{E^{''}_{11,f} + E^{''}_{12,f}} \times N$$

which shows that for an increase in foreign presence γ, domestic firms will unambiguously increase their export intensity, while in contrast its impact on FDI invested firms' export intensity is undetermined and depends on how their activities affect the export cost function.

This is a stylized model, as it makes simplifications in several respects. For example, all firms in the model are homogenous, and FDI invested firms here can act without any constraint from their parent firms, which seems a little unrealistic in reality.

Second, the entry of FDI invested firms is not modelled explicitly, and in the total differentiation above the total number of firms in the industry, *N*, is held constant, which implicitly assumes that FDI can only enter the industry by acquiring domestic firms. However, this assumption is not strong for the subsequent empirical testing in that the empirical testing uses cross-sectional data and no actual firm entry or exit takes place, and hence the number of firms can be reasonably held constant.

It is also likely that FDI can reduce production costs for firms, in which technology spillovers will occur if the technology is cost-reducing. To accommodate this possibility, a firms' cost function can be specified as $C\left(q_i, \sum_{j=1}^{N\gamma} q_j\right)$ with $C_1^{'} > 0$, $C_2^{'} < 0$, and $C_{12}^{''} < 0$, and then $\frac{ds_d}{d\gamma} = -\frac{C_{12,d}^{''} + E_{12,d}^{''}}{E_{11,d}^{''}} \times \frac{Nq_f}{q_d} > 0$, where $C_{12,d}^{''}$ is the cross-derivative of a firm's cost function with respect to its first and second arguments evaluated at the domestic and FDI firms' equilibrium choice of quantity. Hence, the results of the model do not change even if cost-reducing technology spillovers are accounted for.

In the model, we assume that both domestic firms and FDI firms share the same production and export cost functions. Even if we allow for the possibility that they are different, namely the production and export cost functions for domestic firms being $C\left(q_i, \sum_{j=1}^{N\gamma} q_j\right)$ and $E\left(s_i q_i, \sum_{j=1}^{N\gamma} q_j\right)$ respectively and those for FDI firms being $c(q_i)$ and $e(s_i q_i)$ respectively with similar assumptions on the first, second and cross derivatives, the result of the model, namely domestic firms' export intensity will be promoted unambiguously by an exogenous increase in foreign presence, remains unchanged.

The Econometric Specification and Estimation Strategy

Econometric specification

The theoretical model predicts that if the presence of FDI reduces other firms' export costs, then the presence of FDI will promote other firms' exports. Hence, to test whether there exist export spillovers, the following econometric model is set up:

$$s = \beta_0 + \beta_1 X + \beta_2 I + \beta_3 fp + \beta_4 fp \times X + \varepsilon \tag{5.7}$$

where *s* denotes firm export intensity, namely firm's export value divided by its total sale; X is a vector of firm characteristics, which includes firm size, capital intensity, unit production costs, average labour wage, marketing expense, ownership structure, regional dummies, and a dummy that indicates firm's past exporting experience; *I* is a vector of the industry characteristics (excluding FDI) that can affect firm's exports, including industry concentration (Herfindahl index) and a set of industry dummies that capture industry hetereogeneity in exports; and *fp* denotes the foreign presence that proxies for activities of FDI in host country. *X*, and *I* serve as control variables, and *fp* is the variable of interest.

Moreover *fp* is interacted with firm characteristics *X*, which allows for export spillovers to vary across firms, that is, firm characteristics are determinants of spillovers. This is reasonable, as we expect that firms with certain characteristics, such as bigger firms, are generally more capable of absorbing spillovers from FDI invested firms. The marginal impact of *fp* on firm's mean export intensity is:

$$\frac{\partial E[s]}{\partial fp} = \beta_3 + \beta_4 X \tag{5.8}$$

Hence, testing for the existence of export spillovers from FDI follows three steps. First, test the joint significance of the coefficient of *fp* and coefficient of the interaction terms. If they are jointly insignificant, then export spillovers do not exist. Second, test the joint significance of the interaction terms. If the interaction terms are jointly significant, then export spillovers depend on firm characteristics. Third, compute the marginal effect of *fp* (equation 5.8) and evaluate at relevant value of firm characteristics. If the evaluated marginal impact of *fp* is positive, then there exist positive export spillovers from FDI invested firms. If the evaluation is negative, then the presence of FDI in domestic industry actually does harm to domestic firms' exports. In addition, the impact of certain firm characteristics on its capacity to absorb spillovers from FDI invested firms can be measured as:

$$\frac{\partial^2 E[s]}{\partial fp \partial x_i} = \beta_{4,i} \qquad (5.9)$$

where x_i is the *i*th firm characteristic in the firm characteristic vector *X*. A significant and positive estimate of the coefficient implies that the firm characteristic helps the firm to absorb spillovers from FDI invested firms. Otherwise if the coefficient is significantly negative, then firm characteristics keep firms from benefiting from spillovers from FDI invested firms. For example, if the coefficient of *fp*'s interaction with firm size is significantly positive, then it indicates that a bigger firm is more capable of exploiting spillovers from FDI invested firms.

As in previous chapter, *fp* here is also proxied by FDI invested firms' output/employment/assets share in the industry respectively, in recognition of the inherent pitfalls of each of these three measurements.

Equation (5.7) aims at testing the impact of FDI on domestic firm's exports. However, if FDI tends to flow into the industry with higher domestic exports, which can occur if the incentive of FDI is export-oriented, then there is a potential endogeneity problem. In China, the inflow of export-oriented FDI exhibits two characteristics: first export-oriented FDI concentrates within certain industries (so called processing industries), like the textile industry; second most of them are located in coastal China, due to transportation costs. Regional dummies and industry dummies in equation (5.7) control for the potential endogeneity of FDI.

Estimation strategy

One characteristic of the dependent variable *s* is that a large number of *s* may take a value of zero as it is reasonable to expect many firms do not export at all. This makes OLS estimation of equation (5.7) problematic as it will produce biased and inconsistent estimates.

One widely used approach to handle this problem is the censored Tobit model. The advantage of the Tobit model is that it makes the use of all available information from the explanatory variables, and in particular it accounts for the fact that a large number of observations of dependent variable are zero. However, the Tobit model incorporates two decisions into one model, namely the decision to participate and the decision on the level of participation, which implicitly assumes that the explanatory variables will have the same impact on both decisions. In the case of exports here, the Tobit model imposes a constraint that the impact on each firm's decision on whether to export by the explanatory variables is equal to the impact on the firm's decision on how much to export. This may not necessarily be true, in which case the Tobit model is mis-specified and this kind of misspecification may have an undesirable impact on the estimation (Basile, 2001). This constraint can be relaxed by separating the problem into two steps: first look at each firm's decision on whether to export, and then explore each firm's decision on how much to export, conditioned on the fact that the firm has already decided to export. The validity of this kind of relaxation of the constraint can be tested (see Lin and Schmidt, 1984, for details).

Cragg (1971) proposes a two-stage specification that relaxes the constraint of Tobit model. In Cragg's specification, the first stage is to estimate a Probit model in which the dependent variable is the firm's decision on whether to export, namely a binary variable that takes a value of one when firms export. In the second stage, the estimation is made only over the firms that do export, in which the dependent variable is the export intensity and a truncated estimation procedure is applied. However, Cragg's specification implicitly assumes that the two stages are independent of each other. If this is not true, then the truncated estimation at the second stage will be biased, not only for the true whole population but also for the group of population that has been selected (Basile, 2001). The possibility of correlation between two stages can be accounted for by the sample selection model, in which the first stage is carried out using the Probit model, while in the second stage the sample selection bias is dealt with either through Heckman's procedure using either OLS or maximum likelihood estimation.

In the context of firm's exports in this study, the bivariate sample selection model can be written as an export participation equation and an export intensity equation:

$$y^* = Z_1^{'}\beta_1 + \varepsilon_1 \tag{5.10}$$

$$I = \begin{cases} 1, y^* > 0 \\ 0, y^* \leq 0 \end{cases} \tag{5.10'}$$

$$s^* = Z_2^{'}\beta_2 + \varepsilon_2 \tag{5.11}$$

$$s = \begin{cases} s^*, y^* > 0 \\ -, y^* \leq 0 \end{cases} \tag{5.11'}$$

where I is a binary indicator variable which takes a value of one if the firm exports and zero otherwise, s is firm export intensity, y^* and s^* are latent variables, Z_1 and Z_2 are factors listed in equation (5.7), and Z_1 is the union of Z_2 and firm past export experience, that is, firm past export experience does not appear in the export intensity equation. This kind of exogenous variable restriction enables model identification in practice. In addition, it is reasonable to say that a firm's past export experience signals some fixed cost in establishing the export channel, and hence as soon as the export channel has been established, the firm is more likely to participate in exporting. However, as the cost of establishing the export channel has been incurred and becomes sunk cost, it will not affect firm's decision on how much to export.

Because it is reasonable to say a firm's decision on whether to export is correlated with their decision on how much to export, the error terms in equations (5.10) and (5.11) are set to be joint normally distributed and homoskedastic, with

$$\begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \end{bmatrix} \sim N\left[\begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} 1 & \sigma_{12} \\ \sigma_{12} & \sigma_2^2 \end{bmatrix}\right]$$

Then the likelihood function for this bivariate sample selection model can be written as:

$$L = \prod_{i=1}^{N} \left[\Pr\left(y_i^* \leq 0\right)\right]^{1-I_i} \left[f\left(s_i^* \middle| y_i^* > 0\right)\Pr\left(y_i^* > 0\right)\right]^{I_i}$$

where $f(\cdot)$ is the conditional density of s^*. The maximization of the likelihood function gives the MLE estimate of both the export participation equation and the export intensity equation.

The sample selection model of equations (5.10) and (5.11) can also be estimated using Heckman two-step procedure, which uses the inverse Mills ratio to correct for the sample selection bias. The inverse Mills ratio is computed from estimating the binomial probit model (the export participation equation), which is then plugged into the estimation of the export intensity equation to correct for the sample selection bias. Even though the two-step estimator is consistent and computationally easier, the maximum likelihood estimator is more efficient.

The Data and Variable Construction

Variable construction

The data set used is the same as that in Chapter 4. From the data set, two categories of variables are constructed, namely firm characteristics and industry characteristics, such as capital intensity, firm age, foreign presence, ownership structure dummy, regional dummies, and industry dummies. Institutional factors, such as the rate of exports tax refund, are not included, due to lack of variation of these variables. For example, most firms are subject to a 13 per cent rate of export tax refund. In addition, a dummy variable for firm past export experience, is also constructed for the purpose of identifying the sample selection model in the estimation.

Firm characteristics include firm size, which is proxied by a firm's output; firm age; capital intensity, which is equal to total assets divided by firm's number of employees; unit production cost, which is equal to a firm's total production and operation costs divided by its output; the average wage, which is equal to firm's total wages divided by the number of its employees and can proxy for the composition of labour structure in the firm, namely human capital; the unit labour cost , which is equal to total wage divided by firm's output; marketing expenses, which is equal to a firm's total marketing expenses divided by its total sales revenue; and ownership and regional heterogeneity, as defined in Chapter 4. Ownership is a dummy variable, which takes a value of one if the firm is privately owned and zero otherwise. Regional heterogeneity is captured by two regional dummies that take a value of one if a firm is located in west or central China.

We expect firm size, firm age, capital intensity, production cost, average wage, unit labour cost and marketing expense to positively affect firm's exports. For regional heterogeneity, it is expected that firms located in the coastal region are more likely to export than firms located in central China and western China, due to both the transportation cost and different levels of economic development in these regions. However, as these variables interact with foreign presence, *fp*, their impact depends on foreign presence in the industry, and thus no prior expectation on the sign of the coefficients of these variables can be made.

Industry characteristics include the Herfindahl index, which is calculated at the four digit industry level and equal to the sum of squared firm's share in the industry total sale; the foreign presence, which proxies activities of FDI in the industry; and industry heterogeneity (a set of industry dummies). Industry heterogeneity is computed at the two digit level (see Chapter 4), as it is reasonable to believe that firms within the same two digit industry have same export behaviour. The sign of coefficient of Herfindahl index is expected to be negative, as the Herfindahl index proxies for domestic market concentration and with a higher Herfindahl index firms have power over domestic market and are hence less willing to export. For the foreign presence, which is the focus of this study, it is also expected positively affect firm's exports, which is demonstrated in the above theoretical model.

Descriptive statistics

Table 5.1 presents the descriptive statistics of the variables constructed from the data set. For domestic firms' exports intensity, 2,281 firms have a missing value, which occurs because they report zero sales. For the rest of the firms, the average export intensity is 15.1 per cent, and 73.8 per cent of firms do not export, as expected. There are five industries that do not have any exports, namely artificial oil production, tire retread processing, asbestos and cement products manufacturing, nuclear and nuclear radiation measurement equipment manufacturing, and nuclear radiation processing industry, which means that 153 firms have missing values. For production cost, 2,389 firms have missing values, which is again due to these firms having zero output. As production cost is equal to firm's production and operation expenditure divided by output, a value of production cost that is bigger than 1 indicates the firm is suffering loss. Of the total 143,161 domestic firms, 15.1 per cent of firms suffer losses, which significantly increases the mean and standard deviation of the distribution of production cost. On capital intensity and average wages, 820 domestic firms report zero employees, which makes the corresponding variables missing values. For marketing expenses, which is the ratio of total marketing expense against its sales revenue, it can be seen that most firms spend heavily in marketing, with an average value of 0.89. The average Herfindahl index and its standard deviation are rather low (0.0002 and 0.0059 respectively), indicating that most markets are quite competitive. Only two industries are monopolized, namely the nuclear radiation processing and the agricultural, forestry, and fishery specialized equipment and instrument manufacturing. In the former industry, the monopoly firm does not export, while in the latter industry the monopoly firm exports 72.3 per cent of its output. In respect of foreign presence, as discussed in Chapter 4, the three measurements appear to give a consistent proxy on true FDI invested firms' activities in domestic industry, since their means are well within one standard deviation of each other.

Table 5.1 Descriptive Statistics

Variables	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
Exports intensity	140880	0.1517	0.3234	0	1
Firm size	143161	0.0684	0.5470	0	54.8566
Firm age	143161	11.5010	12.9647	0	403
Capital intensity	142341	0.2663	3.6387	0	874.735
Unit Production cost	140772	5.6480	1406.3910	0	527000
Average wage	142341	10.6462	9.7689	0	772.2802
Unit labour cost	140772	0.2992	46.1190	0	17138.5
Marketing expense	140796	0.8923	0.6232	0	174.25
Herfindahl index	143161	0.0002	0.0059	0	1
Fpo	143161	0.3305	0.1811	0	0.9744
Fpe	143161	0.2635	0.1842	0	0.9333
Fpa	143161	0.3478	0.1796	0	0.9379
Dummy variables	**per cent**	**Dummy variables**	**per cent**	**Dummy variables**	**per cent**
Ownership	0.5187	d21	0.0109	d32	0.0237
Western	0.1201	d22	0.0315	d33	0.0193
Middle	0.1895	d23	0.0235	d34	0.0534
Past exporting experience	0.1926	d24	0.0117	d35	0.0734
d14	0.0255	d25	0.0076	d36	0.0415
d15	0.0182	d26	0.0792	d37	0.0480
d16	0.0016	d27	0.0235	d39	0.0575
d17	0.0801	d28	0.0050	d40	0.0288
d18	0.0472	d29	0.0113	d41	0.0133
d19	0.0219	d30	0.0437	d42	0.0210
d20	0.0191	d31	0.0942	d43	0.0006

Note: (1) fpo/fpe/fpa is the foreign presence measured in terms of output/employee/assets share in the industry; (2) Variables starting with letter *d* are the industry dummies, for example *d14* denotes whether the firm is in Industry 14; (3) Percentage for dummy variables denotes the proportion of firms that take value 1, for example for dummy *Western*, 12.01 per cent of domestic firms are located in western China.
Source: Author's calculations based on Enterprise Data, National Bureau of Statistics, Beijing

The bottom panel of Table 5.1 is a set of dummy variables that are used in the estimation, and the percentage is the proportion of firms in the sample that take a value of one for the variable. For example, 51.9 per cent of all domestic firms are privately owned, and 19.3 per cent of domestic firms have export experience in the previous year. Regional dummies indicate that 69.0 per cent of domestic firms are located in coastal China, which obviously implies the gap of regional development.

Table 5.2 presents the correlation matrix for key variables. From the table, we see that for most variables the correlation is rather low, except for unit production cost and unit labour cost. The correlation between unit production cost and unit labour cost is as high as 0.9917, which, nevertheless, does not present a multicollinearity problem in empirical exercises owing to the large sample size. The three proxies of FDI presence are highly correlated with each other, which is expected and desired.

Table 5.2 Correlation Matrix for Key Variables

	Firm size	Firm age	Capital intensity	Unit Production cost	Average wage	Unit labour cost	Marketing expenditure	Herfindahl	exports concentration	fpo	fpe	fpa	ownership	western	middle	past exporting experience
Firm size	1															
Firm age	0.0511	1														
Capital intensity	0.1338	-0.0052	1													
Production cost	-0.0005	0.008	0.0003	1												
Average wage	0.1263	-0.0237	0.285	-0.0022	1											
Unit labour cost	-0.0007	0.0083	-0.0006	0.9917	-0.0014	1										
Marketing expenditure	-0.0041	-0.0097	-0.0017	-0.0038	-0.0174	-0.0034	1									
Herfindahl	0.0997	0.0215	0.0223	-0.0001	0.0306	-0.0002	-0.0022	1								
exports concentration	0.0687	0.0145	0.02	-0.0001	0.033	-0.0002	-0.0014	0.1796	1							
fpo	0.0201	-0.1292	0.0242	-0.002	0.1027	-0.0024	0.006	0.0023	-0.0179	1						
fpe	0.0048	-0.1493	-0.0047	-0.0024	0.0805	-0.0024	0.0096	0.0022	-0.0182	0.9185	1					
fpa	0.0046	-0.1533	0.0044	-0.0029	0.0756	-0.003	0.0087	-0.003	-0.0213	0.9532	0.918	1				
ownership	-0.0244	-0.3811	0.0003	-0.0037	0.0727	-0.0039	0.0052	-0.0159	0.0003	0.1737	0.2008	0.1956	1			
western	-0.0057	0.0971	-0.0069	0.0085	-0.0766	0.0093	-0.0076	-0.0007	0.0023	-0.151	-0.1661	-0.1616	-0.1388	1		
middle	-0.0062	0.0818	-0.0385	-0.0012	-0.1478	-0.0019	-0.0045	-0.0026	-0.0057	-0.1636	-0.1786	-0.1698	-0.1287	-0.1766	1	
past exporting experience	0.0867	0.0384	0.0197	-0.0018	0.1142	-0.0019	0.0021	0.0239	0.0554	0.2064	0.2558	0.2083	0.1006	-0.1079	-0.14	1

Source: Author's calculations based on Enterprise Data, NBS, Beijing, 2003

Export intensity in the manufacturing sector

Table 5.3 Summary Statistics for Export Intensity by Industries

Industry Code	Number of firms	Mean	Std. Dev.	Min	Max	per cent of firms with 0 exports intensity	per cent of firms with 1 exports intensity	per cent of firms with missing value
13	11193	0.11	0.29	0	1	79.66	4.09	2.90
14	4636	0.12	0.29	0	1	72.35	3.88	3.21
15	3194	0.05	0.19	0	1	85.82	1	2.44
16	255	0.01	0.04	0	0.53	76.86	0	3.92
17	14863	0.24	0.37	0	1	60.61	7.93	1.31
18	9717	0.52	0.46	0	1	37.31	28.37	0.55
19	4518	0.50	0.46	0	1	39.35	30.01	0.73
20	3501	0.18	0.36	0	1	74.06	9.08	1.43
21	2046	0.30	0.43	0	1	60.70	16.32	1.12
22	5570	0.05	0.19	0	1	87.97	1.80	1.65
23	4084	0.04	0.19	0	1	90.40	1.91	1.71
24	2516	0.60	0.44	0	1	27.31	36.37	0.64
25	1323	0.01	0.09	0	1	91.38	0.30	2.12
26	13803	0.08	0.23	0	1	78.90	2.09	1.48
27	4063	0.08	0.22	0	1	78.12	1.33	1.80
28	937	0.06	0.20	0	1	83.14	1.81	0.53
29	2016	0.15	0.31	0	1	71.28	5.75	1.29
30	8382	0.19	0.36	0	1	71.14	9.60	0.70
31	16245	0.07	0.23	0	1	86.01	3.30	1.52
32	4119	0.03	0.15	0	1	89.39	1.02	1.97
33	3367	0.07	0.20	0	1	81.68	1.49	1.34
34	9746	0.20	0.37	0	1	69.24	7.94	1.09
35	12546	0.12	0.27	0	1	74.45	3.04	0.97
36	7129	0.07	0.20	0	1	78.73	1.54	1.66
37	8281	0.09	0.24	0	1	78.95	2.46	1.29
39	10400	0.18	0.35	0	1	68.89	7.58	1
40	5857	0.32	0.41	0	1	49.02	13.95	1.33
41	2515	0.28	0.41	0	1	56.78	12.49	1.31
42	4259	0.56	0.46	0	1	33.79	36.82	0.66
43	107	0.02	0.11	0	1	95.33	0.93	0.93

Note: (1) Table 1 presents the name of corresponding Industry Code.
(2) The mean and standard deviation are computed excluding missing values.
Source: Author's calculations based on Enterprise Data, NBS, Beijing, 2003

Table 5.1 presents the summary statistics for exports intensity over the data used in the estimation, and it indicates that on average domestic firms' export intensity is quite low (15 per cent). In this sub-section, we will examine the distribution of all firms' export intensity, including both domestic and FDI invested firms, which will present a picture of China's exporting in the manufacturing sector in 2003. Table 5.3 presents the summary statistics for firm export intensity by two digit industry category. Several conclusions about export intensity can be drawn.

First, there are four industries with average export intensity higher than 50 per cent, namely cultural, educational, sporting products manufacturing (24), crafts and other products industries (42), textile garments, shoes and hats manufacturing (18), and leather, fur, feathers (cashmere) and apparel industry, in all of which China has comparative advantage. Second, except for the tobacco industry (16), all the other industries have firms that are completely specialized in exports, that is, with 100 per cent export intensity. The highest percentage of firms that are completely specialized in exports is 36.8 per cent in the crafts and other products industries (42), and in contrast the lowest percentage is 0 in the tobacco industry (16). Third, there are five industries with average export intensity is lower than 5 per cent, namely printing and reproduction of recorded media industry (23), smelting and rolling of ferrous metals industry (32), waste resources and recycling materials processing industry (43), oil processing, coking and nuclear fuel processing industry (25), and tobacco industry (16). Fourth, the distribution of export intensity across industries displays a rather similar pattern, that is, a large proportion of firms have zero export intensity.

Empirical Results

Equation (5.7) is estimated using the maximum likelihood estimator, with robust standard errors computed to account for potential heteroskedasticity. Table 5.4 reports the estimation of the sample selection model, using output share as a proxy for foreign presence (*fpo*), and Tables 5.5 and 5.6 report the estimation results using the employment (*fpe*) and assets (*fpa*) share respectively.

The estimated correlation (ρ in Table 5.4) between the Probit export participation equation and the export intensity equation is -0.148, which is significant at the 5 per cent level. This indicates that a firm's decision on whether to export is not independent of its decision on how much to export. Hence Cragg's specification of the Tobit model, which assumes the independence between firm's export participation decision and export intensity decision, is inappropriate here. In addition, the significance of *athrho* and *lnsigma* confirms the existence of sample selection bias, and the computed inverse mills ratio is -0.048. Furthermore, the Tobit restriction, that is, explanatory variables have equal effect on both firm's export participation and export intensity decisions, is tested. The test statistics for Tobit restriction are 4090.78, which rejects the null that the Tobit restriction is appropriate at the 1 per cent significance level.

In summary, diagnostic tests suggest that firms with sales abroad cannot represent the sample of exporting firms, and the explanatory variables have different effects on firms' decision on whether to export and how much to export.

Existence of export spillovers from FDI and their determinants

As mentioned earlier, testing for the existence of export spillovers from FDI to domestic firms is made in three steps: first to test the joint significance of foreign presence and its interaction terms; second to test the joint significance of the interaction terms, which is also a test for the determinants of export spillovers; third to compute the marginal effect of foreign presence, which is a function of the determinants and indicates that different firms can benefit differently from FDI. This marginal effect is then evaluated at sample average, which tells on average how FDI affects firms' exports, and at individual firm's value of these determinants, which reveals how FDI affects particular individual firm's exports, respectively.

The test statistics for joint significance of foreign presence and its interaction terms are 413.7 with p-value of 0 in the export intensity equation and 712.4 with p-value of 0 in the export participation equation, which is a necessary condition for the existence of spillovers. Second, the test statistics for joint significance of interaction terms are 271.2 with p-value of 0 in the export intensity equation and 302.1 with p-value of 0 in the export participation equation, which confirms that whether the export spillovers will occur depends on domestic firms' characteristics. Third, the marginal effect of foreign presence in the export intensity equation, obtained by differentiating estimated equation (5.7) with respect to foreign presence (*fpo*), is:

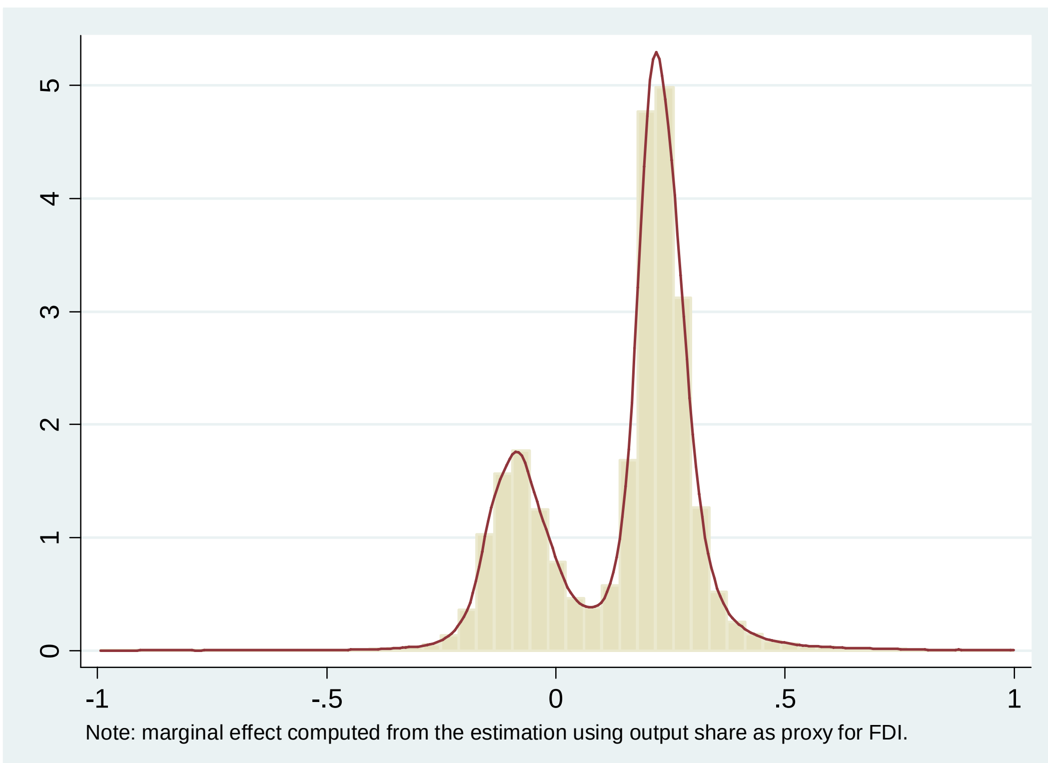
$$\frac{\partial s}{\partial fpo} = 0.4724 + 0.0377 \times size - 0.0028 \times age$$
$$+ 0.0679 \times capital\,\mathrm{int}\,ensity - 0.0448 \times production\,\mathrm{cos}\,t$$
$$- 0.0049 \times averagewage + 0.8123 \times ulabor\,\mathrm{cos}\,t$$
$$- 0.2058 \times marketing\,\mathrm{exp}\,ense - 0.0537 \times ownership$$
$$- 0.2825 \times western - 0.3467 \times middle$$

This marginal effect formula indicates that domestic firm size, age, capital intensity, unit production cost, average wage, unit labour cost, marketing expense, ownership structure and geographical location determine the extent of export spillovers from FDI. Firm size, capital intensity, and unit labour cost have positive impacts on export spillovers. In contrast, firm age, unit production cost, average wage, and marketing expenses have negative impact on export spillovers. State and collectively-owned firms benefit more from foreign presence in the industry than privately owned firms, and firms located in coastal China are more capable of absorbing such export spillovers than firms located in central and western China.

