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TESTING BACKWARD LINKAGES OF FDI IN CHINA

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MPHIL

LINGNAN UNIVERSITY

2005

TESTING BACKWARD LINKAGES OF FDI IN CHINA

by

LIU ZHUOMIN

A thesis
submitted in partial fulfillment
of the requirements for the Degree of
Master of Philosophy

LINGNAN UNIVERSITY

2005

ABSTRACT

TESTING BACKWARD LINKAGES OF FDI IN CHINA

by

LIU ZHUOMIN

Master of Philosophy

Inward FDI (Foreign Direct Investment) affects productivity of local industries through three channels- direct effects, horizontal spillovers, and vertical linkages. This study focuses on the backward linkages of FDI in the 28 two-digit manufacturing sectors in China, as well as their horizontal and forward linkage effects. Two related tests, firm level pooled data test 1999-2002 and industrial level panel data test 1994-2003 are conducted to investigate whether