If the marginal effect formula is evaluated at the sample average, we obtain Table 5.7, which shows that for an average domestic firm, foreign presence need not necessarily benefit its exporting. If the average domestic firm is privately owned and located in western China, then a 1 per cent increase in foreign presence will decrease its export intensity by 0.12 per cent. If a privately owned average domestic firm is located in central China, its export intensity will decrease by 0.19 per cent. For state and collectively owned average domestic firms, foreign presence also harms their exports. A 1 per cent increase in foreign presence will lower the firm's export intensity by 0.069 per cent if it is located in western China, and by 0.13 per cent if it is located in central China. Firms located in coastal China appear to benefit from foreign presence. For an average firm located in coastal China, a 1 per cent increase in foreign presence will increase 0.16 per cent of its export intensity if it is privately owned, and 0.21 per cent if it is state or collectively owned. In regard to the export participation equation, Table 5.4 shows that the marginal effect of foreign presence on the probability of domestic firms' participating in exports depends negatively on their age, unit production cost, average wage, and geographical location, and positively on their ownership structure.

If we evaluate the marginal effect of foreign presence at the value of individual firm characteristics, we then can obtain the distribution of the marginal effect, as in Figure 5.1. Figure 5.1 shows that the marginal effect of foreign presence for most domestic firms is located between –0.5 and 0.5, and there are more firms that have positive marginal effect than firms that have negative marginal effects as the distribution appears to be positively biased.

Figure 5.1 Distribution of Marginal Effect of Foreign Presence on Export Intensity



In summary, the following conclusion can be drawn about export spillovers of FDI in China. Export spillovers of FDI in China exist, but the scale of the spillovers depends on a variety of factors firm characteristics such as domestic firm's size, age, capital intensity, unit production cost, average wage, unit labour cost, marketing expense, ownership structure and geographical location.

Impact of other factors on firm export behaviour

In addition to the foreign presence (*fpo*) and its interaction terms, there are 11 additional variables and 29 industry dummies included in the estimation (see Table 5.4), of which 7 variables in the export intensity equation and 16 variables in the export participation equation are insignificant at the 5 per cent level. In the export intensity equation, the insignificant variables are domestic firms' average wage, a regional dummy (*western*), and five industry dummies. Even though the average wage and the regional dummy are insignificant themselves, their interaction terms with foreign presence are still significant, which indicates that they do have an impact on firm's decisions on how much to export. An *F*-test for joint significance of these individually insignificant variables in the export intensity equation obtains a test statistic of 10.81 with a p-value of 0.15, which fails to reject the null hypothesis of joint insignificance at the 5 per cent level and rules out the possibility that multicollinearity causes these variables to be individually insignificant.

In the export participation equation, capital intensity, unit production cost, unit labour cost, marketing expense, the Herfindahl index, seven industry dummies, and foreign presence's (*fpo*) interaction terms with firm size, capital intensity, unit labour cost, and marketing expense are insignificant individually at the 5 per cent level. However, an *F*-test for joint significance of these variables obtains a test statistic of 36 with a p-value of 0.0018, which rejects the null hypothesis of joint insignificance at 5 per cent level and suggests that there is multicollinearity among these variables. To identify the source of multicollinearity, we first test the joint significance of capital intensity, unit production cost, unit labour cost, and marketing expense, and obtain an *F*-test statistic of 6.28 with a p-value of 0.18, which fails to reject the null hypothesis of joint insignificance at the 5 per cent level. Then we test the joint significance of the other individually insignificant variables, namely the Herfindahl index, seven industry dummies, and foreign presence's (*fpo*) interaction terms with firm size, capital intensity, unit labour cost, and marketing expense, and obtain an *F*-test statistic of 18.78 with a p-value of 0.09, which also fails to reject the null hypothesis of joint insignificance at the 5 per cent level. This suggests that multicollinearity occurs between some variables in capital intensity, unit production cost, unit labour cost, and marketing expense and some variables in the Herfindahl index, 7 industry dummies, and foreign presence's (*fpo*) interaction terms with firm size, capital intensity, unit labour cost, and marketing expense. By examining their correlation, we find that capital intensity, unit labour cost, and marketing expense are highly correlated with their interaction terms with foreign presence (0.8578, 0.9950, and 0.8676 respectively). Hence we re-estimate the model by dropping these three variables' interaction terms with foreign presence in the export participation equation, and the *F*-test is conducted to test the joint significance of individually insignificant variables in the re-estimated model. It is found that these individually insignificant variables are jointly insignificant at the 5 per cent level, ruling out the multicollinearity problem. Compared with these two estimations, we find the estimated coefficients do not appear to be significantly different, except for capital intensity and unit labour cost. The coefficient for the capital intensity in the re-estimated model is -0.0381 with a robust standard error of 0.012, and the coefficient for the unit labour cost is now -0.0134 with a robust standard error of 0.005. Both of them are significant at the 5 per cent level. However, even though dropping the three variables eliminates the multicollinearity problem, it may introduce a misspecification problem. Hence, we decide to keep these three variables, and meanwhile bear in mind that capital intensity and unit labour cost do have significant impact on domestic firms' decision on whether to export. The multicollinearity problem does not affect our testing for export spillovers, as the coefficients estimated do not significantly change after dropping the three variables.

In regard to the size of domestic firms, the coefficients for size itself and its interaction term with foreign presence are -0.0313 and 0.0377 respectively, which are both significant at the 5 per cent level. This indicates that the impact of firm size on the decision on how much to export depends on the activity of FDI in the industry. In an industry with average foreign presence (0.3305) (hereafter called an average industry), the marginal impact of firm size on export intensity is -0.0189, indicating that a 1 per cent increase in firm size will decrease export intensity by -0.0189 per cent. However, regarding export participation, firm size has a positive impact, namely big firms are more likely to participate in export activities. Bigger firms have more resources available for covering the fixed costs of exporting, and hence are more likely to enter export activity. However, as China's comparative advantage lies in labour-intensive goods and bigger firms are usually more capital-intensive, bigger firms tend to export less.

Firm age has a significant and negative impact on domestic firm's export intensity, and on average a year's increase in firm age will decrease export intensity by 0.39 per cent. It also negatively affects a firm's decision on whether to export, and older firms are less likely to participate in exports in an average industry, indicating that young firms are more active in extending their market coverage.

Capital intensity has a negative impact on export intensity, namely in an average industry the increase of capital intensity by 1 per cent will decrease the export intensity by 0.6 per cent. Table 5.4 shows both the capital intensity and its interaction term with foreign presence are insignificant in the export participation equation. However as suggested above this is due to the multicollinearity problem. Re-estimation, dropping the interaction terms, shows the capital intensity has a significant and negative impact on a firm's decision on whether to export. Again, this is due to the comparative advantage. China is a country with a rich labour endowment, which makes firms with lower capital intensity more likely to export and more competitive in the world market.

We expect that production cost has a negative impact on both a firm's decision on whether to export and how much to export, and the estimation confirms our prior expectation. In an average industry, a 1 per cent increase of unit production cost will decrease a firm's export intensity by 0.006 per cent. It also negatively affects the likelihood to export, as shown in Table 5.4.

The average wage is a proxy for human capital, with higher average wages indicating higher human capital assets. The coefficient for average wage in the export intensity equation itself is insignificant at the 5 per cent level (-0.001 with a p-value of 0.07), but the coefficient of its interaction term with foreign presence (-0.0049) is negative and significant, which indicates that firms with higher average wage will export less. In the export participation equation, the coefficients for average wage and its interaction term are both significant, the former being positive (0.0102) the latter being negative (-0.0147). Thus in an average industry, the net impact of average wages on the likelihood of exporting is positive, namely the labour quality matters.

The coefficient of unit labour cost in the export intensity equation is significantly negative (-0.175), however the coefficient of its interaction term is significantly positive (0.812). Thus in an average industry, the marginal effect of unit labour costs on a firm's export intensity is positive with a 1 per cent increase in the unit labour cost producing a 0.093 per cent increase in export intensity. In the export participation equation, the coefficients for both unit labour cost and its interaction terms are insignificant, which is due to the multicollinearity problem. In the regression that drops the interaction terms in the export participation equation, we find that unit labour cost has a significant and negative impact on the probability that firms participate in exports.

Marketing expense has a coefficient that is significant and positive (0.1288), while the coefficient of its interaction term is significant and negative (-0.2058), which makes its net marginal impact on firms' export intensity positive in an average industry, namely a 1 per cent increase in marketing expense will increase export intensity by 0.061 per cent. Marketing expenses appear not to play a role in a firm's decision on whether to export, even after accounting for the multicollinearity problem.

The Herfindahl index has a negative impact on export intensity, which is consistent with the prior expectation, as firms with domestic market power are more willing to exploit such market power than export. Table 5.4 shows that a 1 per cent increase in Herfindahl index will decrease firm's export intensity by 0.781 per cent. In contrast, the domestic market structure appears not to affect a firm's decision on whether to export, as the coefficient of Herfindahl index in the export participation equation is insignificant.

Domestic firm's ownership structure also has a significant impact on both firm export participation and intensity. The coefficients of ownership and its interaction term are significant, with the former being positive (0.114) and the latter being negative (-0.054). Hence in an average industry, the net marginal impact of ownership is positive, that is, the export intensity of privately owned firms is 0.096 higher than that of state and collectively owned firms. The coefficients of ownership and its interaction term in the export participation equation are both significantly positive, indicating privately owned firms are more likely to export. Compared with state and collectively owned firms, privately owned firms are more labour intensive, which gives them a comparative advantage in the world market.

Transportation cost is one important factor that affects international trade, with exports from coastal China incurring less transportation cost than exports from central and western China. In addition, the level of development and infrastructure in coastal China is better than those in central and western China. Hence we expect firms located in coastal China will be more likely to export and will export more than firms located in central and western China. The estimation presented in Table 5.4 confirms this prior expectation. In the export participation equation, the coefficients of regional dummies (*middle* and *western*) and their interaction terms are all significantly negative. In the export intensity equation, the coefficient of *western* is insignificant, but the coefficient of its interaction term is significantly negative (-0.283); the coefficient of *middle* is significantly positive (0.081), but the coefficient of its interaction term is significantly negative (-0.347), which makes the net marginal impact of *western* negative (-0.034) in an average industry.

In summary, the estimation results reported in Table 5.4 confirm a variety of factors that affect domestic firms' export participation and intensity.

Sensitivity analysis

We have shown that FDI affects domestic firms' export participation and intensity, which in turn depends on firm characteristics. To what extent is this result due to the way we measure the FDI? Conventionally, there are three proxies to measure FDI in an industry, namely the FDI invested firms' output, employment, and assets share in the industry. In Chapter 4, we have shown the three proxies measure the FDI consistently in the sense that they are highly correlated with each other and rank the two-digit industries consistently, even though the employment share appears to be different from the output and assets share.

Our previous analysis was based on estimation using output share as the proxy for FDI. To see whether the result is sensitive to the measurement of FDI, we re-estimate the model using the employment and asset share as proxy for FDI respectively. Table 5.5 and 5.6 present the estimation results.

The estimated correlation between the export participation equation and export intensity equation are -0.147 and -0.148 for the regression using employment and assets share as proxy for FDI respectively, which is not significantly different from the estimated correlation in the regression using output share as proxy for FDI (-0.149). Sample selection bias also exists in these two regressions, as the *athrho* and *lnsigma* are both significant. The Tobit restriction is also rejected at the 5 per cent level in both regressions.

Comparing the coefficient estimates, we can find that the estimated coefficients are consistent with each other in the sense that their sign does not change and generally one estimate is within one or two standard deviations of another estimate. For example, for the coefficient of firm size, the three estimates are -0.031 (with robust standard error of 0.005), -0.03 (with robust standard error of 0.005), and -0.031 (with robust standard error of 0.005). One exception is the coefficient of foreign presence. The coefficient of output share foreign presence is 0.472 with robust standard error of 0.086; the coefficient of assets share foreign presence is 0.372 with robust standard error of 0.035; in contrast the coefficient of employment share foreign presence is 0.725 with robust standard error of 0.031, which is higher than other two estimates.

If we evaluate the marginal impact of foreign presence, computed from the three regressions, at the sample average, we obtain Table 5.7. From Table 5.7, we can see the estimation using assets share as proxy for FDI presents a similar picture as the estimation using output share as proxy for FDI. In contrast, the marginal impact in the estimation using employment share as proxy for FDI is higher than the other two. Considering the fact that FDI invested firms are usually more capital intensive than their domestic counterparts and hence the employment share will tend to under-represent the activities of FDI in the industry, the other two estimations are more credible.

Conclusions

This chapter analysed export spillovers from FDI and their determinants, using a firm level cross-sectional micro-data set that consists of over 140 thousand domestic firms in the manufacturing sector in China in 2003. The chapter first showed in a theoretical model that if FDI invested firms can reduce domestic firm's export costs, for example via knowledge spillovers, then domestic firms will benefit from the presence of FDI in the domestic industry unambiguously in the sense that their exports will be promoted. This hypothesis was then tested empirically using the Heckman sample selection model in which firm's decisions about whether to export and how much to export are dependent on each other. The Heckman sample selection model is estimated using a full information maximum likelihood estimation. This estimation found that FDI in the manufacturing sector generates export spillovers, and furthermore that the scale of spillovers depends positively on firm size, capital intensity, and unit labour cost, and negatively on firm age, unit production cost, average wage, marketing expense, ownership structure and geographical location.

Table 5.4 Estimation Results Using Output Share as Foreign Presence

	Exports Intensity		Exports Participation	
Variables	Coefficient	Robust Std.Err.	Coefficient	Robust Std.Err.
firm size	-0.0313	0.0047	0.3575	0.0594
firm age	-0.0029	0.0003	0.0019	0.0009
capital intensity	-0.0621	0.0146	-0.0345*	0.0289
unit production cost	0.0089	0.0020	0.0012*	0.0009
average wage	-0.0010*	0.0005	0.0102	0.0022
unit labour cost	-0.1749	0.0276	-0.0211*	0.0264
marketing expense	0.1288	0.0424	-0.1042*	0.0624
Herfindahl index	-0.7811	0.3328	-0.9255*	0.6766
ownership	0.1138	0.0107	0.1483	0.0236
western	-0.0159*	0.0152	-0.1644	0.0347
middle	0.0810	0.0145	-0.1557	0.0307
fpo	0.4724	0.0863	0.9331	0.1338
fpo ×firm size	0.0377	0.0069	-0.1266*	0.1326
fpo ×firm age	-0.0028	0.0009	-0.0224	0.0026
fpo ×capital intensity	0.0679	0.0159	-0.0057*	0.0430
fpo ×unit production cost	-0.0448	0.0094	-0.0184	0.0058
fpo ×average wage	-0.0049	0.0011	-0.0147	0.0044
fpo ×unit labour cost	0.8123	0.1048	0.0171*	0.0525
fpo ×marketing expense	-0.2058	0.0871	0.1972*	0.1127
fpo ×ownership	-0.0537	0.0246	0.3846	0.0614
fpo ×western	-0.2825	0.0421	-0.3805	0.1040
fpo ×middle	-0.3467	0.0377	-0.6525	0.0891
d14	-0.0198*	0.0173	0.0208*	0.0376
d15	-0.1267	0.0242	-0.1433	0.0463
d16	-0.0796*	0.0421	-0.2979*	0.2032
d17	-0.0138*	0.0108	0.3360	0.0259
d18	0.1316	0.0109	0.5667	0.0318
d19	0.1133	0.0122	0.6062	0.0393
d20	0.1049	0.0165	0.1731	0.0399
d21	0.0693	0.0172	0.2044	0.0474
d22	-0.1692	0.0201	-0.4199	0.0384
d23	-0.1368	0.0287	-0.4707	0.0483
d24	0.0791	0.0132	0.6718	0.0535
d25	-0.1350	0.0409	-0.4817	0.0959
d26	-0.1268	0.0120	0.0253*	0.0269
d27	-0.1195	0.0158	0.1338	0.0366
d28	-0.2266	0.0325	-0.2037	0.0727

d29	-0.1068	0.0195	0.0523*	0.0491
d30	-0.0443	0.0136	-0.0497*	0.0314
d31	-0.0200*	0.0134	-0.0695	0.0270
d32	-0.1156	0.0224	-0.2881	0.0462
d33	-0.1246	0.0185	0.0908	0.0411
d34	0.0545	0.0120	0.1716	0.0286
d35	-0.1067	0.0119	0.1514	0.0269
d36	-0.2270	0.0135	0.0733	0.0319
d37	-0.1567	0.0135	0.0105*	0.0311
d39	-0.0731	0.0121	0.0844	0.0290
d40	-0.1061	0.0138	0.0902	0.0390
d41	-0.0458	0.0164	0.2735	0.0443
d42	0.1846	0.0116	0.8374	0.0387
d43	-0.0093*	0.2580	-0.4010*	0.2715
Past exports experience			2.4345	0.0130
constant	0.4396	0.0425	-1.8156	0.0700
Observations	140,335			
Log pseudolikelihood	-49623.77			
athrho	-0.1487	0.0085		
lnsigma	-1.1238	0.0030		
rho	-0.1476	0.0083		
sigma	0.3251	0.0010		
lambda	-0.0480	0.0027		
Test for Tobit Restriction (chi2)	4090.78			

Note: * denotes insignificance at the 5 per cent level; figures are rounded at the 4 digit level.

Table 5.5 Estimation Results Using Employment Share as Foreign Presence

	Exports Intensity		Exports Participation	
Variables	Coefficient	Robust Std.Err.	Coefficient	Robust Std.Err.
firm size	-0.0302	0.0045	0.3511	0.0606
firm age	-0.0030	0.0003	0.0026	0.0009
capital intensity	-0.0548	0.0128	-0.0219*	0.0249
unit production cost	0.0079	0.0017	0.0011*	0.0010
average wage	-0.0009*	0.0005	0.0108	0.0022
unit labour cost	-0.1508	0.0254	-0.0211*	0.0279
marketing expense	0.2149	0.0226	0.0925*	0.0637
Herfindahl index	-0.8290	0.3228	-1.0843*	0.6355
ownership	0.1187	0.0105	0.1870	0.0236
western	-0.0342	0.0150	-0.1735	0.0339
middle	0.0643	0.0140	-0.1633	0.0299
fpe	0.7252	0.0307	1.7066	0.0852
fpe ×firm size	0.0389	0.0063	-0.0753	0.1370
fpe ×firm age	-0.0020	0.0008	-0.0233*	0.0026
fpe ×capital intensity	0.0660	0.0158	-0.0231*	0.0432
fpe ×unit production cost	-0.0399	0.0082	-0.0181	0.0059
fpe ×average wage	-0.0043	0.0010	-0.0159	0.0043
fpe ×unit labour cost	0.7040	0.0945	0.0159*	0.0552
fpe ×marketing expense	-0.3774	0.0403	-0.1758*	0.1052
fpe ×ownership	-0.0706	0.0239	0.2553	0.0610
fpe ×western	-0.2054	0.0415	-0.2933	0.1018
fpe ×middle	-0.2807	0.0367	-0.5796	0.0868
d14	0.0180*	0.0167	0.0704	0.0378
d15	-0.0646	0.0237	-0.0678*	0.0471
d16	-0.0283*	0.0408	-0.2551*	0.2005
d17	0.0098*	0.0107	0.3327	0.0264
d18	0.1105	0.0107	0.4155	0.0332
d19	0.0638	0.0121	0.4023	0.0413
d20	0.1288	0.0165	0.1721	0.0402
d21	0.0416	0.0173	0.0419*	0.0482
d22	-0.1069	0.0199	-0.3337	0.0390
d23	-0.1001	0.0287	-0.4534	0.0487
d24	0.0308	0.0131	0.4697	0.0552
d25	-0.1043	0.0401	-0.4574	0.0963
d26	-0.0498	0.0122	0.1398	0.0277
d27	-0.0698	0.0158	0.1774	0.0370
d28	-0.1734	0.0331	-0.1637	0.0725
d29	-0.0938	0.0193	0.0141*	0.0498
d30	-0.0577	0.0134	-0.1367	0.0326
d31	0.0307	0.0134	-0.0046*	0.0276

d32	-0.0550	0.0222	-0.2042	0.0465
d33	-0.0736	0.0186	0.1474	0.0414
d34	0.0774	0.0119	0.1745	0.0291
d35	-0.0425	0.0121	0.2290	0.0274
d36	-0.1691	0.0136	0.1373	0.0324
d37	-0.0616	0.0139	0.1495	0.0320
d39	-0.0632	0.0120	0.0324*	0.0297
d40	-0.0900	0.0137	0.0095*	0.0396
d41	-0.0070*	0.0163	0.3215	0.0454
d42	0.1427	0.0115	0.6636	0.0402
d43	0.1001*	0.2601	-0.2610*	0.2719
Past exports experience			2.4222	0.0130
constant	0.3333	0.0210	-2.0460	0.0524
Observations	140,335			
Log pseudolikelihood	-49053.7			
athrho	-0.1478	0.0086		
lnsigma	-1.1334	0.0031		
rho	-0.1468	0.0084		
sigma	0.3219	0.0010		
lambda	-0.0472	0.0027		
Test for Tobit Restriction (chi2)	4138.74			

Note: * denotes insignificance at the 5 per cent level; figures are rounded at the 4 digit level.

Table 5.6 Estimation Results Using Assets Share as Foreign Presence

	Exports Intensity		Exports Participation	
Variables	Coefficient	Robust Std.Err.	Coefficient	Robust Std.Err.
firm size	-0.0314	0.0047	0.3551	0.0595
firm age	-0.0030	0.0003	0.0013*	0.0009
capital intensity	-0.0606	0.0153	-0.0294*	0.0306
unit production cost	0.0097	0.0018	0.0011*	0.0009
average wage	-0.0011	0.0005	0.0096	0.0020
unit labour cost	-0.1782	0.0280	-0.0201*	0.0250
marketing expense	0.0755	0.0247	-0.2645	0.0515
Herfindahl index	-0.7467	0.3335	-0.9023*	0.6709
ownership	0.1096	0.0106	0.1265	0.0231
western	-0.0173*	0.0151	-0.1770	0.0343
middle	0.0838	0.0144	-0.1662	0.0303
fpa	0.3724	0.0350	0.5771	0.0856

fpa ×firm size	0.0387	0.0067	-0.1150*	0.1331
fpa ×firm age	-0.0025	0.0008	-0.0202	0.0025
fpa ×capital intensity	0.0708	0.0187	-0.0150*	0.0490
fpa ×unit production cost	-0.0484	0.0084	-0.0182	0.0058
fpa ×average wage	-0.0044	0.0010	-0.0130	0.0040
fpa ×unit labour cost	0.8282	0.1046	0.0151*	0.0499
fpa ×marketing expense	-0.1020	0.0446	0.4895	0.0934
fpa ×ownership	-0.0458*	0.0241	0.4442	0.0598
fpa ×western	-0.2673	0.0419	-0.3345	0.1031
fpa ×middle	-0.3436	0.0374	-0.6136	0.0883
d14	-0.0005*	0.0174	0.0391*	0.0375
d15	-0.1164	0.0243	-0.1286	0.0465
d16	-0.0803*	0.0412	-0.3169*	0.2029
d17	-0.0081*	0.0107	0.3396	0.0259
d18	0.1438	0.0109	0.5826	0.0317
d19	0.1148	0.0121	0.6056	0.0393
d20	0.0985	0.0165	0.1515	0.0400
d21	0.0760	0.0172	0.2076	0.0474
d22	-0.1794	0.0201	-0.4359	0.0385
d23	-0.1205	0.0290	-0.4553	0.0483
d24	0.0728	0.0131	0.6646	0.0536
d25	-0.1365	0.0409	-0.4862	0.0959
d26	-0.1152	0.0120	0.0381*	0.0270
d27	-0.1060	0.0157	0.1473	0.0369
d28	-0.2269	0.0321	-0.2171	0.0729
d29	-0.1123	0.0195	0.0433*	0.0493
d30	-0.0520	0.0135	-0.0616*	0.0316
d31	-0.0122*	0.0135	-0.0755	0.0270
d32	-0.0913	0.0223	-0.2562	0.0465
d33	-0.1145	0.0187	0.0960	0.0411
d34	0.0588	0.0120	0.1705	0.0286
d35	-0.0990	0.0119	0.1528	0.0269
d36	-0.2095	0.0136	0.0918	0.0321
d37	-0.1360	0.0136	0.0349*	0.0313
d39	-0.0594	0.0121	0.1047	0.0291
d40	-0.0586	0.0143	0.1621	0.0394
d41	-0.0039*	0.0167	0.3391	0.0452
d42	0.1859	0.0115	0.8388*	0.0387
d43	-0.0675*	0.2448	-0.4559	0.2714
Past exports experience			2.4334	0.0130
constant	0.4717	0.0244	-1.6599	0.0523
Observations	140,335			
Log pseudolikelihood	-49574.8			

athrho	-0.1481	0.0085
lnsigma	-1.1252	0.0030
rho	-0.1471	0.0083
sigma	0.3246	0.0010
lambda	-0.0477	0.0027
Test for Tobit Restriction (chi2)	4104.33	

Note: * denotes insignificance at the 5 per cent level; figures are rounded at the 4 digit level.

Table 5.7 Marginal Effect of Foreign Presence on Export Intensity

	Western China			Central China			Coastal China		
	fpo	*fpe*	*fpa*	*fpo*	*fpe*	*fpa*	*Fpo*	*fpe*	*fpa*
Privately owned	-0.1224	0.0478	-0.1137	-0.1867	-0.0274	-0.1900	0.1600	0.2533	0.1536
State/Collectively owned	-0.0687	0.1185	-0.0679	-0.1330	0.0432	-0.1442	0.2137	0.3239	0.1994

Note: The marginal effect is evaluated at sample average.

The *fpo*/*fpe*/*fpa* denotes the marginal effect is computed from the estimation using output/employment/assets share as proxy for FDI.

6. Industrial Evidence of FDI Spillovers

Firms across different industries are heterogeneous. Some industries, and the firms within them, are more export oriented and some are not. The presence of foreign investment in different industries is very different. One way of controlling for these differences is to focus on one industry and look at how the firms in that industry are affected by the presence of FDI in the industry.

In Chapters 4 and 5, we examined technology and export spillovers of FDI in the whole manufacturing sector at a point of time, namely 2003. This chapter focuses on the FDI spillovers in a two-digit industry, the cultural, educational, and sporting product manufacturing industry (hereafter the industry), in which there are significant export activities and high level of FDI and the observations of behaviour in the industry spread over four years. For example, in 2003 the average export intensity in this industry was as high as 60 per cent and the average foreign presence measured in terms of output/assets/employment share was also rather high, from 59 to 65 per cent depending on which measure is used (see Table 4.1 and 5.3 for details). Focusing on an industry alleviates the firm heterogeneity and endogeneity problem of FDI that is caused by the possibility that FDI tends to flow into industries with higher productivity and export intensity. It is reasonable to assume firms within the same two-digit industry have similar export behaviour when firms decide to export, as products of these firms are usually similar to each other and hence their exporting activity, export costs, such as the transportation and insurance costs, and the government's export policy, are similar, and leads to a similar export behaviour.

The chapter is organized into seven sections. In the first section, labour productivity and the export intensity of firms, and activities of FDI in the industry are described, providing background for the subsequent empirical exercise. Then we present two empirical models, namely a panel data model to test technology spillovers and a Heckman sample selection model to test export spillovers, and construct variables used in the estimation in the subsequent two sections. Empirical results from testing technology and export spillovers are reported, and their robustness, that is, whether the results are sensitive to three different measurements of foreign presence, is verified. The last section concludes the chapter.

Table 6.1 Distribution of Firms across Four-digit Industry

Industry Code	Industry Name	Number of Firms			
		2000	2001	2002	2003
24	**Cultural, Educational, and Sporting Product Manufacturing Industry**	**1,879**	**2,024**	**2,327**	**2,814**
2411	Stationery manufacturing	175	193	215	242
2413	Book and pamphlet manufacturing	119	112	126	298
2415	Pen manufacturing	158	185	223	244
2417	Teaching model manufacturing	29	36	38	41
2419	Other cultural product manufacturing	69	63	63	67
2421	Sporting balls manufacturing	82	93	98	115
2423	Sporting equipment manufacturing	110	113	137	134
2429	Other sporting product manufacturing	112	139	190	322
2431	Chinese musical instrument manufacturing	16	17	20	23
2433	Western musical instrument manufacturing	68	80	83	85
2435	Electric musical instrument manufacturing	10	16	25	31
2439	Other musical instrument and product manufacturing	18	20	23	27
2440	Toy manufacturing	850	881	1,015	1,133
2450	Entertainment equipment manufacturing	17	22	24	19
2490	Others not included elsewhere	46	54	47	33

Note: Since 2003, the Industry Classification Code System has been changed from version 1994 to version 2002. The table adopts the Industry Classification Code version 1992, and the 2003 data is converted to the 1992 version.

The cultural, educational and sporting product manufacturing industry is a two digit industry (24), which includes 14 four digit industrial sub-categories. Table 6.1 presents the decomposition of the two-digit industry and number of firms in the industries[24]. Two points can be observed from this table. First, the industry is expanding quickly in terms of the number of firms in it. In 2001, 2002, and 2003, the number of firms in the industry grew by 8.6 per cent, 15.1 per cent, and 14.3 per cent respectively. The number of firms in most of the 14 four-digit industries has increased, except for the sporting equipment manufacturing industry (2423) in 2003,

[24] The data used in this chapter are an unbalanced panel data in the Industry from 2000 to 2003, which comes from the National Bureau of Statistics, Beijing.

other cultural product manufacturing (2419) in 2001, entertainment equipment manufacturing (2450) in 2003, and other products not included elsewhere (2490) in 2002 and 2003. Second, most firms are concentrated in the toy manufacturing industry (2440). In 2000, 2001, 2002, and 2003, firms located in the toy manufacturing industry account for 48.3 per cent, 46.1 per cent, 46.1 per cent, and 45 per cent of the industry respectively.

Firm Productivity, Exports, and FDI in the Industry

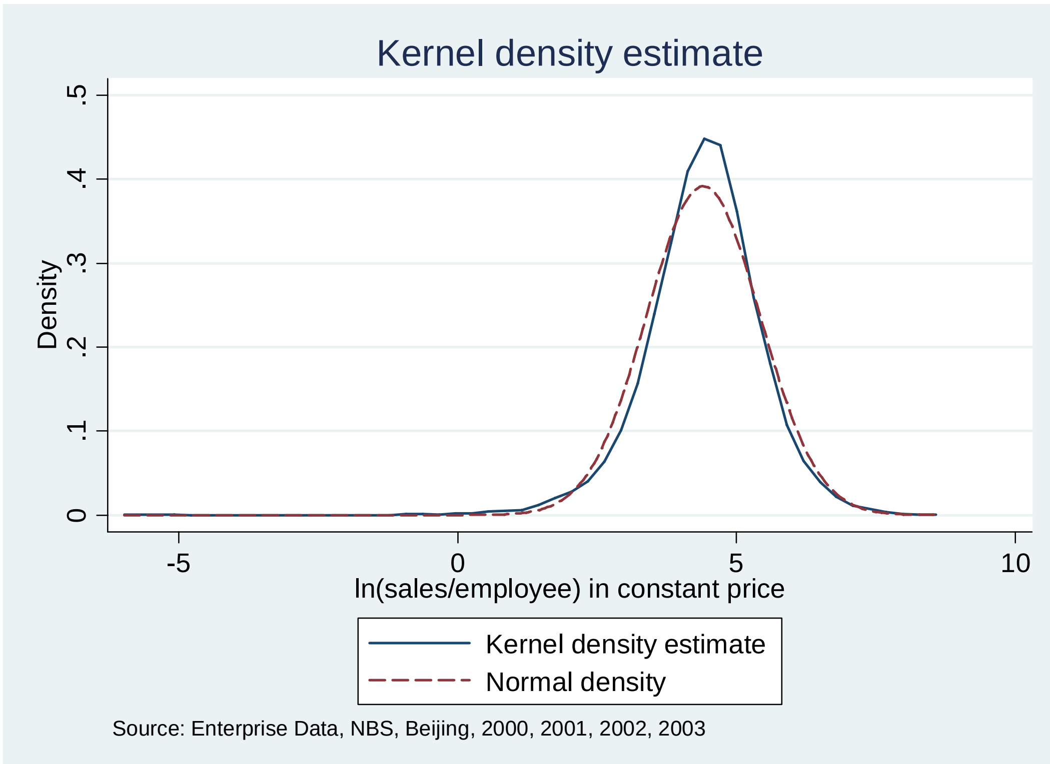
Firm labour productivity in the industry

This subsection describes the picture of firm labour productivity, proxied by the logarithm of sales per employee in the industry from three aspects, namely the distribution across all four-digit industries, its evolution over time, and whether FDI invested firms' labour productivity is different from that of domestic firms, whether the productivity of privately owned firms is distributed differently from that of state and collectively owned firms, and whether the labour productivity distributions exhibit regional heterogeneity.

Figure 6.1 presents a general picture of the distribution of firm labour productivity. Table 6.2 describes distributions across four-digit industries. In Figure 6.1 we observe that the distribution of firms' labour productivity (the solid curve) roughly has the same mean as a normal distribution (the dashed curve), but its standard deviation appears to be smaller.

Table 6.2 presents the mean and standard deviation of firm productivity across four-digit industries in 2000, 2001, 2002, and 2003. From the table, we can see considerable variation of labour productivity across different industries. For example, in 2000, the highest logarithm labour productivity is 5.26 in the electric musical instrument manufacturing industry (2435), and in contrast the lowest is 3.99 in the entertainment equipment manufacturing industry (2450), with the former being 1.27 higher than the latter which if transformed back to the non-logarithm form means the former is 3.5 times the latter. Ranking labour productivity across four-digit industries[25], we can see that even though there is variation in the ranking, industries that are ranked at the top tend to remain at the top. One exception is the entertainment equipment manufacturing industry (2450). In 2000 it is ranked number 14, while in 2003 its rank jumps to number 2, possibly due to technology accumulation or economies of scale.

Figure 6.1 Distribution of Firm Labour Productivity



[25] In 2000 the top five industries are electric musical instrument manufacturing (2435), other sporting product manufacturing (2429), stationery manufacturing (2411), others not included elsewhere (2490), and sporting equipment manufacturing (2423); in 2001 the top five industries are electric musical instrument manufacturing (2435), other sporting product manufacturing (2429), others not included elsewhere (2490), entertainment equipment manufacturing (2450), and stationery manufacturing (2411); in 2002, the top five industries are other sporting product manufacturing (2429), others not included elsewhere (2490), electric musical instrument manufacturing (2435), pen manufacturing (2415), and stationery manufacturing (2411); in 2003, the top five industries are electric musical instrument manufacturing (2435), entertainment equipment manufacturing (2450), other sporting product manufacturing (2429), other musical instrument and product manufacturing (2439), and stationery manufacturing (2411).

Table 6.2 Summary of Firm Labour Productivity in Four-digit Industries

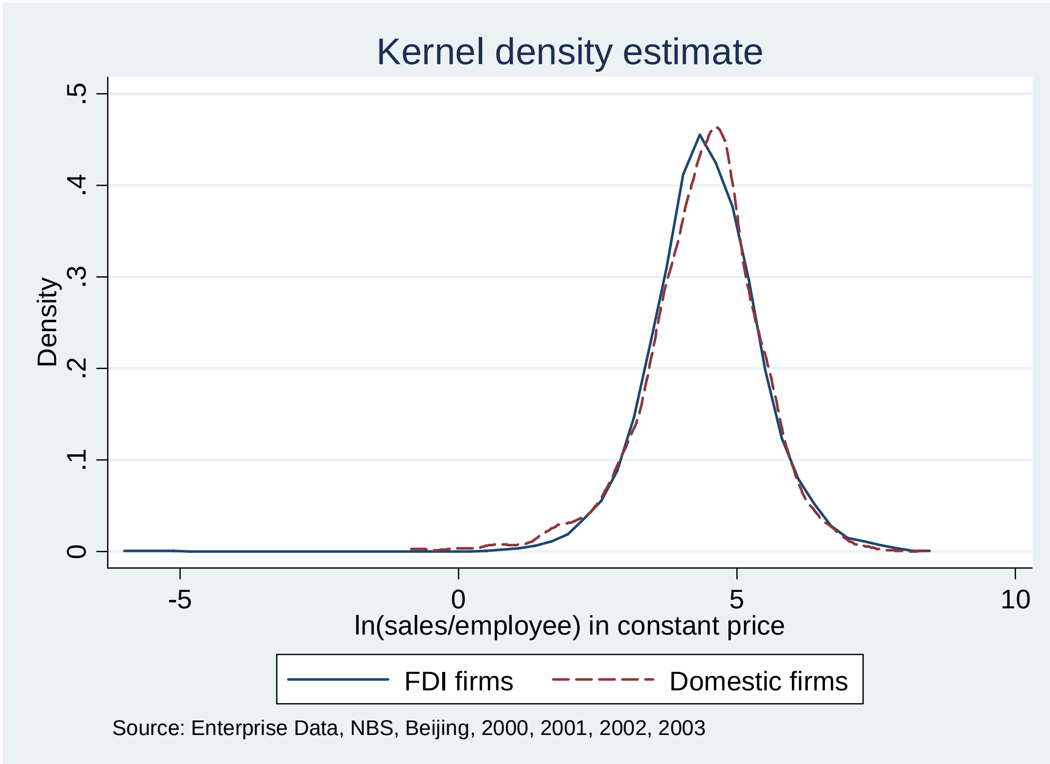
Industry Code	2000			2001			2002			2003		
	No. of obs.	Mean	Std. Dev.	No. of obs.	Mean	Std. Dev.	No. of obs.	Mean	Std. Dev.	No. of obs.	Mean	Std. Dev.
2411	169	4.58	1.03	193	4.62	0.96	211	4.61	0.93	233	4.70	0.90
2413	113	3.79	1.08	107	3.96	1.18	119	4.27	1.21	284	4.28	1.36
2415	148	4.36	1.12	176	4.46	0.99	218	4.63	0.78	236	4.70	0.86
2417	27	4.19	0.98	36	4.11	1.05	38	4.34	1.06	40	4.55	1.16
2419	65	4.13	1.10	62	4.22	0.95	61	4.33	0.95	64	4.56	0.76
2421	81	4.28	0.88	92	4.31	0.94	97	4.36	0.93	115	4.58	0.84
2423	109	4.36	1.00	112	4.57	0.95	137	4.55	1.23	132	4.68	0.76
2429	110	4.78	1.06	137	4.88	0.88	185	4.91	0.86	311	4.77	1.15
2431	16	4.30	0.81	17	3.96	1.55	20	4.14	0.95	23	4.32	0.84
2433	65	4.11	0.90	80	4.29	0.95	81	4.29	0.79	80	4.46	0.95
2435	10	5.26	1.23	16	5.04	1.17	24	4.67	1.08	31	4.93	1.14
2439	17	4.33	0.74	20	4.37	0.74	23	4.45	0.64	27	4.74	0.77
2440	843	4.18	1.03	878	4.22	1.00	1004	4.30	0.95	1106	4.34	0.95
2450	16	3.99	1.56	21	4.76	1.20	23	4.47	0.96	19	4.86	1.20
2490	44	4.56	1.14	53	4.86	1.06	47	4.82	0.85	33	4.54	0.86
Total	1833	4.27	1.06	2000	4.36	1.03	2288	4.44	0.97	2734	4.50	1.02

Note: The firm labour productivity is in logarithm form.
Source: Author's calculation based on Enterprise Data, NBS, Beijing, 2000, 2001, 2002, and 2003

Table 6.2 also reveals the time trend of average labour productivity in different industries, as the figures in the table are all in constant price. Overall, average firm labour productivity increases over time. In 2000, average firm labour productivity is 4.23, and grows to 4.5 in 2003. For different industries, we can also see that almost every industry exhibits this positive trend. One exception is the electric musical instrument manufacturing industry (2435). In 2000, its logarithm labour productivity is 5.26, and it declines to 5.04 in 2001 and 4.67 in 2002. In 2003, logarithm labour productivity in this industry increases to 4.93, which is still lower than its level in 2000. From 2000 to 2003, the standard deviations of labour productivity in different industries appear to have quite small changes. For example, for the electric musical instrument manufacturing industry (2435), the standard deviations in 2000, 2001, 2002, and 2003 are 1.23, 1.17, 1.08, and 1.14 respectively. Combining this information about both mean and standard deviation, we can see that the distribution of firm labour productivity is moving to the right with little change in the spread of the distribution.

One important question in exploring firm labour productivity is whether the FDI invested firms have higher labour productivity than their domestic counterparts. Figure 6.2 presents the distribution of labour productivity for both FDI invested firms and domestic firms. These data show that that the two distributions do not appear to be significantly different from each other. A two-sample Kolmogorov-Smirnov test is carried out to test for equality of these two distributions. The combined K-S obtained is 0.0233 with a p-value of 0.181, which confirms the similarity of these two distributions. In this industry, there is more FDI that comes from overseas multinational enterprises (MNEs) than from non-overseas MNEs. In 2003, the ratio of non-overseas MNE FDI invested firms against overseas MNE FDI invested firms is 0.92 for the whole manufacturing sector, while in contrast this ratio is 0.69 for this industry. Previous studies that focused on the source of FDI have found that the FDI from overseas MNEs tends to generate less, even no, productivity spillovers to domestic firms (Li et al., 2001, and Buckley et al., 2002). Hence it is perhaps not that surprising to see the distribution of labour productivity of FDI invested and domestic firms to be not significantly different from each other in the industry[26].

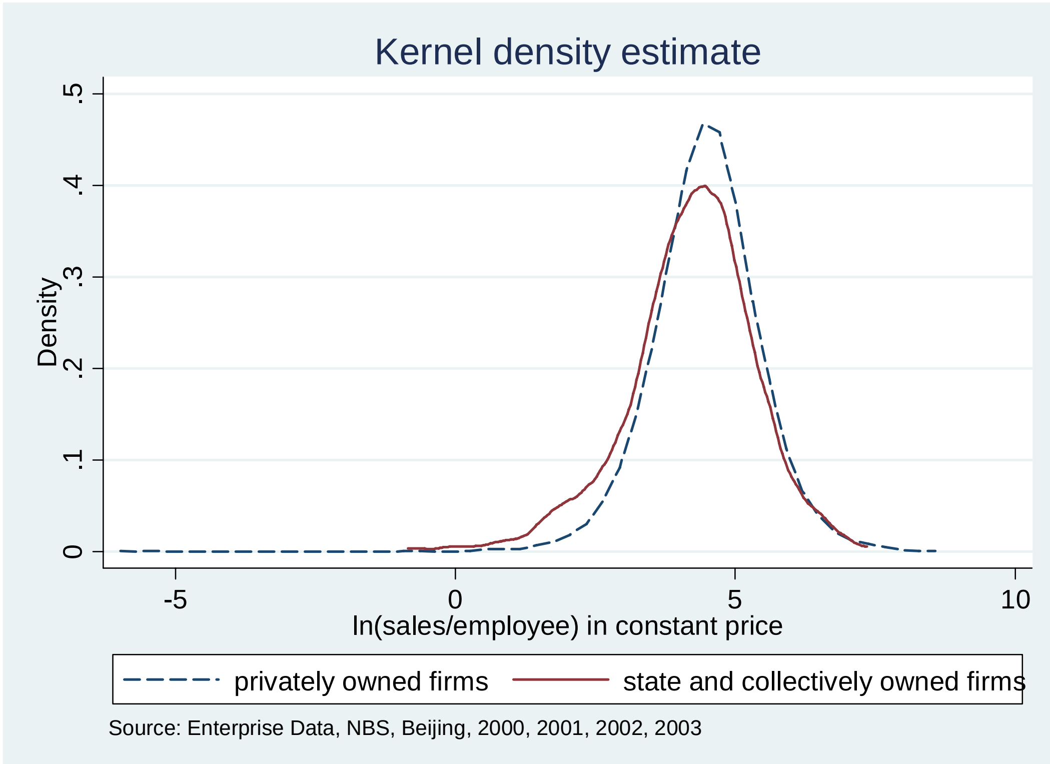
Figure 6.2 Distribution of Labour Productivity of Domestic and FDI Firms



Even though FDI invested firms appear to have the same labour productivity distribution as that of domestic firms, the distribution of state and collectively owned firms appears to be significantly different from that of privately owned firms. Figure 6.3 presents the two distributions. Apparently the distribution of privately owned firms is biased towards the right, compared with that of state and collectively owned firms, which indicates that the mean labour productivity of privately owned firms is higher than that of state and collectively owned firms. The two-sample Kolmogorov-Smirnov test also rejects the hypothesis that the two distributions are not different from each other, with the combined K-S being 0.1063 and a p-value being 0.

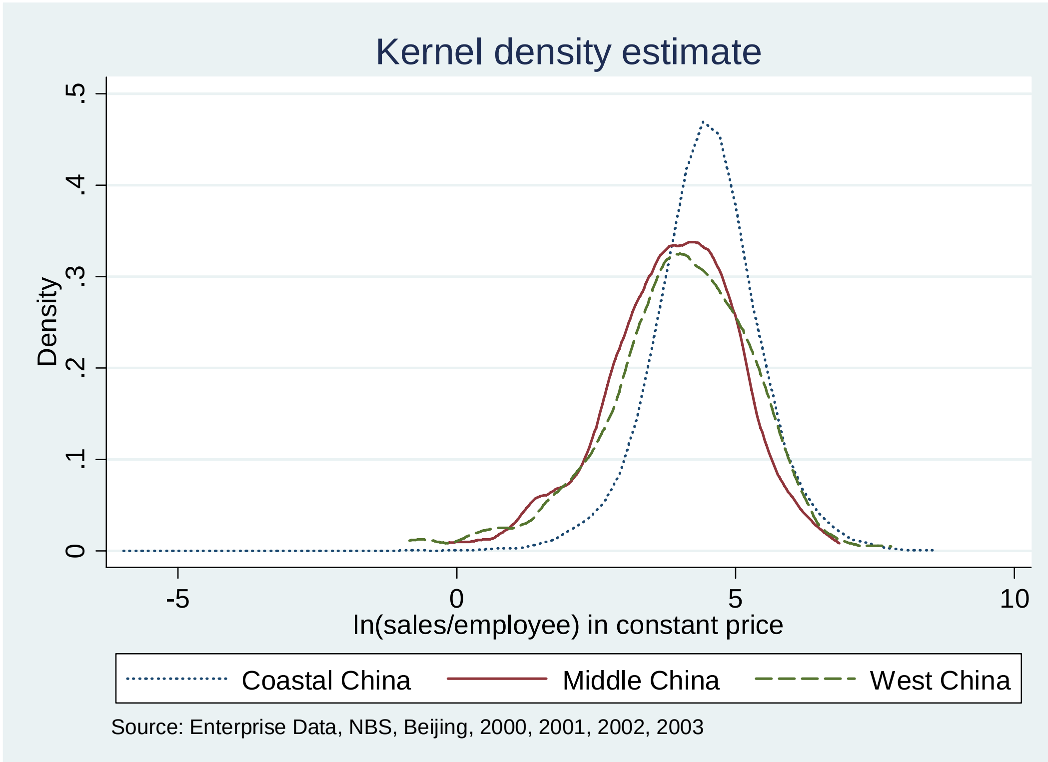
[26] The empirical exercise later finds no evidence of technology spillovers from FDI, further confirming this point.

Figure 6.3 Distribution of Labour Productivity by Ownership



The distribution of firm labour productivity also exhibits regional heterogeneity. Figure 6.4 presents the labour productivity distributions in western, central, and coastal China. The distributions of central and western China do not appear to be very different from each other. The distribution of coastal China is significantly biased to the right compared with the other two distributions, indicating firms in coastal China are more likely to have higher labour productivity than firms located in western and central China.

Figure 6.4 Distribution of Labour Productivity by Regions



Firm exports in the industry

One common feature in manufacturing more generally is that many firms do not export. However in this industry, firms' export activities are much more significant than in other industries. In the industry, on average 67.3 per cent of all firms export[27]. For those firms that do export, the average export intensity is 82 per cent, 84 per cent, 82 per cent, and 83 per cent, in 2000, 2001, 2002, and 2003 respectively. Furthermore, there are a number of firms that specialize entirely in exports. In 2000, 2001, 2002, and 2003, there are 671, 697, 764, and 923 firms with export intensity of 100 per cent respectively. They accounted for 53.3 per cent, 51.3 per cent, 47.2 per cent, and 49.9 per cent of all exporting firms. Hence, we observe a pattern where many firms do export, and furthermore the exporting firms export a significant proportion of their outputs.

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[27] In 2000, 1,258 firms were exporting. They accounted for 67 per cent of the total of 1,879 firms. In 2001, 1,360 firms out of the 2024 firms exported, accounting for 67.2 per cent. In 2002 and 2003, 1,619 and 1,848 firms exported, accounting for 69.6 per cent and 65.7 per cent of the total 2,327 and 2,814 firms respectively.

There are 4,112 firms in the industry across the four years. All together there are 2,704 exporting firms[28], which can be classified into two types: sporadically exporting firms and frequently exporting firms. In terms of the data set used in this chapter, the frequently exporting firms are defined as firms which have export records every year and all the other exporting firms are hence sporadically exporting firms. According to this classification, 2,321 firms are frequently exporting firms, accounting for 85.6 per cent of all exporting firms and 56.4 per cent of all firms. Hence, the majority of exporting firms export frequently.

Table 6.3 presents the distribution of the number of exporting firms across the four-digit industries. Many exporting firms are concentrated in the toy manufacturing industry (2240). Furthermore, firms in this industry are more likely to export, and if they export they tend to be frequent exporters[29]. For firms in the other industries, the variation in the number of firms is much smaller.

[28] 646 firms have export records in all four years, accounting for 23.9 per cent of total exporting firms, 434 firms have export records in three years, accounting for 16.1 per cent, 575 firms export in two years, accounting for 21.3 per cent, and 1,049 firms only export in one years, accounting for 38.8 per cent.

[29] In terms of firm number, 1,681 firms of the total 4,112 firms are located in the toy manufacturing industry, accounting for 40.9 per cent. In contrast in the 2,321 frequent exporting firms 52.0 per cent of them are concentrated in the toy manufacturing industry. For firms that export four/three/two/one times, 53.7/50/50.1/50.3 per cent of them are concentrated in the toy manufacturing industry, which is significantly higher than the average industry proportion of 40.9 per cent. For the non-exporting firms, 21.4 per cent is located in the toy manufacturing industry, and for the sporadically exporting firms 26.5 per cent of them are located in the toy manufacturing industry. Even though this is a higher proportion than that of other industries, it is much lower than the proportion in the industry overall, of 40.9 per cent.

Table 6.3 Distribution of Exporting Firms across Four-digit Industries

Industry Code	[0]		[1]		[2]		[3]		[4]		[frequent]		[sporadic]		[all]	
	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
2411	137	9.73	79	7.53	57	9.91	45	10.37	48	7.43	187	8.06	179	9.99	366	8.90
2413	352	25	20	1.91	16	2.78	9	2.07	8	1.24	39	1.68	366	20.44	405	9.85
2415	124	8.81	69	6.58	55	9.57	35	8.06	58	8.98	178	7.67	163	9.1	341	8.29
2417	49	3.48	4	0.38	4	0.70	0	0	3	0.46	8	0.34	52	2.9	60	1.46
2419	82	5.82	26	2.48	9	1.57	5	1.15	9	1.39	44	1.9	87	4.86	131	3.19
2421	39	2.77	37	3.53	18	3.13	16	3.69	39	6.04	90	3.88	59	3.29	149	3.62
2423	50	3.55	68	6.48	40	6.96	31	7.14	42	6.50	157	6.76	74	4.13	231	5.62
2429	111	7.88	151	14.39	52	9.04	34	7.83	42	6.50	251	10.81	139	7.76	390	9.48
2431	19	1.35	4	0.38	4	0.70	2	0.46	6	0.93	13	0.56	22	1.23	35	0.85
2433	41	2.91	27	2.57	10	1.74	17	3.92	28	4.33	66	2.84	57	3.18	123	2.99
2435	14	0.99	4	0.38	3	0.52	3	0.69	7	1.08	15	0.65	16	0.89	31	0.75
2439	26	1.85	6	0.57	1	0.17	4	0.92	3	0.46	11	0.47	29	1.62	40	0.97
2440	301	21.38	528	50.33	288	50.09	217	50	347	53.72	1206	51.96	475	26.52	1681	40.88
2450	18	1.28	3	0.29	9	1.57	5	1.15	1	0.15	13	0.56	23	1.28	36	0.88
2490	45	3.20	23	2.19	9	1.57	11	2.53	5	0.77	43	1.85	50	2.79	93	2.26
Total	1408	100	1049	100	575	100	434	100	646	100	2321	100	1791	100	4112	100

Note: [4]/[3]/[2]/[1] denote the number of firms that have export records in 4/3/2/1/all years; [0] denotes non-exporting firms; [all] denotes all firms; [frequent] denotes frequent exporters; and [sporadic] denotes sporadic exporters.

Source: Author's calculation based on Enterprise Data, NBS, Beijing, 2000, 2001, 2002, and 2003

FDI in the industry

FDI in the industry will be examined from three perspectives: first the number of FDI invested firms in the industry; second, the acquisition of domestic firms and sale of firms to domestic owners by FDI in the industry; third, foreign presence measured by the output/assets/employment share of FDI invested firms in each four-digit industrial sub-sector.

From 2000 to 2003[30], the number of FDI invested firms has increased by 38.4 per cent. Due to growth of the industry as a whole, the share of FDI in the industry has nonetheless decreased a little. In terms of number of firms, the proportion of FDI invested firms in the industry has stabilized at around 45 per cent, which is certainly big enough to exert a significant impact on the whole industry.

In entering the market, the FDI parent firm can either set up a new firm or acquire an existing domestic firm. Similarly, to exit the market the FDI parent firm can either shut down the firm or sell the firm to domestic parties. If FDI parent firm tends to acquire domestic firms with higher export intensity and/or higher labour productivity or sell firms with lower export intensity and/or lower labour productivity to domestic parties, then testing the spillover effect from the FDI will suffer from an endogeneity problem if both the domestic firms and FDI invested firms are included in the regression. In our subsequent estimation only domestic firms are included, so that this type of endogeneity is avoided. For example, if a firm with a higher export intensity and/or a labour productivity is acquired by an FDI invested firm, then it drops out of the regression; and if a FDI invested firm with a lower export intensity and/or a lower labour productivity is sold to domestic parties, then it is included in the regression. In addition, the number of domestic firms that are acquired by the FDI and the number of FDI invested firms sold to domestic parties are quite small

[30] In 2000 there were 894 FDI invested firms, accounting for 47.6 per cent of total 1,879 firms; in 2001 there were 923 FDI invested firms, accounting for 45.6 per cent of total 2,024 firms; in 2002 there were 1,071 FDI invested firms, accounting for 46 per cent of total 2,327 firms; in 2003 there were 1,237 FDI invested firms, accounting for 44 per cent of total 2,814 firms.

relative to our sample size, and only accounts for around 1-2 per cent of total number of firms[31].

Table 6.4 Foreign Presence across Four-digit Industries

Industry code	2000			2001			2002			2003		
	fpo	fpa	fpe	fpo	fpa	fpe	Fpo	fpa	fpe	fpo	fpa	fpe
2411	0.60	0.64	0.60	0.45	0.52	0.54	0.48	0.54	0.59	0.60	0.64	0.58
2413	0.45	0.37	0.40	0.48	0.41	0.45	0.51	0.49	0.46	0.49	0.41	0.46
2415	0.52	0.52	0.35	0.52	0.54	0.37	0.45	0.50	0.38	0.43	0.50	0.40
2417	0.02	0.03	0.06	0.05	0.09	0.03	0.04	0.06	0.06	0.01	0.01	0.00
2419	0.25	0.21	0.19	0.13	0.15	0.17	0.16	0.19	0.22	0.22	0.35	0.28
2421	0.74	0.69	0.70	0.70	0.70	0.66	0.62	0.61	0.63	0.57	0.56	0.68
2423	0.79	0.82	0.77	0.76	0.81	0.76	0.76	0.81	0.79	0.72	0.76	0.77
2429	0.60	0.62	0.60	0.65	0.67	0.68	0.71	0.71	0.63	0.70	0.72	0.71
2431	0.31	0.24	0.26	0.44	0.34	0.28	0.47	0.44	0.25	0.39	0.36	0.26
2433	0.46	0.44	0.41	0.44	0.39	0.41	0.41	0.31	0.40	0.48	0.40	0.49
2435	0.96	0.91	0.89	0.82	0.73	0.46	0.95	0.93	0.86	0.85	0.74	0.68
2439	0.29	0.35	0.24	0.25	0.32	0.27	0.40	0.46	0.41	0.33	0.41	0.38
2440	0.71	0.80	0.73	0.69	0.74	0.72	0.69	0.77	0.73	0.64	0.74	0.70
2450	0.31	0.38	0.28	0.77	0.85	0.72	0.77	0.81	0.69	0.73	0.57	0.65
2490	0.39	0.33	0.48	0.46	0.41	0.51	0.29	0.29	0.37	0.32	0.34	0.38

Note: fpo/fpa/fpe are the foreign presence measured in terms of output/assets/employment share.
Source: Author's calculation based on Enterprise Data, NBS, Beijing, 2000, 2001, 2002, and 2003

Again we use three measurements for activities of FDI in the industry (foreign presence), namely the FDI invested firms' output/employment/assets share. Table 6.4 shows the foreign presence measured in terms of three different proxies, and indicates that the industry average foreign presence is quite high[32], no matter whether it is measured in terms of output share, assets share or employment share. However there is considerable variation across different industries. For example in 2003 foreign presence measured in terms of assets share in the toy manufacturing industry (2240) is as high as 74 per cent, or over seven times that of the teaching-model manufacturing industry (2417). In addition, it can be observed from Table 6.4

[31] From 2000 to 2001, the FDI acquires 26 domestic firms, and meanwhile 38 FDI invested firms are sold to domestic parties, which only accounts for 1.4 per cent and 2 per cent of the total number of firms in 2000. From 2001 to 2002, 32 domestic firms are acquired by the FDI, accounting for 1.6 per cent of the number of firms in 2002, and 24 FDI invested firms are sold by the FDI to domestic parties, accounting for 1.2 per cent of the number of firms in 2002. From 2002 to 2003, the FDI acquire 34 domestic firms and 29 FDI invested firms are sold to domestic parties, which accounts for 1.5 per cent and 1.2 per cent of the number of firms in 2002.

[32] On average the foreign presence in 2000 is 0.49/0.49/0.47, in 2001 is 0.51/0.51/0.47, in 2002 is 0.51/0.53/0.5, and in 2003 is 0.5/0.5/0.49, measured in terms of output/assets/employment share respectively.

that the foreign presence in different industries tends to remain stable across the four years, as the variation across four years is small[33].

In addition to the variation in different industries, the three measurements of foreign presence also present different pictures. The measurement of employment share tends to be smaller than those of output and assets share, reflecting the fact that FDI invested firms are usually more capital intensive than their domestic counterparts. However the ranking of the industries by all three measurements is weakly consistent in the sense that industries ranked top/bottom in one measurement stay on top/bottom in the other two measurements (see Table 6.5). In addition, the three measurements are highly correlated with each other, with a correlation between the output share and the asset share of 0.95, a correlation between the output share and the employment share of 0.93, and a correlation between the assets share and the employment share of 0.95.

Table 6.5 Ranking of Foreign Presence across Four-digit Industries

Industry code	2000			2001			2002			2003		
	fpo	fpa	fpe	fpo	fpa	fpe	fpo	fpa	fpe	fpo	fpa	fpe
2411	5	5	5	10	8	6	8	7	7	6	5	7
2413	9	10	9	8	10	9	7	9	8	8	9	9
2415	7	7	10	7	7	11	10	8	11	10	8	10
2417	15	15	15	15	15	15	15	15	15	15	15	15
2419	14	14	14	14	14	14	14	14	14	14	13	13
2421	3	4	4	4	5	5	6	6	5	7	7	5
2423	2	2	2	3	2	1	3	2	2	3	1	1
2429	6	6	6	6	6	4	4	5	6	4	4	2
2431	12	13	12	11	12	12	9	11	13	11	12	14
2433	8	8	8	12	11	10	11	12	10	9	11	8
2435	1	1	1	1	4	8	1	1	1	1	3	4
2439	13	11	13	13	13	13	12	10	9	12	10	11
2440	4	3	3	5	3	3	5	4	3	5	2	3
2450	11	9	11	2	1	2	2	3	4	2	6	6
2490	10	12	7	9	9	7	13	13	12	13	14	12

Note: fpo, fpa, and fpe are the foreign presence measured in terms of output/assets/employment share.
Source: Author's calculation based on Enterprise Data, NBS, Beijing, 2000, 2001, 2002, and 2003

[33] An exception is the entertainment equipment manufacturing industry (2450) in 2000. From 2000 to 2001, the foreign presence in this industry jumps from 0.31/0.38/0.28 to 0.77/0.85/0.72 measured in terms of the output/assets/employment share.

Empirical Models

To test both the technology and export spillovers from the FDI in this industry, we deploy the empirical models used. In the following, a fixed effect model is set up to test technology spillovers, and the Heckman sample selection model is set up to test export spillovers.

The fixed effect panel model

Technology spillovers from FDI are most commonly examined by regressing the domestic firm's technology, usually proxied by the labour productivity or value added, against the foreign presence, a measurement of activities of FDI in domestic industry, and other control variables such as capital intensity and intermediate inputs, for example Chuang and Hsu (2004) and Hu and Jefferson (2002). Following this line of study, we set up the following model:

$$
\begin{aligned}
\ln lp_{it} &= \alpha_0 + \alpha_1 \ln kl_{it} + \alpha_2 \ln ml_{it} + \alpha_3 \ln lq_{it} + \alpha_4 age_{it} + \alpha_5 age_{it}^2 + \alpha_6 ownership_{it} \\
&+ \alpha_7 middle_{it} + \alpha_8 western_{it} + \alpha_9 scale_{it} + \alpha_{10} herfindahl_{it} + \alpha_{11} dindustry \\
&+ \alpha_{12} fp_{it} + \alpha_{13} fp_{it} \times \ln kl_{it} + \alpha_{14} fp_{it} \times \ln ml_{it} + \alpha_{15} fp_{it} \times \ln lq_{it} \\
&+ \alpha_{16} fp_{it} \times age_{it} + \alpha_{17} fp_{it} \times middle_{it} + \alpha_{18} fp_{it} \times western_{it} + \alpha_{19} fp_{it} \times ownership_{it} \\
&+ \alpha_{20} dyear_t + \alpha_{21} \tau_i + \varepsilon_{it}
\end{aligned}
\qquad (6.1)
$$

where *ln* denotes natural logarithm; the subscript *i* denotes firm; the subscript *t* denotes time and t=2000, 2001, 2002, and 2003; *lp* denotes firm labour productivity, and is proxied by firm's sale per employee, as firms generally have substantial inventory and hence the value added per employee measurement is not adopted (Chuang and Hsu, 2004); *kl* denotes capital intensity, and is equal to firm's total assets divided by the number of employee; *lq* denotes labour quality, proxied by firm's average wage; *age* denotes firm's age, and its squared term is also added to capture the potential nonlinear relationship; *ownership* captures firm's ownership structure, and is equal to 1 if the firm is privately owned; *middle* and *western* are two regional dummies, which intend to capture the regional heterogeneity in firm's labour productivity distribution and are equal to 1 if the firm is located in central or western China respectively; *scale* denotes the economies of scale in the industry, as defined in Chapter 4; *herfindahl* is the Herfindahl index, intended to capture the domestic market structure; *dindustry* are a set of 14 four-digit industry dummies, which controls the industry heterogeneity at the four-digit level that presumably shall be very small as we already focus on the two-digit industry; *fp* is foreign presence, the proxy for FDI which is measured by the FDI invested firms' output share in the four-digit industry, and furthermore foreign presence is interacted with such firm characteristics as capital intensity, intermediate inputs per employee, labour quality, age, regional location, and ownership (this assumes the technological impact of FDI depends on firm characteristics and hence allows the impact to vary across different firms and industries, namely the heterogeneity of spillover effect); *dyear* is a set of three time dummies, which controls the time effect; τ is the unobserved firm fixed effect; and ε is the i.i.d. normal error term.

The impact of explanatory variables on firm labour productivity has been discussed in Chapter 4. The variable, foreign presence (*fp*), is the interest of this study. It is interacted with firm characteristics, allowing the impact of foreign presence to vary across firms and industries. As in Chapter 4, testing the impact of FDI follows three steps: first test the joint significance of α_{12}, α_{13}, α_{14}, α_{15}, α_{16}, α_{17}, α_{18}, and α_{19}, and if they are jointly insignificant then there is no technology spillovers from the FDI; second, if they are jointly significant, then test the joint significance of α_{13}, α_{14}, α_{15}, α_{16}, α_{17}, α_{18}, and α_{19}, and a joint insignificance of these terms implies the impact of FDI does not depend on firm characteristics; third, evaluate the marginal impact of *fp*, namely the partial derivative of equation (6.1) with respect to *fp*, at firms' level of firm characteristics (capital intensity, intermediate inputs per employee, labour quality, age, ownership structure, and geographical location). If the evaluated marginal impact is positive, then FDI has positive technology spillovers to this firm, and if it is negative the firm actually suffers from the presence of FDI.

The Heckman sample selection model

As discussed in Chapter 5, one characteristic of firm exporting is that many firms do not export. This makes their export behaviour unobservable. In our sample, there are 2,402 observations from domestic firms have zero value of export, accounting for 48.8 per cent of total observations from domestic firms. The impact of this unobserved export behaviour needs to be accounted for in the estimation. The large proportion of zero export observations comes from the fact that many firms decide not to export. Actually, each firm's export behaviour involves a two-step decision: first they decide whether to export and then they determine how much to export conditioned by the export participation decision. Hence we observe firm's export behaviour over a firm self-selected sample. In addition these two decisions are usually correlated with each other.

To account for selectivity bias, the Heckman sample selection model (Heckman, 1979) is employed. The following presents the selection model used to test the export spillovers from FDI:

$$\begin{aligned}
ePART_i &= \beta_0 + \beta_1 firmsize_i + \beta_2 kl_i + \beta_3 upcst_i + \beta_4 ulcst_i \\
&+ \beta_5 averagewage_i + \beta_6 me_i + \beta_7 ownership_i + \beta_8 age_i \\
&+ \beta_9 western_i + \beta_{10} middle_i + \beta_{11} herfindahl_i + \beta_{12} scale_i \\
&+ \beta_{13} fp_i + \beta_{14} fpo_i \times firmsize_i + \beta_{15} fpo_i \times kl_i + \beta_{16} fpo_i \times upcst_i \\
&+ \beta_{17} fpo_i \times ulcst_i + \beta_{18} fpo_i \times averagewage_i + \beta_{19} fpo_i \times me_i \\
&+ \beta_{20} fpo_i \times ownership_i + \beta_{21} fpo_i \times age_i + \beta_{22} fpo \times western_i \\
&+ \beta_{23} fpo \times middle_i + \beta_{24} dindustry_i + \beta_{25} dyear_i + \beta_{25} noofex + u_i
\end{aligned} \tag{6.2}$$

$$\begin{aligned}
eINT_i &= \beta_0 + \beta_1 firmsize_i + \beta_2 kl_i + \beta_3 upcst_i + \beta_4 ulcst_i \\
&+ \beta_5 averagewage_i + \beta_6 me_i + \beta_7 ownership_i + \beta_8 age_i \\
&+ \beta_9 western_i + \beta_{10} middle_i + \beta_{11} herfindahl_i + \beta_{12} scale_i \\
&+ \beta_{13} fp_i + \beta_{14} fpo_i \times firmsize_i + \beta_{15} fpo_i \times kl_i + \beta_{16} fpo_i \times upcst_i \\
&+ \beta_{17} fpo_i \times ulcst_i + \beta_{18} fpo_i \times averagewage_i + \beta_{19} fpo_i \times me_i \\
&+ \beta_{20} fpo_i \times ownership_i + \beta_{21} fpo_i \times age_i + \beta_{22} fpo \times western_i \\
&+ \beta_{23} fpo \times middle_i + \beta_{24} dindustry_i + \beta_{25} dyear_i + v_i
\end{aligned} \tag{6.3}$$

where equation (6.2) is the export participation equation and equation (6.3) is the export intensity equation; *ePART* denotes firm's decision to participate in the export; *eINT* is export intensity, and equal to the proportion of firm's export in its total sale; *firmsize* denotes firm size, and is equal to firm's output in constant price; *kl* denotes capital intensity defined as above; *upcst* is the unit production cost, which is equal to firm's total production and operation cost divided by the number of employees; *ulcst* is the unit labour cost, which is equal to a firm's total salaries payable divided by the output; *averagewage* is firm's average wage and equal to firm's total salary payable divided by the number of employees; *me* is the ratio of sale cost against sale revenue, which shows firm profitability and a value higher than 1 indicates that the firm suffers from loss; *ownership* denotes firm's ownership structure; *age* is firm age; *western* and *middle* are two regional dummies that control for the regional heterogeneity in firm's exports, which is potentially important as firms located in different regions must undertake different export cost such as transportation cost; *herfdindahl* is the Herfindahl index that captures the domestic market structure; *scale* is an index that captures economies of scale in the industry; *fp* is the foreign presence, proxy for the FDI, and as above it is interacted with firm level characteristics such as firm size, capital intensity, and unit production cost etc. to allow for the impact of FDI to vary across firms; *dindustry* is a set of 14 industry dummies that capture the industrial heterogeneity in export; *dyear* is a set of three year dummies that control for time effect in the estimation; *noofex* is the number of firm's exports in the four years and ranges from 0 to 4, which only appears in the firms' export participation equation (equation 6.2) for the purpose of model identification in the estimation. The number of a firm's exports in the four years signals the fixed export cost, and hence the more frequent the firm participates in exporting the more likely it will continue to export. Nevertheless as fixed export cost has been paid and is sunk, it should not affect how much the firm is willing to export. Hence excluding the number of firm export in the four years from the export intensity equation (equation 6.3) is reasonable; u and v are two correlated error terms, and $\begin{bmatrix} u \\ v \end{bmatrix} \sim N\left[\begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} 1 & \sigma_{12} \\ \sigma_{12} & \sigma_2^2 \end{bmatrix}\right]$. Chapter 5 discussed the role of explanatory variables in firm's exports. Following Chapter 5, foreign presence (*fp*) is interacted with firm level characteristics, and testing for export spillovers adopts the same three-step procedure.

Variable Construction

Definitions for explanatory variables follow those in Chapters 4 and 5. All variables are deflated by the implicit deflator obtained from firm output in current prices and in constant prices reported in the original data set. As this chapter aims at examining the impact of FDI on domestic firms, only domestic firms are included in the estimation. Table 6.6 presents the descriptive statistics for the variables used in the technology spillover estimation, and Table 6.7 presents the descriptive statistics for variables used in the export spillover estimation. Six observations can be found from Tables 6.6 and 6.7.

First, there exist missing values. Some firms report either zero employment, zero output, or zero sale revenue. This leaves missing values in constructing labour productivity, export intensity, capital intensity, intermediate inputs per employee, average wage (labour quality), unit production cost, unit labour cost, and the ratio of sale cost against sale revenue. Besides, taking the logarithm also leaves variables with zero value missing. Compared with the sample size, the proportion of missing values is small and furthermore these missing values do not exhibit a systematic pattern. Hence they are not likely to affect the estimation results significantly.

Second, all variables appear to have significant variations, for example for the firm size in Table 6.7, the mean value is 22.5447 while the standard deviation is 62.6309, 2.78 times that of mean value. In addition, taking the logarithm appears to reduce the variation, for example for average wage (labour quality), the standard deviation is 73.85 per cent of its mean value, but after taking the logarithm the standard deviation is reduced to 42.11 per cent of its mean value. Compared with Tables 6.6 and 6.7, we can find that common variables appear in both technology spillover and export spillover estimations. For variables used in the export spillover estimation, no logarithm is taken, as the dependent variable (export intensity) is not in logarithm form, while variables used in the technology spillover estimation, the capital intensity, intermediate inputs per employee, and labour quality are in logarithm form, as the dependent variable (labour productivity) is in logarithm form.

Third, from Table 6.6, we can see that different firms appear in different years. This comes from two sources: firm entry into and exit from the industry, and firms' leaving and entering the sample. As the data set covers all state-owned and non-state-owned firms above a designated size, the possibility that different firms appear in different years due to the latter source is small. Hence it is reasonable to believe that different firms appear in different years as firm enter and exit the industry.

Fourth, the activities of FDI in the industry are quite significant, no matter whether measured in the output, assets, employment share, or weighted capital share in the industry. However, *sfdi*, the proportion of foreign contributed capital in total received capital, weighted by firms' sale share in the four-digit industry constructed following Hu and Jefferson (2002), appears to have a lower value than the other three.

Fifth, domestic firm exports are quite active -- on average they export 40 per cent of their total sales -- but there exists large variation in the standard deviation, as large as 0.4463. Sixth, the market appears to be quite competitive as the Herfindahl index is quite small, on average about 50 per cent of firms are privately owned, and the majority of domestic firms are located in coastal China.

Tables 6.8 and 6.9 present the correlation matrix for variables used in the technology spillover estimation and export spillover estimation respectively. From the two tables, we can see that the correlation among most of variables is low, except for the correlation between Herfindahl index and the four measurements of FDI (*fpo*, *fpa*, *fpe*, and *sfdi*), which is around 0.6. Hence potential multicollinearity may not be a problem for these variables. In addition, the correlations among the four measurements of FDI are positive and rather high, which is desirable.

Table 6.6 Descriptive Statistics for Variables Used in Technology Spillover Study

	2000					2001				
Variables	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max
lnspe	940	4.1667	1.1205	-0.6931	7.6027	1079	4.3048	1.0682	-0.8437	7.3470
lnkl	937	3.8925	1.1052	-1.4899	8.0021	1076	3.8973	1.0314	-0.9555	8.2823
lnml	937	3.9306	1.1697	-1.6094	7.2086	1074	4.0755	1.1170	-3.7842	7.2657
lnlq	938	1.7854	0.7518	-3.1781	4.0810	1068	1.8660	0.7054	-1.7227	4.3405
age	985	15.3127	14.9198	1	106	1096	12.9051	14.6523	1	161
scale	985	0.8590	0.1642	0.4321	1.1571	1101	0.8975	0.1599	0.4141	1.2888
herfindahl	985	0.0599	0.0814	0.0150	0.4661	1101	0.0622	0.0569	0.0108	0.2324
fpo	985	0.5737	0.1759	0.0162	0.9551	1101	0.5554	0.1741	0.0478	0.8186
fpa	985	0.5991	0.2178	0.0271	0.9146	1101	0.5797	0.1876	0.0890	0.8477
fpe	985	0.5516	0.2002	0.0642	0.8883	1101	0.5536	0.1890	0.0250	0.7587
sfdi	985	0.4480	0.1584	0.0084	0.7193	1101	0.4380	0.1707	0.0322	0.7119
ownership	985	0.2873				1101	0.4342			
western	985	0.0670				1101	0.0527			
middle	985	0.1279				1101	0.1262			

	2002					2003				
Variables	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max
lnspe	1223	4.4577	0.9445	-0.8422	7.2900	1519	4.5213	1.0276	-0.7810	8.4485
lnkl	1220	3.9642	1.0571	0.0434	8.4073	1508	4.0926	1.0245	0.5705	7.7121
lnml	1219	4.2069	1.0056	-0.9004	7.0617	1518	4.2511	1.1235	-5.7591	8.4471
lnlq	1211	1.9718	0.6392	-2.0217	3.7994	1518	1.9954	0.6826	-1.7080	4.3354
age	1252	11.9888	13.7089	0	162	1325	10.6657	11.9649	1	139
scale	1256	0.9449	0.2258	0.4734	1.4680	1577	0.9849	0.2106	0.0796	1.2192
herfindahl	1256	0.0531	0.0551	0.0097	0.2470	1577	0.0448	0.0621	0.0229	0.3939
fpo	1256	0.5613	0.1740	0.0447	0.9504	1577	0.5514	0.1487	0.0066	0.8501
fpa	1256	0.6037	0.1955	0.0641	0.9275	1577	0.5859	0.1724	0.0100	0.7644

fpe	1256	0.5698	0.1846	0.0578	0.8603	1577	0.5666	0.1672	0.0027	0.7735
sfdi	1256	0.4466	0.1783	0.0173	0.7263	1577	0.4400	0.1602	0.0017	0.7965
ownership	1256	0.5231				1577	0.7096			
western	1256	0.0406				1577	0.1769			
middle	1256	0.1131				1577	0.0900			

Note: for the dummy variables, *ownership*, *western*, and *middle*, the figure is the percentage of firms that take value 1, for example in 2000 60.4% of firms are privately owned; *fpo*, *fpa*, and *fpe* are the FDI invested firms' output, assets, and employment share in the 4-digit industry; *sfdi* is the firm's proportion of foreign contributed capital in the total received capital, weighted by firms' sale share in the four-digit industry.

Source: Author's calculation based on Enterprise Data, NBS, Beijing, 2000, 2001, 2002, and 2003

Table 6.7 Descriptive Statistics for Variables Used in Export Spillover Study

Variable	Obs	Mean	Std. Dev.	Min	Max
export intensity	4810	0.4004	0.4463	0	1
firm size	4919	22.5447	62.6309	0	1384.444
capital intensity	4800	94.5131	176.6642	0	4479.6270
upcst	4802	0.8032	13.9311	0	901.1000
ulcst	4802	0.1531	0.8849	0	51.8
average wage	4800	8.2889	6.1214	0	76.74276
me	4798	0.8527	0.1736	0	7.5224
age	4658	12.5309	13.8361	0	162.0000
scale	4919	0.9299	0.2015	0.0796	1.468
herfindahl	4919	0.0538	0.0641	0.0097	0.4661
fpo	4919	0.5593	0.1669	0.0066	0.9551
fpa	4919	0.5917	0.1917	0.0100	0.9275
fpe	4919	0.5615	0.1836	0.0027	0.8883
sfdi	4919	0.4428	0.1670	0.0017	0.7965
whetherexport	4919	0.5117			

ownership	4919	0.5158
western	4919	0.0923
middle	4919	0.1116

Note: for the dummy variables, *whetherexport*, *ownership*, *western*, and *middle*, the figure is the percentage of firms that take value 1, for example 51.58% of firms are privately owned; *fpo*, *fpa*, and *fpe* are the FDI invested firms' output, assets, and employment share in the four-digit industry; *sfdi* is the firm's proportion of foreign contributed capital in the total received capital, weighted by firms' sale share in the four-digit industry.
Source: Author's calculation based on Enterprise Data, NBS, Beijing, 2000, 2001, 2002, and 2003

Table 6.8 Correlation Matrix for Variables Used in Technology Spillover Study

	lnkl	*lnml*	*lnlq*	*age*	*scale*	*herfindahl*	*ownership*	*western*	*middle*	*fpo*	*fpa*	*fpe*	*sfdi*
lnkl	1												
lnml	0.4197	1											
lnlq	0.3965	0.3784	1										
age	0.119	-0.25	0.0034	1									
scale	-0.0631	0.0183	0.014	-0.0707	1								
herfindahl	0.158	-0.0165	0.0364	0.1148	-0.431	1							
ownership	-0.1103	0.1888	0.0409	-0.3806	0.136	-0.1725	1						
western	-0.0334	-0.1845	-0.1405	0.1486	-0.0827	0.1021	-0.1941	1					
middle	-0.0876	-0.1926	-0.2495	0.0606	-0.0313	0.0318	-0.0754	-0.0719	1				
fpo	-0.1793	0.0485	-0.0424	-0.1358	0.2729	-0.6065	0.1609	-0.1239	-0.0937	1			
fpa	-0.2056	0.066	-0.0306	-0.171	0.2925	-0.6239	0.2107	-0.1628	-0.0963	0.9637	1		
fpe	-0.2061	0.0706	-0.0267	-0.1548	0.2191	-0.5449	0.1873	-0.1411	-0.1067	0.938	0.9497	1	
sfdi	-0.1922	0.0552	-0.0325	-0.1338	0.2394	-0.5102	0.1685	-0.1262	-0.0957	0.9427	0.9281	0.9443	1

Source: Author's calculation based on Enterprise Data, NBS, Beijing, 2000, 2001, 2002, and 2003

Table 6.9 Correlation Matrix for Variables Used in Export Spillover Study

	firmsize	*capitalintensity*	*upcst*	*ulcst*	*averagewage*	*me*	*age*	*scale*
firmsize	1							
capitalintensity	0.106	1						
upcst	-0.0135	0.0255	1					
ulcst	-0.0312	-0.0082	0.8403	1				
averagewage	0.1147	0.3116	-0.0235	-0.0048	1			
me	-0.0089	-0.0017	-0.0659	-0.0604	0.0124	1		
age	0.0206	0.0695	0.0697	0.1035	0.0339	-0.076	1	
scale	-0.0253	-0.0231	-0.0081	-0.0022	0.0248	0.0774	-0.0752	1
herfindahl	0.0487	0.0539	0.0272	0.0239	0.0094	-0.1436	0.1166	-0.4336
ownership	-0.0165	-0.0972	-0.0382	-0.0625	-0.0011	0.0976	-0.3821	0.1359
western	-0.0631	-0.0393	0.0227	0.0428	-0.1061	-0.1593	0.1527	-0.0941
middle	-0.0454	-0.032	-0.0024	-0.0002	-0.1749	-0.0552	0.0594	-0.0318
fpo	0.0028	-0.0657	-0.0157	-0.0065	-0.0094	0.1333	-0.1382	0.2787
fpa	0.0125	-0.0784	-0.0168	-0.0062	-0.0034	0.145	-0.1732	0.2988
fpe	0.0251	-0.0878	-0.012	0	0.0008	0.1263	-0.157	0.225
sfdi	0.0159	-0.0851	-0.0138	-0.0014	0.0008	0.1219	-0.1367	0.246

	herfindahl	*ownership*	*western*	*middle*	*fpo*	*fpa*	*fpe*	*sfdi*
herfindahl	1							
ownership	-0.1735	1						
western	0.1045	-0.1989	1					
middle	0.0366	-0.0758	-0.074	1				
fpo	-0.6081	0.162	-0.1264	-0.0964	1			
fpa	-0.6248	0.2116	-0.165	-0.0987	0.9637	1		
fpe	-0.5458	0.1888	-0.1428	-0.109	0.9379	0.9497	1	
sfdi	-0.5112	0.17	-0.1304	-0.0976	0.9427	0.9285	0.9446	1

Source: Author’s calculation based on Enterprise Data, NBS, Beijing, 2000, 2001, 2002, and 2003

Empirical Results

This section reports the estimation results for equations (6.1), (6.2) and (6.3). For the technology spillover estimation (equation 6.1), a fixed effect estimator is employed. Before the estimation, the Wooldridge (2002) test for first order autocorrelation is conducted. The test statistic obtained is 2.74, with a p-value of 0.098. Hence we fail to reject the null hypothesis of no first order autocorrelation at the 5% significance level. Then we test for group-wise heteroskedasticity in the residuals using a modified Wald statistic (following Greene, 2000) which is robust to the violation of normality assumption. The test statistic obtained is fairly large (7.4×10^{34}), which rejects the null hypothesis of homoskedasticity at the 5% significance level. Hence the robust standard error that accounts for heteroskedasticity of arbitrary form is computed in the fixed effect estimation. Another potential problem is the impact of firm entry and exit, which will be discussed in the following subsection. For the export spillover estimation (equations 6.2 and 6.3), following the estimation strategy of Greenaway et al. (2004), we pool the four year data together, using time and industry dummies to control for time and industry invariant effects. Treating the data as a large cross-section eliminates concerns about the impact of firm entry and exit, as now we essentially view the observations as being one random draw from the population.

Firm entry and exit

Firm entry and exit may affect testing for technology spillovers, and hence before turning to empirical results we have to check firm entry and exit first. As shown in Table 6.1, from 2000 to 2003 the number of firms in the industry is increasing. Hence there must be firm entry and possibly firm exit during this period. Table 6.10 presents a picture of firm entry and exit in the industry. As shown in Table 6.10, 947 firms appear in the four years, which accounts for 23 per cent of all 4,112 firms. Hence to construct a balanced panel we would have to exclude the remaining 77 per cent of firms. This would mean a substantial loss of information and thus is not done in this study. Besides, there are a considerable number of firms that only appear in one year[34].This would drop out in the fixed effect estimation for the technology spillover estimation but not in the pooled regression for the export spillover estimation. In addition, there are also a few firms that only appear in two or three years[35].

Table 6.10 Firm Entry and Exit

	No. of Firms	%	No. of Obs	%
Firms only appear in one year				
in 2000	497	12.09	497	5.5
in 2001	124	3.02	124	1.37
in 2002	153	3.72	153	1.69
in 2003	927	22.54	927	10.25
Firms appear in two years				
in 2000 and 2001	193	4.69	386	4.27
in 2000 and 2002	9	0.22	18	0.2
in 2000 and 2003	25	0.61	50	0.55
in 2001 and 2002	139	3.38	278	3.08
in 2001 and 2003	13	0.32	26	0.29
in 2002 and 2003	458	11.14	916	10.13
Firms appear in three years				
in 2000, 2001, and 2002	183	4.45	549	6.07
in 2000, 2001, and 2003	6	0.15	18	0.2
in 2000, 2002, and 2003	19	0.46	57	0.63
in 2001, 2002, and 2003	419	10.19	1,257	13.9
Firms appear in all four years				
	947	23.03	3,788	41.88
Total	4112	100	9,044	100

Source: Author's calculation based on Enterprise Data, NBS, Beijing, 2000, 2001, 2002, and 2003

So it appears that firm entry and exit is not random. Then what determines firm entry and exit in the industry? To examine this, we hypothesize that firm entry and exit depends on the previous year's foreign presence, four-digit industry export intensity, and four-digit industry labour productivity. Firm entry is a dichotomous variable, and is defined as taking a value of one if the firm appears in this year but not in previous year, and taking a value of zero otherwise. Firm exit is also a dichotomous

[34] In 2000, there are 497 such firms; in 2001, there are 124 this kind of firm; in 2002, there are 153 such firms; and in 2003 there are 927 such firms. Altogether they account for 41.4 per cent of total number of firms and 18.8 per cent of all observations.

[35] 458 firms only appear in 2002 and 2003, accounting for 11.1 per cent of total number of firms and 10.13per cent of all observations. 419 firms only appear in 2001, 2002, and 2003, accounting for 10.2 per cent of total number of firms and 13.9 per cent of total observations.

variable, and is defined as taking a value of one if the firm appears in this year but not in next year and taking a value of zero otherwise. Four-digit industry export intensity is equal to the four-digit industry's total exports divided by the industry's total sales. Four-digit industry labour productivity is proxied by the industry's total sales divided by the total number of employees. All explanatory variables are industry level variables, as is reasonable to believe firm's entry and exit depends on the industry environment. Table 6.11 presents the Probit estimation results. From the table, we find that foreign presence has significantly positive impact on a firm's entry decision and significantly negative effect on a firm's exit decision, namely the more FDI the more likely firms will enter the market and the less likely firms will leave the market. Even though more FDI usually means more competition in the market, this may happen if firms are trying to learn from FDI or activities of are positively correlated with unobserved factors that increase the probability of a firm's entry and decreases its probability of exit. The industry export intensity has significantly negative impact on a firm's decision to enter the industry and significantly positive impact on a firm's exit decision, reflecting the impact of industry competition. For industry labour productivity, firms are more likely to enter and less likely to leave an industry if they have high labour productivity.

Table 6.11 Determinants of Firm Entry and Exit

	Entry		Exit	
Variables	coef.	Robust std.err.	coef.	Robust std.err.
foreign presence	2.3710	0.2292	-1.7558	0.2037
industry export intensity	-1.4993	0.1881	0.9592	0.1766
industry labour productivity	0.3895	0.0506	-0.2831	0.0582
Constant	-3.2533	0.2408	0.5598	0.2928
Log pseudo likelihood	-5750.4163		-4233.7823	
Number of obs	12336		12336	
Pseudo R2	0.0321		0.0158	
Wald chi2(3) for overall significance	328.57		121.95	

Note: the estimation is Probit model over pooled data, and robust standard errors are computed; As there are 4112 firms, the total observations are 12336 for three years. One year is dropped due to the lag in explanatory variables; foreign presence is the output share measurement of FDI.
Source: Author's calculation based on Enterprise Data, NBS, Beijing, 2000, 2001, 2002, and 2003

So we conclude that a firm's entry and exit (panel attrition) in the industry is not random. The non-randomness of a firm's entry and exit may affect the fixed effect estimation in the technology spillover study. Table 6.11 reveals that firm entry and exit is affected by foreign presence in the industry. Fortunately, as shown in Wooldridge (2002, pp578-581), the impact of foreign presence on firm entry and exit will not affect the validity of the fixed effect estimation, as the foreign presence is one explanatory variable in the technology spillover study (equation 6.1). For a linear unobserved effect model like $y_{it} = x_{it}\beta + c_i + u_{it}$, $t = 1,\cdots,T$, where x_{it} is $1\times K$ and β is the $K\times 1$ vector of interest, let $s_i \equiv (s_{i1},\cdots,s_{iT})'$ denote the $T\times 1$ vector of selection indicators, where $s_{it} = 1$ if (x_{it}, y_{it}) is observed and zero otherwise. Then we can treat $\{(x_i, y_i, s_i), i = 1,2,\cdots,N\}$ as a random sample from the population. Under the regular fixed effect model assumption, namely (a) $E(u_{it}|x_i, s_i, c_i) = 0$, $t = 1,2,\cdots,T$, (b) $\sum_{t=1}^{T} E(s_{it}\ddot{x}_{it}'\ddot{x}_{it})$ is nonsingular, where $\ddot{x}_{it} \equiv x_{it} - T_i^{-1}\sum_{r=1}^{T} s_{ir}x_{ir}$ and $T_i \equiv \sum_{t=1}^{T} s_{it}$, and (c) $E(u_i u_i' | x_i, s_i, c_i) = \sigma_u^2 I_T$, we can find the consistent estimate of β , as $\hat{\beta} = \left(N^{-1}\sum_{i=1}^{N}\sum_{t=1}^{T} s_{it}\ddot{x}_{it}'\ddot{x}_{it}\right)^{-1}\left(N^{-1}\sum_{i=1}^{N}\sum_{t=1}^{T} s_{it}\ddot{x}_{it}'\ddot{y}_{it}\right)$, where $\ddot{y}_{it} \equiv y_{it} - T_i^{-1}\sum_{r=1}^{T} s_{ir}y_{ir}$, $\ddot{x}_{it}$ and T_i are defined as above. Assumption (a) ensures the consistency of the coefficient estimate; assumption (b) rules out the perfect collinearity; and assumption (c) is the homosekedasticity and no serial correlation assumption, which can be relaxed. In all three assumptions, the selection indicator s_i is allowed to be correlated with explanatory variables x_i . Hence the fact that firm entry and exit depends on foreign presence in the industry does not cause problems for the fixed effect estimation of equation (6.1).

Nevertheless firm entry and exit also depends on variables that do not appear in equation (6.1), which can make the selection indicator s_i correlated with the idiosyncratic error term in equation (6.1) and thus make the fixed effect estimation problematic. If the selection indicator s_i is correlated with the idiosyncratic error term, then assumption (a) in the above is violated and the coefficient estimate will be inconsistent. To test this, Nijman and Verbeek (1992) suggest a simple test in the context of random effect estimation, which according to Wooldridge (2002) is also applicable in the fixed effect estimation. The Nijman and Verbeek test adds a lagged selection indicator to the main equation, which is estimated by fixed effect estimator, and then under the null hypothesis that the selection indicator is uncorrelated with the idiosyncratic error term, the lagged selection indicator will be insignificant. Hence we first construct two lagged dummy variables of firm entry and exit, and then plug them into equation (6.1). Before estimating equation (6.1) augmented with firm entry and exit, the Wooldridge (2002) test for first order autocorrelation is conducted, with a test statistic of 3.157 with a p-value of 0.0765. Hence we fail to reject the null hypothesis of no first order autocorrelation at the 5% significance level. Then the augmented equation (6.1) is estimated using a fixed effect estimator and the robust standard errors are computed to account for possible heteroskedasticity. The estimated coefficient for the lagged firm entry dummy is -0.0557 with a p-value of 0.07, and the estimated coefficient for the lagged firm exit dummy is 0.0438 with a p-value of 0.797. An *F* test for the joint significance of these two dummies obtains a test statistic of 1.75 with a p-value of 0.174. Hence, at the 5% significance level we fail to reject the null hypothesis that they are insignificant. So in the technology spillover study, we estimate equation (6.1) without considering firm entry and exit.

Technology analysis

Equation (6.1) is estimated using the fixed effect estimator, and Table 6.12 presents the estimation results. The [1] in Table 6.12 presents estimation results with the full set of explanatory variables. The test statistic for the significance of the unobserved fixed effect is 2.2, which rejects the null of hypothesis at the 5% level, and the fixed effect estimation is thus appropriate. In [1] of Table 6.12, only the logarithm intermediate inputs per employee (*lnml*) and two industry dummies (*dindustry2* and *dindustry13*) are significant at the 5% level . An *F*-test for the joint significance of foreign presence and its interaction terms obtains a test statistic of 0.72, which fails to reject the null hypothesis that they are jointly insignificant at the 5% level. Hence the estimation [1] shows there are no technology spillovers from FDI.

However, there may be a multicollinearity problem. Capital intensity (*lnkl*) and its interaction term with foreign presence (*fpo_lnkl*), are individually insignificant at the 5% level but are jointly significant with an *F*-test statistic of 13.53 and p-value of 0. For the labour quality (*lnlq*) and its interaction term with foreign presence (*fpo_lnlq*), both of them are individually insignificant at the 5% level, but are jointly significant with an *F*-test statistic of 10.81 and p-value of 0. As the individual insignificance and jointly significance suggests existence of multicollinearity, we drop these two interaction terms (*fpo_lnkl* and *fpo_lnlq*) and re-estimate the model. The [2] in Table 6.12 presents the regression results.

For the estimation in [2], the test statistic for the existence of unobserved fixed effects is 2.18, which rejects the null of non-existence of fixed effects at the 5% level. Compared with [1], the coefficients of logarithm capital intensity (*lnkl*) and logarithm labour quality (*lnlq*) are both significant at the 5% level, and their magnitude is increased. The coefficient of labour quality increases from -0.0201 to 0.0926. For the coefficient of logarithm intermediate inputs per employee, which is significant at the 5% level in both [1] and [2], the estimate is stable in the sense that one estimate is within one standard error of the other. Then we test the joint significance of foreign presence and its interaction terms, and obtain an *F*-test statistic of 0.73 with a p-value of 0.62, which fails to reject the null hypothesis of joint insignificance. Hence the estimation in [2] concludes there are no technology spillovers from FDI. In [2], there are a few variables that are insignificant. An *F*-test for the joint significance of these individually insignificant variable obtains a test statistic of 1.09 with a p-value of 0.3404, which hence rules out the possibility that multicollinearity causes these variables to be individually insignificant.

We drop all individually insignificant variables in [2], including the foreign presence and its interaction terms, and re-estimate the model. The [3] in Table 6.12 reports these estimation results. Now all included variables are significant at the 5% level, and the test for significance of unobserved fixed effects (test statistic of 2.06) also rejects the null hypothesis of nonexistence at the 5% level. In [3] of Table 6.12, domestic firm capital intensity, intermediate inputs per employee, and labour quality positively affect their labour productivity, with a 1 per cent increase in capital intensity, intermediate inputs per employee, and labour quality leading to domestic firm's labour productivity increase by 0.16 per cent, 0.62 per cent, and 0.1 per cent respectively.

Compared with [2], the point estimate of coefficient of logarithm capital intensity (*lnkl*) is increased from 0.15 to 0.16, which however is within one standard error of each other; for the logarithm labour quality (*lnlq*), similarly the coefficient point estimate is increased from 0.09 to 0.1, which again is within one standard error of each other; for the logarithm intermediate inputs per employee, the coefficient point estimate is decreased from 0.79 to 0.62, with the former estimate being within three standard errors of the latter and the latter being within two standard errors of the former. However, we can reasonably conclude that dropping the insignificant variables does not result in drastic change in the coefficient estimate, and the foreign presence does not affect domestic firms' labour productivity.

Table 6.12 Estimation Results for Technology Spillover Study

	[1]		[2]		[3]	
	Coef.	Robust Std. Err.	Coef.	Robust Std. Err.	Coef.	Robust Std. Err.
Lnkl	0.0486	0.0689	0.1540*	0.0307	0.1617*	0.0380
Lnml	0.8539*	0.1658	0.7934*	0.1386	0.6167*	0.0825
Lnlq	-0.0201	0.0868	0.0926*	0.0201	0.1044*	0.0279
Age	-0.0039	0.0056	-0.0049	0.0056		
Age2	0.000013	0.000015	0.000012	0.000015		
Scale	-0.0479	0.0388	-0.0442	0.0388		
Herfindahl	-0.1108	0.2294	-0.0997	0.2348		
Ownership	0.0490	0.0657	0.0754	0.0724		
Fpo	0.6335	0.9945	1.3334	1.3466		
fpo_lnkl	0.1766	0.1321				
fpo_lnml	-0.3852	0.3408	-0.2836	0.2973		
fpo_lnlq	0.1900	0.1529				
fpo_age	0.0037	0.0086	0.0059	0.0085		
fpo_ownership	-0.0828	0.1176	-0.1315	0.1317		
fpo_middle	-0.1370	0.3956	-0.2565	0.4362		
fpo_western	0.6461	0.7163	0.4661	0.7565		
Dyear2	-0.0382	0.0200	-0.0384	0.0202		
Dyear3	0.0005	0.0216	-0.0015	0.0218		
Dyear4	0.0246	0.0236	0.0254	0.0242		
Dindustry2	0.4998*	0.2320	0.5017	0.2360		
Dindustry3	-0.1066	0.1387	-0.1399	0.1380		
Dindustry4	0.0472	0.1329	0.0021	0.1356		
Dindustry5	0.0328	0.1257	-0.0029	0.1312		
Dindustry6	0.0505	0.1141	0.0401	0.1201		
Dindustry7	0.0428	0.1121	0.0332	0.1170		
Dindustry8	0.0336	0.0986	0.0249	0.1046		
Dindustry9	-0.0087	0.3487	-0.0136	0.3138		
dindustry10	0.1035	0.2044	0.1324	0.1632		
dindustry11	0.7504	0.6133	0.7746	0.6291		
dindustry12	0.1281	0.2206	0.1479	0.1828		
dindustry13	0.9426*	0.1405	0.7820*	0.1395	0.9097*	0.0914
dindustry14	0.2162	0.1632	0.2842	0.1906		
dindustry15	0.0751	0.1106	0.0266	0.1204		
Constant	0.3353	0.4863	-0.0124	0.6576	0.6725*	0.1614
Number of obs		4468		4468		4711
Overall R2		0.6657		0.7113		0.7045
Overall significance F(33,2181)		2.0700E+08		2.4600E+08		379.7600
Correlation between unobserved effect and explanatory variables		-0.0987		-0.0162		-0.0258
sigma_u		0.5780		0.5347		0.5509
sigma_e		0.2546		0.2555		0.2611
Rho		0.8375		0.8141		0.8166
Test for joint significance of *fp* interaction terms		0.72		0.73		

Test for significance of unobserved effects	2.2	2.18	2.06

Note: [1] is the estimation with full set of explanatory variables; [2] is the estimation without interaction terms between *fpo* and *lnkl* and *lnlq*; [3] is the estimation dropping jointly insignificant variables in [2]. * denotes significance at the 5% level
Source: Author's estimation based on Enterprise Data, NBS, Beijing, 2000, 2001, 2002, and 2003

Export analysis

Equations (6.2) and (6.3) are estimated jointly by the maximum likelihood estimator with robust standard error computed to account for possible heteroskedasticity of arbitrary form. Table 6.13 reports the estimation results. The [1] in Table 6.13 is the estimation with full set of explanatory variables, which has a multicollinearity problem, since, for example, the variable firm size (*firmsize*) and its interaction term with foreign presence (*fpo_firmsize*) are individually insignificant (with p-value of 0.225 and 0.549 respectively), while they are jointly significant (with an *F*-test statistic of 16.28 and a p-value of 0.0003). Hence the foreign presence's interaction terms with firm size (*firmsize*), capital intensity (*kl*), average wage (*averagewage*), age (*age*), unit production cost (*upcst*), and unit labour cost (*ulcst*), together with other jointly insignificant variables except the time and industry dummies, are dropped and the model is re-estimated, which is presented in the [2] of Table 6.13. For both estimations, they are significant, and sample selection exits in that the inverse mills ratio (*lambda* in Table 6.13) is significant. In addition, the export intensity equation is significantly correlated with the export participation equation, as the test obtains a chi-square statistic of 35.48 in [1] and 35.79 in [2], which are both significant and rejects the null of insignificance. The existence of sample selection and correlation between two equations justify the application of Heckman sample selection model.

Comparing the two estimations reported in Table 6.13, the coefficients of most variables are within one standard error of each other, except for the capital intensity, average wage, and age. For the coefficient of capital intensity (*kl*) in the export intensity equation, the point estimate in [1] is -0.0007 with a standard error of 0.0003, and the point estimate in [2] is -0.0004 with a standard error of 0.0001, with the former being within three standard errors of the latter and the latter being within one standard error of the former. For the coefficient of average wage (*averagewage*) in the export intensity equation, the point estimate in [1] is 0.0062 with a standard error of 0.0065, and the point estimate in [2] is 0.003 with a standard error of 0.001, with the former being within four standard errors of the latter and the latter being within one standard error of the former. Regarding the coefficient of age (*age*) in the export intensity equation, the point estimate in [1] is -0.0054 with a standard error of 0.0024, and the point estimate in [2] is -0.0027 with a standard error of 0.0005, with the former being within eight standard errors of the latter and the latter being within two standard errors of the former. However, for all variables, including the capital intensity, average wage, and age, the coefficient estimates in the two estimations do not reveal any reversal of sign. Hence, we conclude that the two estimations are consistent with each other, but the estimation [2] is not subject to a multicollinearity problem. Hence we base our interpretation of the results on the estimation of [2].

Testing the existence of export spillovers follows the three steps as described above. In the export intensity equation, we first test the joint significance of foreign presence and its interaction terms, and obtain an *F*-test statistic of 74.57 with a p-value of 0, which rejects the null hypothesis of joint insignificance at the 5% level. Then we test the joint significance of foreign presence's interaction terms and obtain an *F*-test statistic of 73.86 with a p-value of 0, which also rejects the null hypothesis of joint insignificance. Then the marginal effect of foreign presence is computed by differentiating equation (6.2) with respect to foreign presence (*fpo*) as:

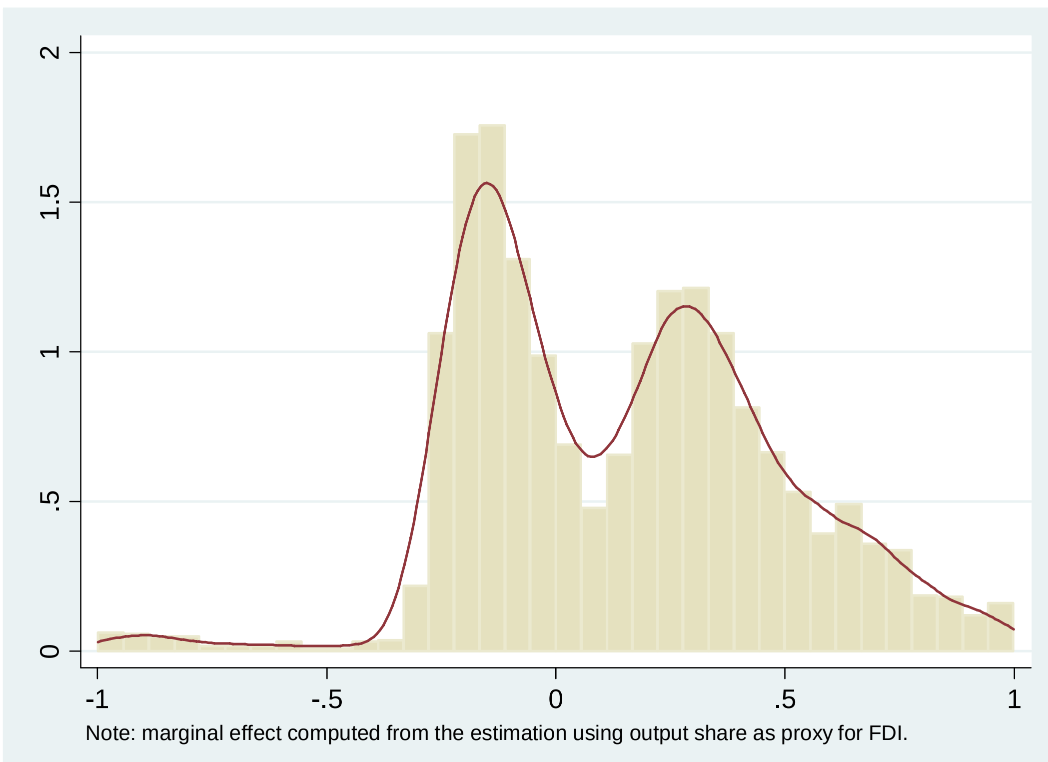
$$\frac{\partial eINT}{\partial fpo} = 1.9819 - 1.8678me - 0.43ownership - 1.7306western + 0.8473middle$$

Evaluating this marginal impact formula at the sample average, we obtain Table 6.14. From Table 6.14, we can find that domestic firms in western China suffer from the foreign presence, no matter whether they are privately owned or state and collectively owned. If they are privately owned, a 1 per cent increase in foreign presence is associated with a decrease of their export intensity by 1.77 per cent, and 1.34 per cent if they are state and collectively owned. Firms in central China appear to benefit from foreign presence, no matter whether they are privately owned or state and collectively owned. A 1 per cent increase in foreign presence is associated with a 0.77 per cent increase in export intensity if they are privately owned and a 1.2 per cent increase if they are state and collectively owned. For firms located in coastal China, privately owned firms suffer from foreign presence in the sense that a 1 per cent increase in foreign presence is associated with 0.04 per cent decrease in their export intensity, while in contrast the state and collectively owned firms benefit from the foreign presence with a 1 per cent increase in foreign presence leading to 0.39 per cent increase in their export intensity.

If we evaluate the marginal impact formula at domestic firms' value of the sales cost and sales revenue ratio, ownership structure and geographical location, we obtain the distribution of the marginal effect, as shown in Figure 6.5. Figure 6.5 shows that the marginal impact mainly ranges from -0.5 to 0.5, and some firms benefit from the foreign presence while other firms suffer, which is consistent with findings of Chapter 5. Nevertheless it appears that there are more firms that benefit than firms that suffer.

The marginal impact formula also shows that the sales cost and revenue ratio (*me*), ownership structure (*ownership*), and geographical location in western China (*western*) have negative impact on the scale of export spillovers, and the geographical location in central China (*middle*) has positive impact on the scale of export spillovers. A 1 per cent increase of the sale cost and revenue ratio will result in 1.87 per cent decrease in the scale of export spillovers. The sale cost and revenue ratio captures the firm's profitability, with higher ratio indicating lower profitability. Hence low profitability domestic firms are less capable of absorbing export spillovers from the FDI. Privately owned firms are less capable of benefiting from the FDI than the state and collectively owned firms, with the scale of export spillovers being 43 per cent less. This may result from the state and collectively owned firms have some policy privileges -- for example it is easier for them to get loan from the state owned banks -- that shield them from the direct competition with FDI invested firms. In regard to firm's geographical location, firms located in western China are disadvantaged, which is intuitive as western China is less developed compared with the rest of China and hence firms in western China are less capable of handling the challenge from FDI invested firms. However firms located in central China appear to benefit more from the FDI than firms in coastal China, with export spillovers being 85 per cent higher. This is somewhat surprising but may occur because they face less competition from FDI invested firms than their counterparts in coastal China. In our sample, there are only 68 observations that are FDI invested and located in central China, while in contrast there are 4,002 observations that are FDI invested and located in coastal China. Hence domestic firms located in coastal China are confronted with much more competition from FDI invested firms than their counterparts in central and western China.

Figure 6.5 Distribution of Marginal Effect of Output Share Foreign Presence on Export Intensity



In the export participation equation, the *F*-test for the joint significance of foreign presence and its interaction terms obtains a test statistic of 11.83 with a p-value of 0.0372, which rejects the null hypothesis of joint insignificance at the 5% level. Then the *F*-test for the joint significance of interaction terms obtains a test statistic of 9.35 with a p-value of 0.053, which is marginally significant at the 5% level. However foreign presence (*fpo*) and its interaction terms with the sales cost and revenue ratio (*me*), ownership structure (*ownership*), and geographical location in western China (*western*) are all individually insignificant at the 5% level, and an *F*-test for their joint significance also fails to reject their joint insignificance with *F*-test statistic of 5.03 and a p-value of 0.2841. The coefficient of the interaction term between foreign presence and geographical location in central China (*middle*) is significantly positive. So, in respect of the domestic firm's export participation decision, FDI only positively affects domestic firms in central China, but not other domestic firms. The higher is foreign presence, the more likely domestic firms that are located in central China will participate in export.

Table 6.13 Estimation Results for Export Spillover Study

	[1]				[2]			
	Export Intensity		Export Participation		Export Intensity		Export Participation	
Variables	Coef.	Robust Std. Err.	Coef.	Robust Std. Err.	Coef.	Robust Std. Err.	Coef.	Robust Std. Err.
firmsize	-0.0002	0.0002	-0.0003	0.0016	-0.0003*	0.0001	-0.0001	0.0008
kl	-0.0007*	0.0003	-0.0004	0.0012	-0.0004*	0.0001	-0.0004	0.0003
upcst	0.0244	0.0144	0.0581	0.0466				
ulcst	-0.4705	0.3357	-2.3119*	0.9737				
averagewage	0.0062	0.0065	0.0334	0.0262	0.0030*	0.0010	-0.0046	0.0069
me	1.3290*	0.3152	-0.0147	0.7205	1.4592*	0.3100	-0.1563	0.6541
age	-0.0054*	0.0024	-0.0060	0.0087	-0.0027*	0.0005	-0.0004	0.0023
ownership	0.2651*	0.0709	0.3384	0.2297	0.3228*	0.0635	0.4631*	0.2131
western	0.9511*	0.2768	-0.4657	0.3368	0.9332*	0.2702	-0.6836*	0.3148
middle	-0.5328*	0.1203	-0.7848*	0.3319	-0.5138*	0.1206	-0.8795*	0.3141
Herfindahl	0.0177	0.3292	-1.7845	1.3565				
scale	-0.0569	0.0469	-0.1318	0.2128				
fpo	1.7068*	0.4948	-0.4174	1.6055	1.9819*	0.4538	0.3242	1.3068
fpo_firmsize	-0.0002	0.0004	-0.0001	0.0032				
fpo_kl	0.0005	0.0005	-0.0005	0.0021				
fpo_upcst	-0.0521	0.0331	-0.0750	0.0762				
fpo_ulcst	0.7241	0.5141	3.2933*	1.3629				
fpo_averagwage	-0.0053	0.0100	-0.0613	0.0426				
fpo_me	-1.6811*	0.4805	1.2537	1.3404	-1.8678*	0.4736	1.1854	1.2587
fpo_age	0.0049	0.0040	0.0117	0.0159				
fpo_ownership	-0.3394*	0.1112	-0.2403	0.3904	-0.4300*	0.0990	-0.4229	0.3586
fpo_western	-1.7738*	0.4411	-1.0071	0.6118	-1.7306*	0.4284	-0.4414	0.5228
fpo_middle	0.8473*	0.1812	1.0770	0.5730	0.8151*	0.1807	1.2438*	0.5450
dyear2	0.0253	0.0191	-0.5169*	0.1194	0.0150	0.0178	-0.5241*	0.1185

dyear3	-0.0039	0.0216	-0.1714	0.1065	-0.0174	0.0186	-0.1611	0.1016
dyear4	0.0217	0.0237	0.1078	0.1062	0.0077	0.0195	0.1281	0.0992
dindustry2	-0.0763	0.0693	-0.9200*	0.2655	-0.0669	0.0664	-0.8316*	0.2475
dindustry3	0.0707	0.0415	-0.0831	0.1848	0.0554*	0.0265	0.0319	0.1380
dindustry4	0.1162	0.1437	0.2790	0.4370	0.1165	0.1347	0.2342	0.4410
dindustry5	-0.0936	0.0965	0.1055	0.3638	-0.1086	0.0744	0.4193	0.2832
dindustry6	0.0298	0.0449	-0.2931	0.2023	0.0298	0.0447	-0.2836	0.2023
dindustry7	-0.0058	0.0570	0.1389	0.2446	-0.0037	0.0518	0.0093	0.2161
dindustry8	0.0490	0.0427	0.1883	0.1781	0.0537	0.0422	0.1169	0.1756
dindustry9	-0.2608*	0.0815	-0.2976	0.3762	-0.2782*	0.0790	-0.2857	0.3689
dindustry10	0.0128	0.0428	0.1258	0.1771	-0.0032	0.0393	0.1513	0.1677
dindustry11	-0.1945	0.1349	-0.2071	0.5349	-0.1807	0.1064	-0.6433	0.4156
dindustry12	-0.1282	0.0753	-0.1472	0.3040	-0.1469*	0.0647	-0.0105	0.2748
dindustry13	0.1630*	0.0337	0.0170	0.1463	0.1610*	0.0331	0.0303	0.1444
dindustry14	0.0194	0.1115	-0.4837	0.3876	0.0133	0.1042	-0.7008*	0.3528
dindustry15	0.0290	0.0679	0.0561	0.2914	0.0445	0.0629	0.2149	0.2651
noofex			1.3376*	0.0491			1.3322*	0.0489
Constant	-0.5480	0.3293	-1.5253	0.9945	-0.7734*	0.2918	-2.0721*	0.7141
Number of obs			4527				4527	
Log pseudo likelihood			-1286.099				-1300.096	
Overall significance Wald chi2			1101.63	(0.0)			973.48	(0.0)
athrho			-0.3583*	0.0601			-0.3597*	0.0601
lnsigma			-1.2924*	0.0168			-1.2900*	0.0168
rho			-0.3437	0.0530			-0.3450	0.0530
sigma			0.2746	0.0046			0.2753	0.0046
lambda			-0.0944	0.0150			-0.0950	0.0150
Test for independence between export participation equation and intensity equation chi2(1)			35.48	(0.0)			35.79	(0.0)

Note: [1] is the estimation with full set of explanatory variables; [2] is the estimation dropping jointly insignificant variables except year and industry dummies; * denotes significance at 5% level; figures in () is the p-value.

Source: Author's estimation based on Enterprise Data, NBS, Beijing, 2000, 2001, 2002, and 2003

Table 6.14 Marginal Effect of Foreign Presence on Export Intensity

	Coastal China	Middle China	West China
Privately owned	-0.0408	0.7743	-1.7714
State and collectively owned	0.3892	1.2043	-1.3414

Note: the foreign presence is measured in terms of output share.

Source: Author's estimation based on Enterprise Data, NBS, Beijing, 2000, 2001, 2002, and 2003

On the impact of the other factors on domestic firm's export intensity, Table 6.13 shows that firm size (*firmsize*), capital intensity (*kl*), and firm age (*age*) have significantly negative impact on domestic firm's export intensity. The negative sign of firm size and age contradicts with findings in Chapter 5 for the whole manufacturing sector, reflecting export behaviour specific to the industry. For firm size, an increase in the firm size by 1 million RMB will result in the decrease of export intensity by 0.03 per cent. The negative impact of firm size is also contrary to the findings of Wakelin (1998) and Barrios et al. (2003). On the one hand, bigger firms are usually more able to overcome export entry costs, but on the other hand, smaller firms in the industry tend to be more dependent on exports, and some even 100 per cent depends on their export for survival. As firms get bigger, their dependence on export is reduced. Similarly, the capital intensity (*kl*) also has a significantly negative impact on domestic firm export intensity, with an increase of 1 per cent leading to a decrease in export intensity by 0.0004 per cent.

Domestic firm's age also negatively affects its export intensity, as a firm grows older it become less and less dependent on export markets. The average wage (*averagewage*), a proxy for labour quality, has a positive impact on domestic firm's export intensity, indicating firms with more capable staff are more able to export. For the intermediate inputs per employee (*me*), as it is interacts with the foreign presence, the impact on firm export intensity depends on the level of foreign presence. Evaluating the marginal impact of the intermediate inputs per employee at the sample average level of foreign presence, we obtain the marginal impact of 0.4146, indicating a positive impact on firm's export intensity. Similarly the impact of ownership structure and geographical location dummies also depend on the foreign presence, and if evaluated at the sample average level of foreign presence, the marginal effects obtained are 0.0823, -0.0347, and -0.0579 for the ownership, geographical location in western China and geographical location in central China respectively. This indicates that on average privately owned firms export more than state and collectively owned firms, and domestic firms located in western and central China export less than their counterparts in coastal China.

For the export participation equation, the number of exports in the four years (*noofex*) and the ownership structure (*ownership*) have significantly positive impact on domestic firm's export participation, indicating that the more frequent the firm exports the more likely it will continue to export, and privately owned domestic firms are more likely to export than their state and collectively owned counterparts.

The geographical location dummy (*western*) has a significantly negative coefficient, indicating domestic firms located in western China are less likely to export. For the variable *middle*, its marginal impact depends on foreign presence due to the interaction term, and evaluating its marginal impact at the sample average of foreign presence, we obtain -0.1839, which indicates that on average domestic firms located in central China are less likely to export than their counterparts in coastal China.

Sensitivity

Using the FDI invested firms' output share in the four-digit industry, we find that FDI does not significantly affect domestic firm's labour productivity, but they do affect domestic firm's exports, with the scale of export spillovers positively depending on firm's sales cost and revenue ratio and geographical location in central China and negatively depending on firm ownership structure and geographical location in western China. However, are our findings sensitive to the way we measure FDI? To examine this, we re-estimate the models using the FDI invested firms' assets and employment share in the industry as proxy for FDI respectively. For the technology spillover study, the re-estimation is undertaken following the specification in the [2] in Table 6.12. For the export spillover study, the re-estimation is made following the specification in the [2] in Table 6.13. Table 6.15 reports the estimation results for the technology spillover study, and Table 6.16 reports the estimation results for the export spillover study.

Comparing Table 6.15 with the [2] in Table 6.12, the coefficient estimates are consistent with each other in the sense that the point estimate of most variables are within one standard error of each other. For example, for the logarithm capital intensity, the point estimates are 0.1555, 0.1536, and 0.1540 in the estimations using three different proxies of FDI, which are very close to each other. One exception is the coefficient of logarithm intermediate inputs per employee (*lnml*). The point estimates are 0.6244 with a standard error of 0.0862, 0.5694 with a standard error of 0.0931, and 0.7934 with a standard error of 0.1386 in the estimation using assets, employment, and output share measurements of FDI respectively. The former two point estimates are significantly smaller than the latter one. The *F*-test for joint significance of foreign presence and its interaction terms obtains a test statistic of 0.56 with a p-value of 0.7593 in the estimation using assets share measurement of FDI, and a test statistic of 0.83 with a p-value of 0.5477, both of which fail to reject the null hypothesis of joint insignificance at the 5% level. Hence, with these two measurements, we still find no evidence of technology spillovers from FDI.

Table 6.15 Estimation for Sensitivity Analysis in Technology Spillover Study

	[1]		[2]	
	Coef.	Robust Std. Err.	Coef.	Robust Std. Err.
lnkl	0.1555*	0.0336	0.1536*	0.0327
lnml	0.6244*	0.0862	0.5694*	0.0931
lnlq	0.0966*	0.0221	0.0980*	0.0230
age	-0.0045	0.0059	-0.0019	0.0060
age2	0.000010	0.000014	0.000008	0.000015
scale	-0.0426	0.0391	-0.0508	0.0410
herfindahl	-0.1949	0.2253	-0.2101	0.1857
ownership	0.0629	0.0767	0.0608	0.0707
fp	0.0434	0.8863	-0.1889	0.9393
fp_lnml	-0.0067	0.1883	0.0868	0.1971
fp_age	0.0050	0.0084	0.0009	0.0091
fp_ownership	-0.1015	0.1283	-0.1075	0.1233
fp_middle	-0.0942	0.3824	0.5169	0.3734
fp_western	0.7522	0.6943	0.3700	0.6672
dyear2	-0.0424*	0.0209	-0.0413*	0.0190
dyear3	-0.0067	0.0203	-0.0063	0.0191
dyear4	0.0169	0.0216	0.0173	0.0202
dindustry2	0.5479*	0.2463	0.5041	0.2423
dindustry3	-0.1612	0.1494	-0.1687	0.1493
dindustry4	0.0745	0.1311	0.1848	0.1592
dindustry5	0.0286	0.1277	0.0680	0.1334
dindustry6	0.0656	0.1152	0.0279	0.1210
dindustry7	0.0534	0.1106	-0.0097	0.1075
dindustry8	0.0544	0.0910	0.0107	0.0950
dindustry9	-0.0754	0.3100	-0.1645	0.3176
dindustry10	0.1050	0.1838	0.0119	0.1929
dindustry11	0.8479	0.7750	0.7210	0.7512
dindustry12	0.1390	0.1983	0.0606	0.2106
dindustry13	0.8949*	0.1231	0.9179*	0.1303
dindustry14	0.2135	0.1582	0.1309	0.1143
dindustry15	0.0832	0.1158	0.0830	0.1065
constant	0.6954	0.4656	0.8210	0.4524
Number of obs		4468		4468
Overall R2		0.6748		0.6382
Overall significance F(33,2181)		2.5100E+08		1.0400E+09

	[1]	[2]
Correlation between unobserved effect and explanatory variables	-0.0428	-0.0834
sigma_u	0.5652	0.5956
sigma_e	0.2575	0.2576
rho	0.8281	0.8424
Test for joint significance of fp and interaction terms	0.56	0.83
Test for significance of unobserved effects	2.13	2.13

Note: [1] is the estimation using FDI invested firms' assets share in the industry as proxy for FDI; [2] is the estimation using FDI invested firms' employment share in the industry as proxy for FDI; * denotes significance at 5% level.
Source: Author's estimation based on Enterprise Data, NBS, Beijing, 2000, 2001, 2002, and 2003

The coefficient estimate presented in Table 6.16 shows only negligible difference with that of [2] in Table 6.13. Some coefficient point estimates even remain unchanged across three estimations, for example for the coefficient of firm size, the three estimations obtain the same point estimate (-0.0003). The *F*-test for the joint significance of foreign presence and its interaction terms obtains a test statistic of 86.32 with a p-value of 0 in the estimation with assets share as proxy for FDI, and a test statistic of 118.96 with a p-value of 0, which both rejects the null hypothesis of joint insignificance at the 5% level. Then evaluate the marginal impact of foreign presence at both the sample average and domestic firm's value of firm characteristics, we obtain Table 6.17, Figure 6.6 and 6.7.Comparing Table 6.17 and 6.14, there are some variations in the magnitude, but the signs of marginal impacts do not change. Figure 6.6 and 6.7 also present a very similar picture to that of Figure 6.5. Hence, we conclude our findings in testing export spillovers are not sensitive to different measurements of FDI.

Figure 6.6 Distribution of Marginal Effect of Assets Share Foreign Presence on Export Intensity

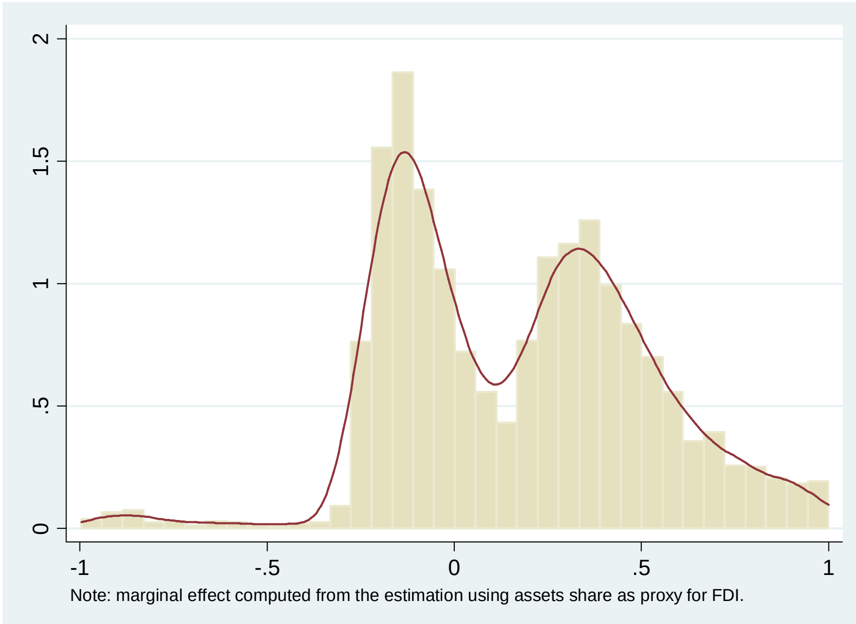


Figure 6.7 Distribution of Marginal Effect of Employment Share Foreign Presence on Export Intensity

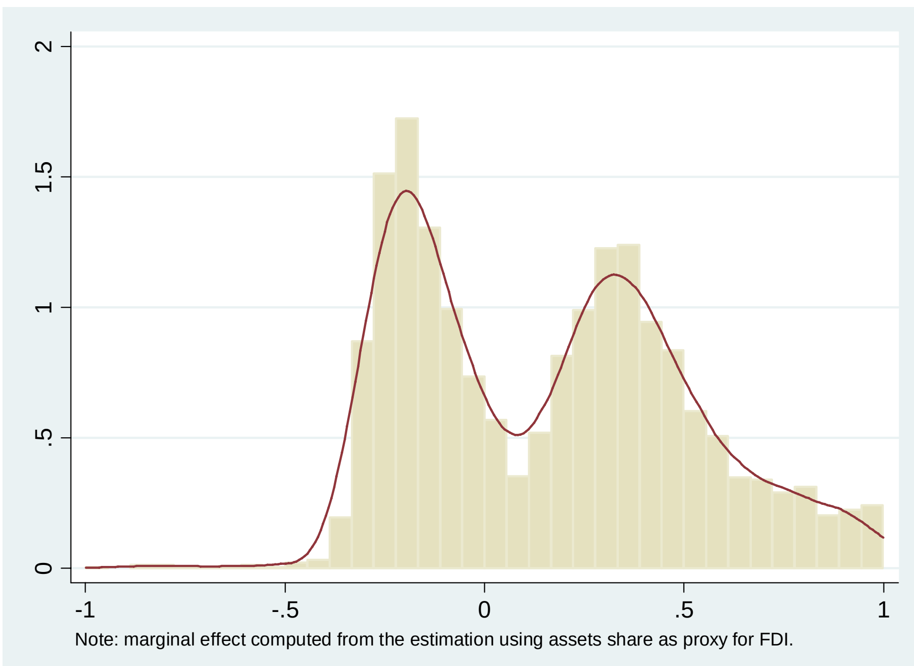


Table 6.16 Estimation for Sensitivity Analysis in Export Spillover Study

	[1]				[2]			
	Export Intensity		Export Participation		Export Intensity		Export Participation	
Variables	Coef.	Robust Std. Err.	Coef.	Robust Std. Err.	Coef.	Robust Std. Err.	Coef.	Robust Std. Err.
firmsize	-0.0003	0.0001	-0.0002	0.0008	-0.0003	0.0001	-0.0002	0.0008
capitalintensity	-0.0004	0.0001	-0.0004	0.0003	-0.0004	0.0001	-0.0004	0.0003
averagewage	0.0030	0.0010	-0.0046	0.0068	0.0030	0.0010	-0.0048	0.0068
mexpense	1.5643	0.2763	-0.0400	0.4115	1.6059	0.2899	-0.1138	0.5191
age	-0.0026	0.0005	-0.0003	0.0023	-0.0025	0.0005	-0.0004	0.0023
ownership	0.3573	0.0602	0.4331	0.2141	0.3720	0.0558	0.3616	0.2119
western	0.9589	0.2328	-0.6874	0.2794	1.3773	0.1795	-0.9466	0.2539
middle	-0.4357	0.1166	-0.6311	0.2935	-0.3742	0.1134	-0.8537	0.3146
Fp	2.0109	0.3844	0.9345	1.0203	2.1641	0.4344	0.5154	1.2862
Fp_mexpense	-1.8612	0.3843	1.0360	0.8453	-2.0397	0.4294	1.1503	1.0540
Fp_ownership	-0.4474	0.0852	-0.3442	0.3327	-0.4983	0.0838	-0.2472	0.3449
Fp_western	-1.7315	0.4003	-0.3767	0.4934	-2.5788	0.3563	0.1338	0.4754
Fp_middle	0.6373	0.1592	0.7639	0.4750	0.5867	0.1644	1.1695	0.5250
Dyear2	0.0171	0.0190	-0.4992	0.1190	0.0073	0.0172	-0.5460	0.1166
Dyear3	-0.0181	0.0184	-0.1686	0.1004	-0.0282	0.0172	-0.2041	0.0989
Dyear4	0.0067	0.0184	0.1146	0.0962	-0.0030	0.0168	0.0662	0.0951
Dindustry2	-0.0423	0.0713	-0.5991	0.2629	-0.0498	0.0713	-0.7012	0.2715
Dindustry3	0.0583	0.0278	0.0885	0.1400	0.0638	0.0482	0.2457	0.2223
Dindustry4	0.1484	0.1402	0.5568	0.4658	0.1474	0.1500	0.3842	0.5553
Dindustry5	-0.0977	0.0795	0.5980	0.2805	-0.1141	0.0886	0.5227	0.3496
Dindustry6	0.0415	0.0409	-0.2043	0.1898	0.0395	0.0437	-0.2924	0.2054
Dindustry7	-0.0045	0.0521	-0.0876	0.2103	0.0072	0.0543	-0.0233	0.2369
Dindustry8	0.0551	0.0374	0.1192	0.1531	0.0616	0.0368	0.1585	0.1584
Dindustry9	-0.2302	0.0898	-0.0458	0.4006	-0.2206	0.1000	0.0524	0.4546
dindustry10	0.0401	0.0514	0.3832	0.2137	0.0169	0.0482	0.2457	0.2012
dindustry11	-0.1655	0.0881	-0.6128	0.3717	-0.1518	0.0782	-0.4486	0.3360
dindustry12	-0.1416	0.0651	0.0811	0.2689	-0.1400	0.0724	0.0871	0.3110
dindustry13	0.1533	0.0384	-0.0898	0.1631	0.1647	0.0367	-0.0077	0.1665
dindustry14	0.0163	0.1002	-0.6661	0.3493	0.0236	0.0991	-0.5858	0.3371
dindustry15	0.0557	0.0720	0.4281	0.2930	0.0393	0.0631	0.2063	0.2660
noofex			1.3314	0.0489			1.3281	0.0486
constant	-0.9053	0.2687	-2.5255	0.5765	-0.9250	0.2846	-2.2065	0.7030
Number of obs			4527				4527	
Log pseudolikelihood			-1291.867				-1282.299	
Overall significance Wald chi2			974.64				1009.81	
athrho			-0.3692	0.0613			-0.3684	0.0613
lnsigma			-1.2924	0.0168			-1.2967	0.0169
rho			-0.3533	0.0536			-0.3526	0.0537
sigma			0.2746	0.0046			0.2734	0.0046
lambda			-0.0970	0.0152			-0.0964	0.0152
Test for independence between export participatio equation and intensity equation chi2(1)			36.31				36.11	

Note: [1] is the estimation using FDI invested firms' assets share in the industry as proxy for FDI; [2] is the estimation using FDI invested firms' employment share in the industry as proxy for FDI.
Source: Author's estimation based on Enterprise Data, NBS, Beijing, 2000, 2001, 2002, and 2003

Table 6.17 Marginal Impact of FDI Estimated Using Assets and Employment Share Measurements

	Coastal China		Middle China		Western China	
	[1]	[2]	[1]	[2]	[1]	[2]
Privately owned	-0.0236	-0.0735	0.6137	0.5133	-1.7551	-2.6522
State and collectively owned	0.4238	0.4249	1.0612	1.0116	-1.3077	-2.1539

Note: [1] is the estimation using FDI invested firms' assets share in the industry as proxy for FDI; [2] is the estimation using FDI invested firms' employment share in the industry as proxy for FDI.
Source: Author's estimation based on Enterprise Data, NBS, Beijing, 2000, 2001, 2002, and 2003

Conclusions

This chapter explored both technology spillovers and export spillovers from the FDI in the cultural, educational, and sporting product manufacturing industry, where there are is significant proportion of FDI activities and firms are very active in exporting. We found no evidence of technology spillovers. However, we did find that there exist export spillovers from FDI, for which the scale positively depends on firm's sales cost and revenue ratio and geographical location in central China and negatively depends on firm's ownership structure and geographical location in western China.

7. Technology Spillovers of FDI in Gansu Province[36]

FDI technology spillovers in a less developed region have the potential to accelerate economic development. A study of technology spillovers at the firm level, in Gansu province, a much less developed region in China where there are fewer FDI invested firms compared with the rest of China, potentially offers insight into the role of FDI in promoting economic development in less developed regions.

Analysis of spillovers from FDI at the firm level also offers additional insight into the nature of technology spillovers. As shown by Caballero and Lyons (1989), the externality at one level of aggregation can become internal at a higher level of aggregation. This characteristic of spillovers means measuring their effects requires analysis at different level of aggregation.

The rest of the chapter is organized into six sections. The first section deals with the background about the subject of this study, Gansu province. Then we present the analytical framework and estimation strategy, and construct variables used in the empirical study. The regression results and sensitivity analysis are discussed in the subsequent two sections. The last section concludes the chapter.

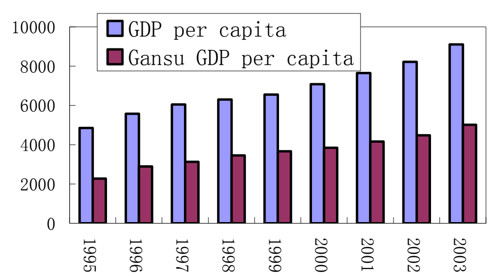
Background

Gansu province has two distinct underlying characteristics compared with China as a whole: it is relatively under-developed and it is rich in natural resources. Figure 7.1 compares GDP per capita in Gansu and China nationally. Since 1995, the GDP per capita of Gansu has been well below that of all China. In 2003, GDP per capita in Gansu was 5,012 RMB, while the national average was 9,101

[36] The methodology and data in this chapter draws from Sun (2006), Technical Efficiency and Its Determinants in Gansu, West China, *Pacific Economic Papers*, no.355, http://www.crawford.anu.edu.au/pdf/pep/pep-355.pdf

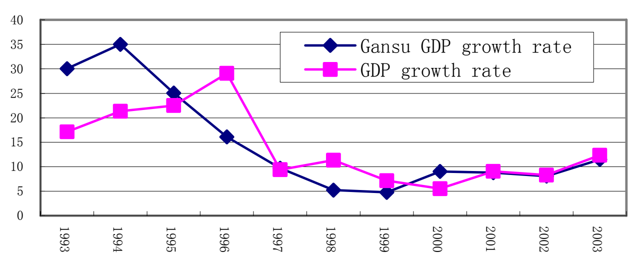
RMB; that is, Gansu's GDP per capita was only about 55 per cent of the national average. From 1995 to 2003 GDP per capita in Gansu averaged only 54 per cent of the national level. Figure 7.2 compares Gansu's GDP growth rate with the national average. Gansu's GDP growth rate is no higher than the national average in most of years since 1995, implying that the gap in GDP per capita has not narrowed unless the population growth rate was lower than the national average, and that is unlikely.

Figure 7.1 Comparison of GDP Per Capita (unit: RMB)



Source: China Statistical Yearbook, various issues

Figure 7.2 Comparison of GDP Growth Rate (unit: per cent)



Source: National Bureau of Statistics of China, various issues

Gansu is well known for its high endowment of natural resources (see Figure 7.3 for a distribution of major natural resources). It has reserves of 11 minerals that rank as China's largest, 32 minerals that rank in China's top five, and 51 minerals that rank in China's top 10. Reserves of nickel-cobalt ranks in the world's top three, reserves of zinc ranks in China's top three, and reserves of copper ranks in China's top four. This resource endowment means that Gansu's industry is heavily resource-based. Value added in the non-ferrous metals industry and the metallurgy industries accounts for 25 per cent of the total added value of industry. In 2003, the output of electrolytic aluminium was 500,000 tonnes, which accounted for 9.3 per cent of provincial output. During the period of January–May 2005, the value added of the eight main industries (all resource-based) accounted for 80 per cent of total provincial output.

Figure 7.3 presents the geographical location of firms and the distribution of Gansu's main resources. We find that firm concentration generally does not match the distribution of resources, even though Gansu's industries are heavily resource-based, except for Baiyin and Longnan. Baiyin city has lead-zinc deposits and Longnan is very near to stibium, copper and gold deposits. These minerals are commonly located in mountainous areas unsuited to the establishment of manufacturing activities.

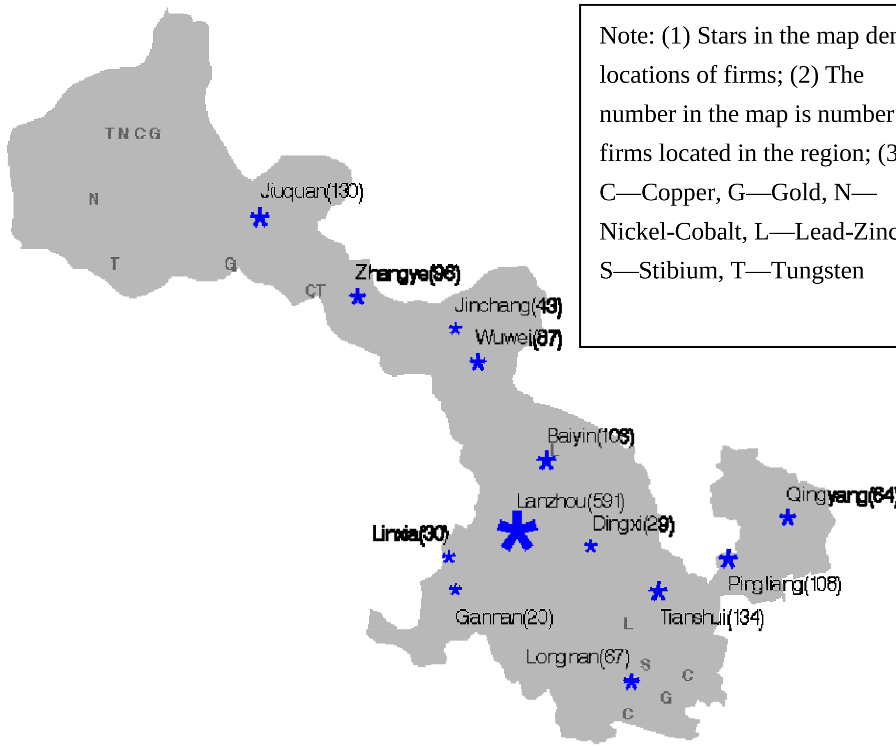
Gansu has not attracted foreign investment to the same extent as other provinces. The FDI-GDP ratio is significantly below the national average (see Table 7.1). In 2000, 2001, 2002, and 2003, the FDI-GDP ratio in Gansu was 0.52 per cent, 0.57 per cent, 0.44 per cent, and 0.15 per cent respectively, while over the same period, the national average was 2.41 per cent, 2.63 per cent, 2.61 per cent, 2.26 per cent respectively. The gap appears to be growing, as in 2000 and 2001 the national average FDI-GDP ratio was about 4.6 times that of Gansu, but in 2002 and 2003 the gap had risen to 6 and 15 times respectively. In terms of ranking across provinces, Gansu is ranked 27 in 2000, 25 in 2001, 27 in 2002, and 29 in 2003 among all 31 provinces and cities.

Table 7.1 FDI-GDP Ratio across Provinces (per cent)

Provinces	2000	2001	2002	2003
Beijing	5.62	5.14	4.44	4.95
Tianjin	5.89	9.60	6.38	5.19
Hebei	1.10	0.99	1.06	1.12
Shanxi	1.13	1.09	0.87	0.72
Inner Mongolia	0.62	0.57	0.83	0.34
Liaoling	3.62	4.14	5.36	3.89
Jilin	1.53	1.38	0.90	0.63
Heilongjiang	0.77	0.79	0.76	0.60
Shanghai	5.75	7.17	6.54	7.24
Jiangsu	6.20	6.02	7.93	7.02
Zhejiang	2.21	2.71	3.27	4.39
Anhui	0.87	0.85	0.89	0.77
Fujian	7.25	7.62	6.79	4.11
Jiangxi	0.94	1.51	3.65	4.71
Shandong	2.88	3.09	3.71	4.00
Henan	0.91	0.67	0.54	0.63
Hubei	1.83	2.11	2.44	2.40
Hunan	1.52	1.68	1.80	1.82
Guangdong	9.67	9.28	7.99	4.75
Guangxi	2.12	1.43	1.41	1.27
Hainan	6.88	7.08	7.09	5.20
Chongqing	1.27	1.21	0.82	0.96
Sichuan	0.90	1.09	0.94	0.63
Guizhou	0.21	0.22	0.27	0.28
Yunnan	0.54	0.26	0.41	0.28
Tibet	0.00	0.00	0.00	0.00
Shannxi	1.44	1.58	1.42	1.15
Gansu	0.52	0.57	0.44	0.15
Qinghai	0.00	1.00	1.15	0.53
Ningxia	0.54	0.47	0.55	0.37
Xinjiang	0.12	0.11	0.10	0.07
Average	2.41	2.63	2.61	2.26

Source: *China Statistical Yearbook*, 2002, 2003, 2005

Figure 7.3 Distribution of Firms and Major Resources in Gansu



Note: (1) Stars in the map denotes locations of firms; (2) The number in the map is number of firms located in the region; (3) C—Copper, G—Gold, N—Nickel-Cobalt, L—Lead-Zinc, S—Stibium, T—Tungsten

Source: MOF 2001, *Gansu Yearbook* 2005

It is clear that Gansu is a less developed province in terms of both aggregate GDP, GDP per capita, and its capacity to attract foreign direct investment. However its rich natural resource endowment is a source of advantage. This makes the study of technology spillovers and their determinants in Gansu province interesting not only for what tells us about technology spillovers, but also because of what it implies for economic development potential.

Analytical Framework

In earlier chapters the focus was on regression of labour productivity against the foreign presence to test technology spillovers. This chapter explores whether the foreign presence affects domestic firm technical efficiency. If FDI invested firms have a positive impact on domestic firms' technical efficiency, then technology spillovers occur. Here the testing of spillovers is undertaken within the framework of a stochastic production frontier and technical inefficiency model.

This methodology does not require using a proxy of labour productivity for domestic firm technology and a consequent deficiency in the earlier analysis. The stochastic production frontier also reveals firm technical efficiency in Gansu province, itself of significant analytic and policy interest. This section lays out the analytical framework within which the study is undertaken.

Technical efficiency and its measurement

Farrell (1957) argues that total economic efficiency can be decomposed into two components: technical efficiency and allocative efficiency. Technical efficiency reflects a firm's ability to maximize output for a given set of inputs (or operate at the boundary of a production possibility frontier), or the firm's ability to minimize inputs used for a given set of outputs; and allocative efficiency reflects the firm's ability to use inputs in optimal proportions given their market prices and the production technology used.

The measurement of technical inefficiency falls into two categories: input-oriented measures and output-oriented measures. Koopmans (1951) gives these measures formal definitions. This paper will use an output-oriented measure. Its formal definition is as follows:

> An output vector $y \in L(y)$ is technically efficient, if and only
>
> if, $y' \notin L(y)$ for $y' \geq y$

This definition says that for given inputs and technology, any output that is higher than the current output is not available to the firm if the firm is already technically efficient.

Many different methods have been adopted to estimate technical efficiency. The two main approaches are data envelopment analysis (DEA) and the stochastic production frontier model. The former involves mathematical programming, and the latter uses econometric methods. This chapter uses the latter approach.

Stochastic production frontier and technical inefficiency model

The stochastic production frontier model is a widely used approach in measuring technical efficiency, as first proposed independently by Aigner, Lovell, and Schmidt (1977) and Meeusen and van den Broeck (1977). This model says that a firm's production process is subject to two disturbances: technical inefficiency and other random shocks that are outside of the firm's control. If factors that affect these two disturbances are independent of each other, that is, the two disturbances can be separated, then the firm's technical efficiency can be estimated accordingly. The model can be summarized as:

$$\ln(y_i) = x_i\beta + v_i - u_i \quad \text{i=1, 2, … , N} \qquad (7.1)$$

where y is the output; x is the vector of inputs; β is a vector of production parameters; the random error v (two-sided "noise" component) accounts for the effect of all random factors, such as the measurement error, the effects of weather, and luck. The v_i s are assumed to be independently and identically distributed as normal random variables with mean zero and constant variance σ_v^2, and are also assumed to be independent of u_i and the inputs vector *x*. The u_i s are non-negative random components and capture technical inefficiency, since the non-negative assumption of u ensures that the firm's actual production point always lies beneath the stochastic frontier and the gap thus measures technical inefficiency.

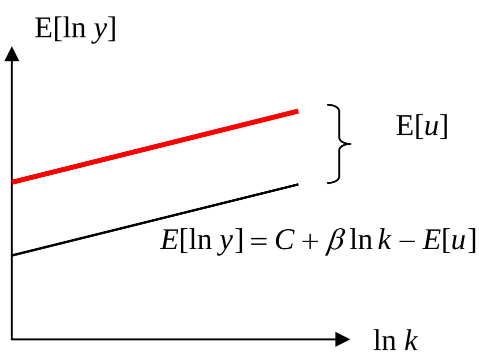
Hence this model is also called an error component model, as the error term is actually composed of two components. The OLS estimate of the equation will have a consistent estimate of $(\beta_1,...,\beta_k)$ if the u_i s are uncorrelated with the input vector, but not the intercept β_0 (unless the mean of u_i is zero). So in order to obtain the estimate of the production technology parameters vector, β, and to estimate the technical efficiency of each firm, the distribution of u_i must be assumed. Commonly, u_i are assumed to be independently distributed as a non-negative truncation (at zero) of the normal distribution $N(m_i, \sigma_u^2)$.

Each firm's technical efficiency can be measured as the ratio of actual output against potential output, as follows:

$$TE_i = \frac{E(Y_i | u_i, x_i)}{E(Y_i | u_i = 0, x_i)} = e^{-u_i}$$

Where u is zero, then the firm achieves its maximum output capacity and technical efficiency is 100 per cent. If we take expectation on both sides of equation (1), and plot the expectation of log output against the log capital input, holding everything else constant, we can see that the technical inefficiency term shifts the production schedule downward, as:

Figure 7.4 Illustration of Technical Efficiency



Furthermore, in order to obtain the specific factors that affect each firm's technical efficiency, following Battese and Coelli (1995), the mean of u (the technical inefficiency term) can be specified as:

$$m_i = z_i \delta + w_i \qquad (7.2)$$

where z_i is a p×1 vector of firm-specific variables that may influence the technical efficiency of the firm, w_i is i.i.d. normal white noise, and δ is the vector of parameters to be estimated.

Thus, the mean log technical efficiency and log output of firm <u>i</u> are $E[\ln y_i | x, z] = x_i\beta - z_i\delta - w_i$ and $E[\ln TE_i | x, z] = -z_i\delta - w_i$ respectively. The partial effect of the factor z_{ik} (the kth factor of vector z_i) is:

$$\frac{\partial E[\ln y_i | x_i, z_i]}{\partial z_{ik}} = -\delta_k$$

$$\frac{\partial E[\ln TE_i | x_i, z_i]}{\partial z_{ik}} = -\delta_k$$

Equation (7.1) is the stochastic production frontier model and equation (7.2) is the technical inefficiency model. They are linked to each other by the one-sided error term *u*. Battese and Corra (1977) parameterise the variance terms of *u* and *v* as $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and $\gamma = \sigma_u^2 / \sigma^2$, where σ^2 is the variance of output conditioned on inputs. This expression says that production uncertainty comes from two sources: pure random factors and technical inefficiency. Hence if γ, the proportion of uncertainty coming from technical inefficiency, is equal to zero, then there is no technical inefficiency. This can be used to test whether technical inefficiency is present in the firm. To estimate equations (7.1) and (7.2), a three-step procedure is employed37. An OLS estimation is carried out to obtain the estimation of β and σ as the first step; then as the second step, the estimation of β and σ is adjusted to correct for the bias; as the third step, the Davidon-

37 Here, Frontier 4.1 (Coelli 1996) is used to estimate equation (7.1) and (7.2).

Fletcher-Powell iterative maximisation routine is carried out to obtain the ML estimates.

Estimation strategy

To apply the stochastic frontier model and technical inefficiency model, we start from the following production function:

$$\ln y = \beta_0 + \beta_1 d + \left(\beta_0^k + \beta_1^k d\right)\ln k + \left(\beta_0^l + \beta_1^l d\right)\ln l + \left(\beta_0^{kl} + \beta_1^{kl} d\right)\ln k \ln l + v - u \quad (7.3)$$

where y is the output value; k is the capital input; l is the labour input; d is a 12×1 vector of industry dummies; v is the random error term that captures the effect of all other random factors on the production and is i.i.d. $N\left(0, \sigma_v^2\right)$; and u is non-negatively distributed, which is affected by exogenous factors, such as firm characteristics and the market structure.

The industry dummy vector is intended to capture the industry heterogeneity, namely the possibility that firm production functions may differ across different industries, as different production functions in different industries mean the coefficients (both the intercept and slopes) will be different across industries. Failure to account for this possibility may lead to inconsistent and biased estimation. Suppose true production functions do differ across industries, and for simplicity only labour plays a role in production, that is, the true production function is $\ln y = \beta_0 + \beta_1 d + \left(\beta_2 + \beta_3 d\right)\ln l + v$. If the production function is estimated without accounting for production function differences across industries, then essentially the production function is estimated as: $\ln y = \beta_0 + \beta_2 \ln l + \varepsilon$, where $\varepsilon = \beta_1 d + \beta_3 d \ln l + v$. Hence the estimation will be biased and inconsistent unless $\beta_3 = 0$.

In order to study the impact of exogenous factors on firm technical efficiency, particularly foreign presence, the mean of u is set as a function of foreign presence, geographical location dummy, the Herfindahl index which proxies for the market structure, employee training expenses, R&D expenses, expenses on labour insurance, firm age, expenses on introducing technology, dummy variables for whether the firm is resource based, firm size, and ownership (see Table 7.2 for a summary of variables used in the estimation), as:

$$\begin{aligned} m_i &= \delta_0 + \delta_1 fp + \delta_2 dlocation + \delta_3 herfindale + \delta_4 ete + \delta_5 rde + \delta_6 lie + \delta_7 yoo \\ &+ \delta_8 yoo2 + \delta_9 ite + \delta_{10} wrb + \delta_{11} wp + \delta_{12} db + \delta_{13} dm + \delta_{14} fp \times X + w_i \end{aligned} \qquad (7.4)$$

where X is the vector of all other factors[38] (*dlocation*, *herfindahl*, *ete*, *rde*, *lie*, *yoo*, *yoo2*, *ite*, *wrb*, *wfi*, *wp*, *db*, and *dm*). The test for the presence of technology spillovers of FDI can be made by testing the joint significance of δ_1 and δ_{14}, and the significance of δ_{14} will reveal the determinants of this kind of spillover. This equation is estimated by a general-to-specific approach, that is, insignificant variables are dropped sequentially and the likelihood ratio tests are made to test whether the dropping of variables is appropriate.

In equation (7.4), we expect the sign of coefficient of *dlocation* to be negative, as when firms agglomerate they can usually learn from each other easily and share infrastructure. The sign of the coefficient of Herfindahl index is expected to be positive. On the one hand, a more competitive market, that is, a lower Herfindahl index, typically forces firms to perform better, while on the other hand, firms in a more concentrated market are better able to pay for fixed costs in improving their efficiency, such as R&D, personnel training, and introducing new technology. However, as we control for these factors, we expect the coefficient of Herfindahl index to be positive. For firm training expenses (*ete*), R&D expenses (*rde*), the expense of introducing new technology (*ite*), a positive effect on efficiency is expected, that is, the sign of the coefficients is expected to be negative, since

[38] In the final estimation, the vector X only contains R&D expense (*rde*), as the likelihood ratio test rejects the significance of all other factors.

training is likely to make employees more skillful, and R&D will help to improve the firm's technology level, while introducing technology will obviously improve the technology level of the firm, and thus possibly improve their technical efficiency. Expenditure on labour insurance (*lie*) is expected to have a negative effect on a firm technical efficiency since the insurance should have a negative influence on the employees' incentive to work hard. The age of the firm (*yoo*) is considered to have a quadratic effect on firm technical efficiency since when firms are young, they may be too inexperienced to operate efficiently, and when firms are too old, inertia may make them unresponsive to adjustments to achieve the technical efficiency.

Table 7.2 Variables and Their Descriptions

Variable Name	Description
lny	The output of the firm, proxied by the sales income of the firm. (the log form of the output)
lnk	The capital input of the firm, proxied by fixed capital asset. (the log form of the capital)
lnl	The labour input of the firm, proxied by the number of average annual workers. (the log form of the labour force.)
d	A 12×1 vector of industry dummies, which include agrilcutal industry, mining industry, elestricity, gas and water supply industry, construction industry, prospecting and water management industry, transportation, storage, and postal service industry, wholesale, retail, and restaurant industry, financial, insurance service and real estate industry, social service industry, education, arts, and media industry, scientific research and technological service industry, and governments, parties, and social organization.
fp	Foreign presence, proxy for foreign direct investment, calculated as the share of FDI invested firm's output/employment/assets in the whole industry.
dlocation	A dummy that takes value 1 if the firm is located in a Zip Code where over 40% firms are located.
herfindahl	The Herfindahl Index calculated at 4-digit industry level.
ete	The employee's training expenses by the firm (its log form).
rde	The firm's R&D expenses (its log form).
lie	The firm's expenses on labour insurance (its log form).
yoo	Years of operation of the firm.
yoo2	The square of years of operation of the firm.
ite	The firm's expenses on introducing the technology (its log form).
wrb	The dummy variable, indicating whether the firm is resource-based. If the firm is resource-based, *wrb*=1.
wp	The dummy variable, indicating ownership structure, i.e. whether the firm is privately owned. If the firm is privately owned, *wp*=1. Otherwise, *wp*=0.
db	The dummy variable, indicating the firms' size. If the firm is big in size, *db*=1. Otherwise, *db*=0.
dm	The dummy variable, indicating the firms' size. If the firm is medium-sized, *dm*=1. Otherwise, *dm*=0.

The data

Data description and variable construction

The data set is cross-sectional firm level micro-data, which comes from Ministry of Finance, China, 2001. It comprises 1,503 firms, of which 1,466 firms are selected from the sample since the other 37 firms did not report the variables of capital or labour. This kind of selection does not affect the estimation results, as the selection criterion is exogenous. Altogether, 28 variables (see Table 7.2) are constructed from the data set.

The agglomeration dummy (*dlocation*) is constructed by setting the value to be 1 if the firm is located in the zip code 730030, 730050, 730000, 730060, 730900, and 741000. Zip codes in China have six digits, where the first two digits denote provinces, the third and fourth digits denote cities, and the fifth and sixth digits denote counties, towns or suburbs. For example, in the zip code 730000, '73' denotes Gansu province, '00' denotes Lanzhou city, and '00' denotes the city area. Hence the zip code can reveal the geographical location of firms accurately. Some 40.6 per cent of firms are concentrated in these six zip codes. If geographical concentration has a positive impact on firm technical efficiency, then firms located in these six zip codes will be systematically more technically efficient than firms located outside, after controlling all other factors. Table 7.3 shows a summary of the distribution of firms by zip code and their scale. Some 910 firms (about 61 per cent) are concentrated between zip code 730000 and 735000, and over 80 per cent of large scale firms (with log of sales not less than 20) are located in this region.

Table 7.3 Firm Geographical Locations and Output Scale

	Ln(Sale)			
ZIP Code	[10, 15)	[15, 20)	[20, 25)	Total
[730000, 735000)	289	607	14	910
	(19.23)	(40.39)	(0.93)	(60.55)
[735000, 740000)	63	107	3	173
	(4.19)	(7.12)	(0.20)	(11.51)
[740000, 745000)	95	192	0	287
	(6.32)	(12.77)	(0.00)	(19.10)
[745000, 750000)	54	79	0	133
	(3.59)	(5.26)	(0.00)	(8.85)
Total	501	985	17	1503
	(33.33)	(65.54)	(1.13)	(100.00)

Note: Number in bracket is the percentage.
Source: MOF, 2001

Resource-based firms are defined as firms with either inputs or outputs that are related to natural resources, namely in the mining industry, the production and supply of electricity, gas, and water, and some parts of manufacturing, such as the petrol processing industry, and the steel industry. This criterion is used to construct the dummy variable *wrb* for resource based. The dummy variables of firm size (*dm* and *db*) are constructed according to the Chinese Standard Classification of Firm Size, which classifies firms by their output and number of employees. A firm with over 2,000 employees, sales of over 300 million RMB and total assets of over 400 million RMB is classified as a big firm, and a firm with employees between 300 and 2,000, sales of 30-300 million RMB, and total assets of 40-400 million RMB is classified as a medium-size firm. Herfindahl index, as in previous chapters, is calculated at the four-digit industry level.

The original data set directly reports all the other variables. However, due to the accounting properties in the raw data set, variables such as *ete* (employee training expenses), *rde* (R&D expenses), *lie* (expenses on labour insurance), and *ite* (expenses on introducing technology) for some firms are reported to be negative. This indicates that the firm is delaying the payment of these expenses, and thus a value of zero is set to these variables when they are negative. For employee training expenses (*ete*), three firms' values are set to zero; for R&D expenses (*rde*), one firm's value is set to zero; the firm expenses on labour insurance (*lie*) has six firms' values set to zero; and the firm expenses on introducing technology (*ite*) has one firm's value set to zero. The setting of zero is made on the assumption that since the firm did not make actual payment on these accounts, this is equivalent to the firm having zero expenses on these items.

Foreign presence in Gansu

The presence of FDI in Gansu province in 2001 is rather low. In the total of 1,503 firms, only 65 firms are foreign invested. This accounts for 4.3 per cent of all firms in the sample. These 65 firms are distributed across 44 four-digit industries. The foreign presence is calculated in terms of the output share, the employment share, and the assets share in the whole four-digit industry, using the formula in set out in Chapter 4. Table 7.4 presents the results of the calculation.

Table 7.4 Foreign Presence in Gansu Province, 2001

Industry Code	Industry Name	Foreign Presence (per cent)		
		output	employment	assets
320	Poultry breeding	100	100	100
1311	Rice milling	100	100	100
1314	Assorted and mixed feeding stuff manufacturing	100	100	100
1319	Other feeding stuff manufacturing	100	100	100
2224	Converted paper manufacturing	100	100	100
2652	Dope manufacturing	100	100	100
2654	Paint manufacturing	100	100	100
3533	Pump manufacturing	100	100	100
3564	Sintered metal product manufacturing	100	100	100
3621	Specialized petroleum industry equipment manufacturing	100	100	100
4213	Optical instrument manufacturing	100	100	100
6131	Textile wholesale	100	100	100
6720	Snack food	100	100	100
1390	Other food processing	99	93	98
1890	Other fiber products manufacturing	97	35	66
3151	Construction ceramics, sanitary ceramics industry	95	71	18
2661	Polyolefin plastics manufacturing	90	57	97
3030	Plastic silk, woven goods manufacturing	89	44	99
4021	Transformer manufacturing	89	85	80
6220	Chemical material wholesale	85	87	100
3619	Other special mechanical and electrical equipment manufacturing	76	69	24
1590	Other beverage manufacturing	73	33	31
6710	Restaurant	64	18	74
1513	Beer manufacturing	60	65	74
2677	Additives manufacturing	54	30	66
3321	Aluminum smelting industry	47	41	26
2720	Chemical drug manufacturing	36	14	28
7200	Real estate development and management industry	34	8	52
3020	Plastic plates and bar industry	33	6	8
4411	Steam electric power generation	32	0.3	35
1011	Limestone mining	30	8	5
3134	Light building materials manufacturing	27	15	1
8100	Entertainment industry	17	37	17
9910	Enterprise management	10	5	0.01
8310	Software development and consulting industry	7	2	3
2671	Chemical reagents and auxiliary agent manufacturing	4	3	7

6262	Ferrous metal material wholesale	3	23	6
5310	Automobile transportation	3	8	6
9020	Publishing	3	12	4
8000	Tourism	2	6	11
9990	Others	1	0.3	0.1
4710	Housing construction	1	0.3	1
2750	Biological products manufacturing	1	1	2
8490	Others	1	1	0.5

Note: all other industries have zero foreign presence
Source: author's calculation

The table shows that there are 13 industries in which firms are all foreign invested, and 9 out of all 13 industries are in the manufacturing sector. This is consistent with the fact that a large proportion of FDI flows into the manufacturing sector in China. Foreign presence measured in terms of output share, employment share, and assets share are highly and positively correlated with each other[39]. This indicates that if one index measures foreign activities correctly then the other two indices also tend to capture them correctly. However this is not enough to justify using one index over the other two in the regression analysis. As we can see from the table, these three indices do not rank the foreign activities across industries consistently[40]. The value of these three indices can also be extremely different from each other, for example in the housing construction industry (4710), the value of output share index is over three times of the value of employment share index. In addition, by comparing the value of the three indices across industries, we also find that the employment share measurement tends to have smaller value than those of the other two measurements. This reflects the fact that FDI invested firms are usually more capital intensive and have bigger production capacity than domestic firms. The examination of the table shows the necessity of using all the three measurements in the regression analysis, in order to recognize the inbuilt pitfalls of these measurements and obtain robust results.

[39] The correlation between output share and employment share is 0.91, between output share and assets share is 0.91, and between employment share and assets share is 0.87.
[40] For example, in the other fibre products manufacturing industry (1890), the output share index is 0.97 and ranked 15, while the employment share index is 0.35 and ranked 24, and the assets share index is 0.66 and ranked 22.

Descriptive statistics

Table 7.5 sets out the descriptive statistics of variables. From this table, we can see that owing to the fact that the data set covers all kinds of firms in Gansu province, the values of variables used have comparatively large standard deviations compared with the sample average. For example, for output, the average is about 60 million RMB, while the standard deviation is about 736 million RMB, and the maximum value is about 554,794 times of the minimum value.

Another point about the data is that for R&D expenses and the expenses of introducing technology, a large proportion of firms reported zero values. For the former variable, 1,370 firms out of the total of 1,466 (93.5 per cent) did not have such expenses, and for the latter variable, 1,444 firms out of the total of 1,466 (98.5 per cent) did not have such expenses.

Table 7.5 Descriptive Statistics for Firms in Gansu Province, 2001

Variable	Unit	Average	Stdev	Min	Max
Output	100 thousand RMB	60.03	736.24	0.05	26,736.66
Capital	100 thousand RMB	36.95	363.09	0.001	12,464.07
Labour	Persons	298.03	1,346.95	2	31,189
Foreign Presence (output share)		0.053	0.177	0	1
Foreign Presence (employment share)		0.036	0.146	0	1
Foreign Presence (asset share)		0.056	0.186	0	1
Herfindahl Index		0.389	0.302	0.033	1
Expense on employee training	thousand RMB	39.86	316.46	0	8073.47
R&D expense	thousand	48.5	716.92	0	23531.35
Expense on labour insurance	thousand	573.2	6493.45	0	159306.9
Years of operation	Years	26.81	19.10	1	99
Expense on introducing technology	thousand	3	52.26	0	1685.25

Source: Constructed from the data from Ministry of Finance, PRC, 2001

Correlation matrix

Tables 7.6 and 7.7 present the correlation matrix of variables in the production function and the technical inefficiency model. In Table 7.6, we find that there does not appear to be a multicollinearity problem between industry dummies and labour and capital. The correlation between labour (in log form) and capital (in log form) is 0.73. However, since the sample size is large (1,466), there is unlikely to be a multicollinearity problem.

Table 7.7 is the correlation matrix for variables in the technical inefficiency model. As expected, foreign presence measured in terms of the output share, employment share, and assets share are highly correlated with each other. These three measures of foreign presence are used separately in the empirical estimation because of the possible distortion that is inherent in these measurements. In addition, employee training expenses (*ete*) are also correlated with R&D expenses (*rde*) and labour insurance expenses (*lie*), with the correlation being 0.8 and 0.94 respectively, and the correlation between R&D expenses (*rde*) and labour insurance expenses (*lie*) is 0.8. Besides, the interaction terms are also highly correlated with interacted variables. These potential multicollinearity problems are taken account of in the general-to-specific sequential estimation search by checking the symptom that coefficients are individually insignificant while jointly significant.

Table 7.6 Correlation Matrix between Labour, Capital and Industry Dummies

	lnk	*lnl*	*dagriculture*	*dconstruction*	*deam*	*degws*	*dfinance*	*dgpso*	*dgpwm*	*dmining*	*dsale*	*dsservice*	*dst*	*dtransportation*
lnk	1													
lnl	0.73	1												
dagriculture	0.03	0.00	1											
dconstruction	0.01	0.11	-0.03	1										
deam	-0.01	-0.05	-0.01	-0.02	1									
degws	0.18	0.11	-0.03	-0.07	-0.02	1								
dfinance	-0.08	-0.19	-0.04	-0.08	-0.02	-0.07	1							
dgpso	-0.10	-0.08	-0.04	-0.08	-0.02	-0.07	-0.08	1						
dgpwm	0.01	0.02	-0.01	-0.02	-0.01	-0.01	-0.02	-0.02	1					
dmining	0.10	0.13	-0.02	-0.05	-0.02	-0.05	-0.05	-0.05	-0.01	1				
dsale	-0.18	-0.28	-0.07	-0.15	-0.05	-0.14	-0.16	-0.16	-0.03	-0.11	1			
dsservice	-0.08	-0.09	-0.04	-0.08	-0.03	-0.08	-0.08	-0.09	-0.02	-0.06	-0.17	1		
dst	-0.02	-0.02	-0.02	-0.04	-0.01	-0.03	-0.04	-0.04	-0.01	-0.03	-0.08	-0.04	1	
dtransportation	0.02	0.04	-0.02	-0.05	-0.02	-0.05	-0.05	-0.05	-0.01	-0.04	-0.11	-0.06	-0.03	1

Note: variables starting with 'd' is industry dummies, e.g. dagriculture is agriculture industry dummy.

Source: author's calculation

Table 7.7 Correlation Matrix between Variables in Technical Inefficiency Model

	fpo	*fpe*	*fpa*	*dlocation*	*Herfindahl*	*ete*	*rde*	*lie*	*yoo*	*yoo2*	*ite*	*wrb*	*wp*	*db*	*dm*
fpo	1														
fpe	0.90	1													
fpa	0.94	0.82	1												
dlocation	0.14	0.10	0.16	1											
Herfindahl	0.10	0.15	0.05	0.07	1										
ete	0.00	0.00	-0.01	0.02	0.08	1									
rde	-0.01	-0.01	-0.01	0.03	0.07	0.80	1								
lie	-0.01	-0.01	-0.01	0.02	0.06	0.94	0.80	1							
yoo	-0.05	-0.03	-0.05	-0.10	0.00	0.07	0.04	0.07	1						
yoo2	-0.05	-0.03	-0.05	-0.10	0.01	0.05	0.03	0.05	0.94	1					
ite	0.00	-0.01	0.00	0.02	0.03	0.06	0.00	0.03	0.03	0.02	1				
wrb	-0.03	-0.04	-0.09	-0.18	0.12	0.15	0.08	0.12	0.06	0.04	0.09	1			
wp	0.29	0.28	0.26	0.09	0.06	-0.01	-0.01	-0.01	-0.04	-0.04	-0.01	-0.03	1		
db	0.00	0.00	-0.01	0.10	0.09	0.27	0.20	0.24	0.07	0.07	0.11	0.10	0.00	1	
dm	0.09	0.11	0.09	0.07	0.01	0.03	0.01	0.02	0.04	0.02	0.02	0.03	0.07	-0.09	1

Note: fpo is the foreign presence in terms of output share, fpe is in terms of employment share, fpa in terms of asset share.

Source: Author's calculation

Table 7.8 Estimation Results with Three Measurements of Foreign Presence

Variables		Model 1: Output share			Model 2: Employment share			Model 3: Asset share		
		coefficient	S.E.	t	coefficient	S.E.	t	coefficient	S.E.	t
	beta0	12.85	0.39	32.85	12.04	0.36	33.38	11.83	0.35	33.87
lnk1	beta1	0.18	0.02	7.82	0.17	0.02	7.17	0.19	0.03	7.60
lnl1	beta2	0.51	0.04	13.83	0.52	0.04	13.49	0.50	0.04	12.10
dagriculture	beta3	-4.16	1.00	-4.16	-4.15	0.99	-4.19	-4.04	0.99	-4.07
dagriculture_lnk1	beta4	0.63	0.12	5.21	0.64	0.12	5.19	0.62	0.12	5.07
dagriculture_lnl1	beta5	-1.01	0.29	-3.54	-1.03	0.29	-3.48	-1.05	0.29	-3.57
dmining	beta6	0.09*	0.17	0.50	0.10*	0.18	0.55	0.07*	0.18	0.40
degws	beta7	-2.17	0.99	-2.18	-2.06	0.97	-2.14	-2.82	1.00	-2.83
degws_lnk1	beta8	0.13	0.06	2.08	0.12	0.06	2.11	0.17	0.06	2.70
dconstruction_lnk1	beta9	0.01*	0.01	1.31	0.01*	0.01	1.20	0.01*	0.01	0.74
dgpwm	beta10	-11.48	1.28	-8.98	-11.58	1.00	-11.53	-10.74	1.00	-10.76
dgpwm_lnk1	beta11	0.76	0.09	8.49	0.77	0.07	10.41	0.70	0.07	9.40
dtransportation	beta12	-0.25*	0.18	-1.45	-0.24*	0.18	-1.35	-0.25*	0.18	-1.45
dsale	beta13	1.19	0.43	2.76	1.26	0.52	2.42	1.28	0.53	2.41
dsale_lnk1	beta14	0.06*	0.04	1.44	0.06*	0.05	1.17	0.05*	0.05	0.90
dsale_lnl1	beta15	-0.29	0.08	-3.38	-0.31	0.09	-3.59	-0.27	0.09	-3.02
dfinance	beta16	0.07*	0.15	0.49	0.11*	0.15	0.72	0.05*	0.15	0.37
dsservice	beta17	-0.65	0.13	-4.86	-0.69	0.13	-5.21	-0.69	0.13	-5.11
deam	beta18	-0.06*	0.36	-0.16	-0.16*	0.39	-0.41	-0.04*	0.36	-0.11
dst	beta19	-2.37	1.00	-2.36	-2.85	1.00	-2.85	-2.41	0.99	-2.42
dst_lnk1	beta20	0.13*	0.07	1.82	0.16	0.07	2.31	0.13	0.07	1.85
dgpso	beta21	0.36	0.14	2.56	0.32	0.14	2.21	0.37	0.14	2.57
doutlier					1.23	0.27	4.61			
	delta0	2.21	0.27	8.10	1.33	0.19	6.87	1.32	0.23	5.67
dlocation4	delta1	-0.32	0.08	-4.08	-0.31	0.08	-3.67	-0.39	0.10	-4.12

herfindahl	delta2	0.36	0.14	2.63	0.40	0.17	2.35	0.41	0.15	2.70
ete	delta3	-1.5×10^{-6}	3.5×10^{-7}	-4.35	-1.5×10^{-6}	1.3×10^{-7}	-11.34	-1.7×10^{-6}	8.3×10^{-7}	-2.03
lie	delta4	4×10^{-8}	1.8×10^{-8}	2.25	5.4×10^{-8}	1.0×10^{-8}	5.24	4.3×10^{-8}	1.9×10^{-8}	2.25
yoo	delta5	1.3×10^{-3} *	1.9×10^{-3}	0.70	1.6×10^{-3} *	2.1×10^{-3}	0.75	8.6×10^{-4} *	2.0×10^{-3}	0.44
ite	delta6	-3.2×10^{-6}	7×10^{-7}	-4.49	-1.6×10^{-6}	2.1×10^{-7}	-7.43	-3.3×10^{-6}	5.0×10^{-7}	-6.63
db	delta7	-0.86	0.17	-5.01	-0.79	0.24	-3.33	-1.21	0.33	-3.70
dm	delta8	-0.65	0.09	-6.99	-0.66	0.12	-5.38	-0.77	0.17	-4.46
fp	delta9	-0.49	0.24	-2.04	-0.73	0.24	-3.01	-0.63	0.30	-2.13
fp_rde	delta10	-6.2×10^{-6} *	1.2×10^{-5}	-0.51	-3.0×10^{-6}	4.9×10^{-7}	-6.22	-7.4×10^{-6} *	5.0×10^{-6}	-1.48
	gamma	0.21	0.10	2.11	0.06	0.01	5.37	0.38	0.06	6.59
log likelihood function		-2291.43			log likelihood function		-2281.67	log likelihood function		-2309.6

Notes: The sample size is 1466. The shaded area is the estimation of the production frontier model.
* indicates the coefficient is insignificant at 5% level.
** indicates the coefficient is significant at 10% level.
For Model 2, the outlier dummy, *doutlier*, is incorporated as the sensitivity test in the subsequent section confirms that the outliers have significant impact.
Source: Estimation by Frontier 4.1 with data constructed from Ministry of Finance, China, 2001

Empirical Results

The estimation is carried out using Frontier 4.1 developed by Coelli (1996). As described in the section on estimation strategy, the regressions are made sequentially, following a general-to-specific approach in search for the best fit parsimonious model. The sequential search is made by first only dropping insignificant variables in the production function, holding all variables in the technical inefficiency model, and then holding variables in production function, while dropping insignificant variables in the technical inefficiency model. The search is made using the foreign presence measure of output share, and after reaching the best fit parsimonious model, foreign presence measured in terms of the employment share and assets share are incorporated into the regression by replacing the measure of foreign presence in terms of output share. At every step, a likelihood ratio test is performed to determine whether the step is appropriate[41]. The likelihood ratio test statistic used is the asymptotic version, since the sample size is as large as 1,466, as follows:

$$LR = 2(\ln L_u - \ln L_c)$$

where L denotes the value of likelihood function, the subscript u denotes the unconstrained regression, and the subscript c denotes the constrained regression. If the likelihood ratio test rejects the step, then regression is re-made based on the previous step. This process is repeated until dropping of any variable results in a significant change of the value of likelihood function.

Table 7.8 presents the final estimate of the model, using both the foreign presence of output share, employment share, and assets share. The following interpretation is based on the estimation using output share in Table 7.8, while estimations using the other two measurements are used by way of comparison. Table 7.9 provides the estimated results for the full model with foreign presence measured in terms of output share, presented here for comparison even though it is rejected in favour of estimated results in Table 7.8. Table 7.10 shows the relevant hypothesis tests,

[41] The test results are not reported here to save space. However the results are available upon request.

namely the test for the presence of technical inefficiency and test for technology spillovers from FDI.

Production frontier estimates

The shaded area in Table 7.8 presents the estimate of the production function. The magnitude of the coefficients estimated is within a reasonable range. The coefficient of *lnk* is 0.18, and the coefficient for *lnl* is 0.51, which indicates that in the manufacturing sector the elasticity of output to capital is 0.18 and the elasticity of output to labour is 0.51. In respect of factor intensity, the factor elasticities estimated also give us a reasonable picture. As factor that is used more intensively will have a lower marginal product due to diminishing marginal product, and hence it will have a smaller elasticity. In the manufacturing sector, the capital elasticity is 0.18 and the labour elasticity is 0.51, implying that the manufacturing sector is capital intensive.

If we compare the estimations across Model 1, 2, and 3 in Table 7.8, we find that the coefficients do not change significantly, as one estimate is within one standard deviation of other corresponding estimates. In addition, the significance of industry dummies in all the three models confirms the existence of industry heterogeneity.

Technology spillovers of FDI

Technology spillovers from FDI in this chapter are defined as a positive impact of foreign presence on firm technical efficiency. To test the presence of technology spillovers of FDI is equivalent to first test the joint significance of foreign presence (*fp*) and its interaction term with R&D expenses (*fp_rde*), and then check the sign of these two variables. If the coefficients of both variables have a negative sign and are significant, then technology spillovers occur as foreign presence positively affects firm technical efficiency, and firm R&D has positive impact on the magnitude of the spillovers. If both coefficients are significant, but one is negatively signed and the other is positively signed, then spillovers may occur, but depend on firm R&D input. If both coefficients are significant and positively signed, then foreign presence actually has a negative impact on firm technical efficiency. Finally, if both coefficients are insignificant, then no technology spillovers occur.

Table 7.10 (b) and (c) present the hypothesis tests for the presence of technology spillovers from FDI and the role of R&D. The results are somewhat mixed. For Model 1 and 2, which use FDI invested firms' output share and employment share in the industry as the measure of foreign presence respectively, the null hypothesis of no technology spillovers from FDI is rejected at the 5% significance level. In contrast, Model 3, which uses assets share as the measure of foreign presence, the LR test statistics are negative, which indicates a strong support for the null, namely that there are no technology spillovers from FDI. The contrasting results suggest that different measurements of FDI do affect the outcome of empirical testing. Theoretically we expect R&D to exert a positive impact on technology spillovers, as the more R&D activities the firm conducts, the bigger capacity the firm will have to learn from FDI invested firms and compete with FDI invested firms. In the present context, this means that the sign of *fp_rde* coefficient should be negative. All three models give a negative sign, although the significance of the coefficient is mixed. For Model 3, as *fp* and *fp_rde* is jointly insignificant, hence it is meaningless to explore the significance of *fp_rde* individually. For Model 2, both the *t* test and LR test reject the null of insignificance at the 5% level. For Model 1, the *t*-statistic and LR test give contradictory results on the significance of *fp_rde* coefficient. The *t* test shows that coefficient of *fp_rde* is insignificant, while the LR test indicates that it is significant.

In respect of the other variables in the technical inefficiency model, the estimate from Model 1 shows that geographical agglomeration has a positive impact on firm mean technical efficiency, with firms located in agglomerated area are 0.32 per cent more technically efficient than firms located in other areas. A competitive market structure improves firm technical efficiency in that a 1 per cent decrease in Herfindahl index is associated with 0.36 per cent increase in technical efficiency. Employee training expenses also positively affect firm technical efficiency, and 1 million RMB more spending on employee training will increase technical efficiency by 1.5 per cent. In contrast, labour insurance expenses have a negative impact on firm technical efficiency with 100 million RMB spending leading to 4 per cent decrease in technical efficiency. Compared with small firms, large and medium firms are more technically efficient with 0.86 per cent and 0.65 per cent more efficiency, and the impact of firm age appears to be insignificant. Looking across Models 1, 2, and 3, the estimates are consistent with each other in the sense that one estimate is within one standard deviation of another estimate, except for *fp* and *fp_rde*. The scale of these control variables suggests that the estimation is reasonable.

Firm technical efficiency

One major application of the stochastic production frontier model and technical inefficiency model is to measure firm technical efficiency. Hence it is worthwhile looking at the estimated technical efficiency of the firm sample. Table 7.11 presents the distribution of technical efficiency estimated in Models 1, 2, and 3. It shows that the technical efficiency estimated differs across Models 1, 2, and 3. Technical efficiency in Model 1 is lower than Model 2 and 3. Nevertheless, the general conclusion that can be drawn is that firm technical efficiency in Gansu province is generally not high. This conclusion is significant in that it points to the potential for large improvements in technical efficiency in Gansu firms.

Sensitivity Analysis

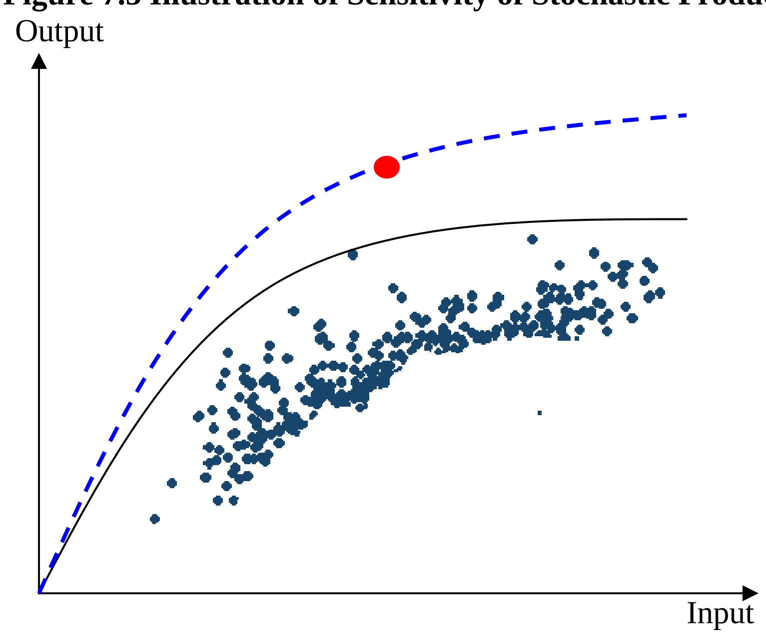
Impact of outliers

The essence of stochastic production frontier model is to infer the production frontier from firms' actual production activities. Hence, it may be sensitive to the outliers, particularly extremely large production point. This can be illustrated in Figure 7.5. In Figure 7.5, the red point represents an outlier, which may be caused by measurement error or even a firm's exaggerated reporting. The red point may shift the production frontier significantly from the solid curve (the true production frontier) to the dashed curve, and hence the technical efficiency estimate may be lowered significantly, and subsequently affect estimation of technical inefficiency model.

To examine this sensitivity, we first parameterize the outliers by constructing a dummy variable, which takes a value of one if the firm is an outlier and zero otherwise. Then the outlier dummy is incorporated into the regression, and the significance of the outlier dummy is tested by LR test. If the coefficient of the outlier dummy is significant, then it shows that outliers have significant impact on the regression. Otherwise the estimation is robust to outliers. In this case, the construction of the outlier dummy is based on the log of output. If the firms' log output is bigger than 20 or smaller than 11.4, then the outlier dummy takes value 1. Altogether 19 firms are identified as outliers.

For Model 1, the value of LR test statistic is 4.27. For Model 2, the value is 43.07. For Model 3, the value is -28.35. With degree of freedom one, the 5% critical value of the test statistic is 3.84, and the 1% critical value of the test statistic is 6.38. Hence for Model 1, we can not reject the null that outlier dummy is insignificant, that is, outliers do not have a significant impact on the regression, at the 1% significance level, but the null is rejected at the 5% significance level. For Model 2, the null is rejected at both the 5% and 1% significance level[42]. For Model 3, as the value of LR test statistic is negative, it strongly supports the null of insignificance of the outlier dummy.

Figure 7.5 Illustration of Sensitivity of Stochastic Production Frontier Model



[42] The estimation results reported in Table 7.8 is based on the regression accounting for the impact of outliers.

Conclusions

This chapter explored technology spillovers from FDI in Gansu province, China. By using a firm level cross sectional data set, we found that if the FDI invested firms' activities are measured in terms of output share and employment share, FDI invested firms do have a positive impact on other firms' technical efficiency, namely technology spillovers exist, and domestic firm's R&D spending plays a positive role in the scale of technology spillovers. However, this result is not robust to different measurements of FDI invested firms' activities. When the foreign presence measured in terms of assets share, the impact of foreign presence on domestic firms' technical efficiency becomes insignificant. Hence, even though we trust more the output measurement as both the employment and assets measurements can be prone to distortion, the finding of this chapter should be interpreted with caution.

Nevertheless, the analysis does suggest the potential role of FDI in technology spillovers to domestic firms. The inflow of FDI into Gansu province, and more generally less developed regions in China, would seem to merit cautious encouragement and as does firm R&D activities, for example by tax instruments, as that would help domestic firms take better advantage of spillovers from FDI. In addition, since firms in Gansu are performing at a low level of technical efficiency, there is a big room for improvement of technical efficiency. The government can play a role in assisting firms to improve their technical efficiency gradually through learning by doing, for example, by encouraging firms to agglomerate through setting up high-tech parks, a measure that has been successfully adopted in other parts of China, as we find that firms located in areas where there is agglomeration of manufacturing are more technical efficient.

Table 7.9 Estimation Results with C-D Production and Full Set of Industry Dummies

Variables		coefficient	standard-error	t-ratio
	beta0	13.2	0.48	27.30
lnk1	beta1	0.15	0.04	4.28
lnl1	beta2	0.56	0.07	8.53
dagriculture	beta3	-4.21	1.02	-4.12
dagriculture_lnk1	beta4	0.66	0.13	5.25
dagriculture_lnl1	beta5	-1.06	0.30	-3.55
dmining	beta6	-0.38*	1.00	-0.38
dmining_lnk1	beta7	0.14*	0.11	1.24
dmining_lnl1	beta8	-0.34*	0.19	-1.75
degws	beta9	-2.47	0.97	-2.55
degws_lnk1	beta10	0.2	0.08	2.58
degws_lnl1	beta11	-0.18*	0.13	-1.41
dconstruction	beta12	-1.72*	1.00	-1.73
dconstruction_lnk1	beta13	0.21	0.09	2.28
dconstruction_lnl1	beta14	-0.22*	0.13	-1.73
dgpwm	beta15	-12.3	1.02	-12.10
dgpwm_lnk1	beta16	0.97	0.31	3.11
dgpwm_lnl1	beta17	-0.49*	0.95	-0.51
dtransportation	beta18	0.33*	1.01	0.33
dtransportation_lnk1	beta19	0.06*	0.09	0.69
dtransportation_lnl1	beta20	-0.32*	0.19	-1.69
dsale	beta21	1.12*	0.57	1.95
dsale_lnk1	beta22	0.08*	0.06	1.48
dsale_lnl1	beta23	-0.34	0.10	-3.25
dfinance	beta24	0.55*	0.99	0.55
dfinance_lnk1	beta25	-0.08*	0.08	-0.96
dfinance_lnl1	beta26	0.23*	0.15	1.54
dsservice	beta27	-0.85*	0.97	-0.87
dsservice_lnk1	beta28	-0.0015*	0.09	-0.02
dsservice_lnl1	beta29	0.08*	0.14	0.59
deam	beta30	-0.42*	1.10	-0.39
deam_lnk1	beta31	-0.10*	0.25	-0.39
deam_lnl1	beta32	0.53*	0.95	0.56
dst	beta33	-2.18	1.03	-2.12
dst_lnk1	beta34	0.12*	0.13	0.91
dst_lnl1	beta35	0.01*	0.28	0.05
dgpso	beta36	0.86*	0.97	0.89
dgpso_lnk1	beta37	0.01*	0.08	0.14
dgpso_lnl1	beta38	-0.15*	0.12	-1.23
	delta0	2.4	0.28	8.56
dlocation4	delta1	-0.33	0.08	-3.99
herfindahlindex	delta2	0.31	0.15	2.13

ete	delta3	-1.74×10^{-6}	3.77×10^{-7}	-4.62
rde	delta4	-3.74×10^{-8} *	2.35×10^{-8}	-1.59
lie	delta5	4.81×10^{-8}	1.96×10^{-8}	2.45
yoo	delta6	9.36×10^{-3} *	0.01	1.74
yoo2	delta7	-1.05×10^{-4} *	6.32×10^{-5}	-1.66
ite	delta8	-3.08×10^{-6}	5.69×10^{-7}	-5.42
wrb	delta9	-0.17*	0.15	-1.17
wp	delta10	0.08*	0.20	0.41
db	delta11	-0.82	0.19	-4.37
dm	delta12	-0.66	0.12	-5.38
fp	delta13	-0.53	0.23	-2.29
fp_rde	delta14	-7.24×10^{-6}	1.25E-06	-5.80
	gamma	0.27	0.09	3.20
log likelihood function			-2280.00	

Notes: The sample size is 1466. The shaded area is the estimation of the production frontier model. * indicates the coefficient is insignificant at 5% level.
Source: Estimation by Frontier 4.1 with data constructed from Ministry of Finance, China, 2001

Table 7.10 Hypothesis Tests

Null Hypothesis	Model	Test Statistics		Critical Value	Decision
(a) Test for presence of technical inefficiency					
H0: gamma=0 (no technical efficiency present)	Model 1	t	2.11	1.96	reject H0
	Model 2	t	5.37	1.96	reject H0
	Model 3	t	6.59	1.96	reject H0
(b) Test for presence of technology spillovers of FDI					
H0: delta9=0, delta10=0	Model 1	LR	12.10	5.99	reject H0
	Model 2	LR	13.96	5.99	reject H0
	Model 3	LR	-24.23	5.99	fail to reject H0
(c) Test for R&D's role in technology spillovers					
H0: delta10=0	Model 1	t	-0.51	1.96	fail to reject H0
		LR	31.23	3.84	reject H0
	Model 2	t	-6.22	1.96	reject H0
		LR	2.28	3.84	fail to reject H0
	Model 3	t	-1.48	1.96	fail to reject H0
		LR	-5.60	3.84	fail to reject H0

Note: the significance level is 5%.

Table 7.11 Summary of Estimated Technical Efficiency

	TEO	TEE	TEA
Mean	0.16	0.32	0.36
Median	0.13	0.27	0.33
Maximum	0.94	0.97	0.92
Minimum	0.04	0.07	0.05
Std. Dev.	0.11	0.15	0.16
Skewness	3.44	1.83	0.80
Kurtosis	19.70	6.27	3.25

Note: TEO/TEE/TEA denote technical efficiency estimated using foreign presence measured in terms of output share, employment share, assets share respectively.

Source: Estimate with Frontier 4.1

8. Conclusions and Policy Implications

FDI into China makes a large contribution to the Chinese economy and to Chinese exports. The study examined evidence that confirms the presence of important spillover effects from FDI to domestic firms and industries. The evidence has been drawn from cross-sectional and panel data for industries and firms and has allowed technology and export spillover effects to be evaluated by industry and region. While there is evidence of spillover effects, they are not universal or necessarily strong. The magnitude of the spillover effect depends on the characteristics of the domestic industry or firms, and their capacity to absorb technology or engage in export activity. Besides, there is also some evidence of negative spillovers. This chapter summarises the main findings.

Findings

In Chapter 3, we analysed technology spillovers from FDI and their determinants using eight-year balanced industry level panel data. Based on an econometric specification, in which domestic industry value added is a function of the capital stock, labour supply and the interaction terms of the FDI technology transfer with the technology gap, relative factor intensity, and relative labour supply, we found that FDI inflow in China had a quite different impact on technology in different industries, and that, on average, FDI exerted a negative impact on domestic industries. For every 1 per cent increase of FDI, domestic industry productivity on average decreased by 0.11 per cent. There are problems in interpreting these results because aggregation to industry level may disguise the significant effects. Moreover, technology spillovers from FDI over time were positive in the sense that from 1995 to 2003 more and more industries began to receive positive benefits from FDI. In 1995 only one industry benefited from the presence of FDI, while in 2003 there are 20 industries that benefited from the presence of FDI. In addition, even for industries that never benefited from the presence of FDI in our sample periods, the negative impact from FDI became smaller between 1995 and 2003.

The positive dynamics of technology spillovers from FDI during the period between 1995 and 2003 was driven by the technology gap, relative factor intensity, and relative labour supply. These three factors are a measure of the absorptive capacity of domestic industries. We found that the technology gap had a negative influence on the extent of technology spillovers, while relative factor intensity and relative labour supply played a positive role. A bigger technology gap makes it more difficult for domestic industries to learn from FDI. In contrast, a higher relative factor intensity and relative labour supply contribute positively to the occurrence of spillovers, as a higher relative factor intensity implies domestic industries can afford to invest more on R&D, a highly capital-intensive activity that enhances the absorptive capacity of domestic industries. A higher relative labour supply increases the likelihood of technology diffusion through labour mobility, namely the contagious effect. The upward trend of technology spillovers from FDI indicates that Chinese industries show capacity to absorb technology from FDI continuously over, possibly through learning by doing and other institutional reforms. These results are consistent with what might be expected a priori.

As noted, there are problems in isolating FDI spillover effects using industry level data. In Chapter 4, we explored the technology spillovers from FDI by examining a comprehensive firm level micro-data set in the manufacturing sector in 2003, covering over 140,000 domestic firms. In this chapter, following previous studies, we hypothesized that domestic firms' labour productivity depends on their capital intensity, intermediate inputs per employee, labour quality, age, FDI, economies of scale in the industry, domestic market structure, ownership structure, regional location, and industry heterogeneity, in which the coefficient of FDI, measured by foreign presence, is the focus of interest. At the same time FDI (foreign presence) depends on domestic market size, the industry's export intensity, industry unit production costs, domestic firms' labour productivity, regional location and industry heterogeneity. Hence there exists a simultaneity between domestic firms' labour productivity and foreign presence. This simultaneity allows for the possibility that, on the one hand, FDI inflow promotes domestic firms' labour productivity and, on the other hand, FDI tends to flow into industries with higher domestic labour productivity. The simultaneous equation model was estimated using a 3SLS estimator, and it was found that FDI generated a positive impact on domestic firms' labour productivity, and meanwhile that FDI also tended to flow into industries with higher domestic labour productivity. For a 1 per cent increase in the presence of FDI in the domestic industry the domestic firms' labour productivity was boosted by 5.77 per cent, and in turn 1 per cent increase in domestic firms' labour productivity enlarged the foreign presence by 0.01 per cent. This chapter's findings confirmed the findings in Chapter 3 that 20 industries out of all 23 industries benefited positively from FDI presence in 2003.

Using the same data set, we then turned to the analysis of export spillovers from FDI in China in Chapter 5. We first set up a partial equilibrium model, in which the representative domestic firm and FDI invested firm are engaged in Cournot competition in the domestic market and are faced with a competitive world market. The FDI invested firms' activities help to reduce other firms' export costs, because of such factors as spillovers of knowledge about foreign markets and employee movement. Both firms choose their quantity of production and export intensity to maximize profit. Firms' profit maximization behaviour leads to the prediction that domestic firms will unambiguously increase their export intensity for an exogenous increase in foreign presence. This hypothesis was then tested using a sample selection model, to account for the fact that we observe firms' export intensity only if they decide to participate in exporting. In the sample selection model, domestic firms' decisions on whether to export depends on firm size, age, capital intensity, unit production cost, average wage, unit labour cost, marketing expenses, the Herfindahl index, ownership structure, regional heterogeneity, industry heterogeneity, past export experience, foreign presence, and its interaction terms with such firm characteristics as size and age. Conditional on each firm deciding to participate in exporting, the domestic firm's export intensity depends on the same set of explanatory variables except for past export experience. Regional heterogeneity and industry heterogeneity also control for the potential endogeneity of FDI, namely that FDI tends to flow into industries with higher export intensity. The sample selection model was then estimated using a maximum likelihood estimator. It was found that FDI in manufacturing industry generated export spillovers, and that the scale of the spillovers depended positively on domestic firm size, capital intensity, and unit labour cost, and negatively on firm age, unit production cost, average wage, marketing expense, ownership structure and geographical location.

Chapters 6 and 7 focused on an industry case study of technology and export spillovers and a regional case study of technology spillovers. In Chapter 6, we examined both the technology and export spillovers from FDI in the cultural, educational, and sporting product manufacturing industry, where both FDI and exporting were active, in a panel data context. By focusing on a particular industry, we avoided the FDI endogeneity problem that derives from the possibility that FDI tends to flow into industries with higher productivity and/or export intensity, and the panel data context allowed us to pick up the dynamic nature of spillovers.

Following Chapter 4, the econometric specification used in testing technology spillovers hypothesized that domestic firms' labour productivity depends on a set of firm characteristics, such as capital intensity and labour quality, and foreign presence and its interaction terms. The econometric specification in testing export spillovers follows that of Chapter 5, namely, export intensity was hypothesized to depend on a set of firm characteristics, industry characteristics, foreign presence, and its interaction with firm characteristics. The data set used was a four-year unbalanced panel data in the cultural, educational, and sporting product manufacturing industry from 2000 to 2003. The fixed effect estimator was employed in testing for technology spillovers, and for testing export spillovers the Heckman sample selection model was estimated, which pooled the four year data together. We found no evidence for technology spillovers, which may be due to the fact that FDI in this industry mainly comes from overseas Chinese MNEs as previous studies found that FDI from overseas Chinese MNEs generates much fewer, or even no, technology spillovers. For export spillovers, we found they depended on firm characteristics, such as firm ownership and geographical location, and there were more domestic firms that benefited from FDI than those that suffered from FDI.

Chapter 7 focused on Gansu Province, one of the least developed provinces in China. It handled technology spillovers in the stochastic production frontier framework, in which technology spillovers exist if the foreign presence positively affects domestic firms' technical efficiency. The chapter started from a general specification of a production function, in which different industries were allowed to have different production functions by using industry dummies. The use of industry dummies also controlled for the potential endogeneity of foreign presence, namely the FDI tends to flow into industries with higher technical efficiency. Firms' mean technical efficiency was hypothesized to depend on firm geographical location, the Herfindahl index, employee training expenses, R&D expenses, labour insurance expenses, age, expenditure on introducing technology, whether they are resource based, ownership structure, firm scale, foreign presence, and its interaction with previous variables. A general-to-specific approach was adopted to estimate the empirical model, using a cross-sectional firm level micro-data set that covers 1,466 firms. It was found that if the FDI invested firms' activities are measured in terms of output share and employment share, the FDI invested firms do have a positive impact on other firms' technical efficiency, namely that technology spillovers exist, and domestic firms' R&D spending plays a positive role in the scale of such technology spillovers.

To summarize, the thesis finds that the FDI inflow in China does have significant impact on domestic industries and firms. However, it is too simplistic to say the impact is positive or negative. The impact varies across industries, firms, and regions, which in turn requires related policies, such as the policy to encourage FDI to flow into western China, to specifically take account of these differences. At the same time, China's FDI policy needs to be more open, as FDI has positive spillovers on a large majority of firms.

In Chapter 4, we tried to accommodate the impact of round-tripping FDI on examining FDI spillovers. To our best knowledge, this is the first attempt to do this. We were not able to do so in the subsequent chapters due to lack of data. The nature of the data used in these chapters to a greater or lesser extent may distort the findings, owing to the presence of round-tripping FDI and to other factors. This constitutes the weak point in the argument of the thesis, even though similar studies on China are also subject to this same problem. To disentangle the impact of round-tripping FDI, we need to separate round-tripping FDI from genuine FDI and this requires information on the source of the investment at a project level. This would be an appropriate direction in which to take future research as more detailed survey data becomes available.

The thesis systematically examined intra-industry spillovers from FDI in China, with a particular focus on the determinants of the magnitude of such spillovers and emphasizing the role of the capacity to absorb spillovers, signalled by different characteristics of firms and industries. Nevertheless, as mentioned previously, the thesis does not cover all aspects of FDI spillovers, for example the inter-industry spillovers, which are a subject for further study

Policy Implications and Conclusions

This review of findings reveals that spillovers from FDI have important industrial and regional dimensions and implications for policy. First of all, China will benefit from attracting more FDI inflow in that positive spillovers from FDI outweigh the negative impact. For export spillovers, as shown in Chapters 5 and 6, there are more domestic firms that obtained positive export spillovers from FDI than firms that did not. In respect of technology spillovers, Chapter 3 revealed that domestic industries have become more and more capable of benefiting from the presence of FDI from 1995 to 2003, and in 2003 most industries obtained positive technology spillovers, a finding which was confirmed in Chapter 4. In addition, FDI also exerted positive technology spillovers on domestic firms in Gansu province, a less developed region in China. Thus generally speaking, FDI inflow into China has had a positive impact on the underlying forces that promote the growth of productivity in the Chinese economy. Nevertheless, some firms and industries may suffer. Hence, it appears that a more focused industrial policy may be called for, which of course should not be targeted at shielding domestic industries/firms from the competition of FDI, but rather helping domestic industries/firms face the challenge of FDI and reap the benefits from it.

As shown in Chapter 3, some industries will suffer from foreign presence, and whether the industry suffers depends negatively on the technology gap, and positively on the relative factor intensity and relative labour supply. It is likely to take time for domestic industry to absorb the benefits from the presence of FDI. For industries that are less developed compared with their counterparts in the world, for example for industries that are technological inferior like petroleum processing and coking products industry and printing and record pressing industry and for industries that have less favourable domestic configuration, namely with lower relative capital intensity and less relative labour supply, like smelting and pressing of nonferrous metals industry, with the inflow of FDI, policies might be adopted to help domestic industries to handle the challenge from FDI. Such policies might include, but not be limited to, tax privileges or subsidies to encourage domestic R&D activities, encouragement in introducing technology, and enhancing labour quality, and other non-tax policy instruments, such as promoting the agglomeration of domestic and FDI invested firms through establishing technological parks.

It can occur that industries that suffer from the presence of FDI initially can grow and benefit from it in the future, as revealed by the dynamic process of technology spillovers from FDI in Chapter 3. The improvement of industries implies that policies that are originally designed to help domestic industries can become outmoded and should be amended, if the government values fair competition between domestic and FDI invested firms.

Second, in framing industrial policy, the distributional characteristics of domestic firms in the industry should also be considered, even though typically we do not worry about whether one firm will gain or lose from the presence of FDI and instead we are more interested in whether the industry as a whole will gain or lose. As shown in Chapter 5, we find that domestic firm size, capital intensity, and unit labour cost positively affect the scale of spillovers from FDI, while the firm age, unit production cost, and marketing expenses affect the scale negatively. Thus, these factors need to be considered in framing industry policy.

Third, concerning regional aspects of FDI policy, currently China has been offering more policy privileges to attract FDI to western China, in the hope that FDI will promote domestic development. In Chapter 7, where we studied technology spillovers from FDI in Gansu Province, one of the much less developed regions in western China, the impact of FDI was found to be positive, even though it appears to be sensitive to different measurements of foreign presence. Thus encouraging FDI to flow into western China appears to be justifiable.

Compared with their counterparts in central and coastal China, domestic firms in western China appear to be less developed, measured in terms of such firm characteristics as capital intensity. This weakness may indicate that they have less absorptive capacity to benefit from the foreign presence. Hence, while encouraging FDI to flow into western China, other supporting policies need to be implemented. Investment in infrastructure, such as road and other transportation, should be increased, which provides a better economic environment not only for FDI invested firms but also for domestic firms, and policies, such as a reduction on red-tape procedures, tax privileges or subsidies on R&D activities and introducing technology, support for labour quality upgrading, and industry information provision, should be designed to help domestic firms. Again, all these policies should be designed with an aim of eventually providing a competitive environment to both FDI invested firms and domestic firms.

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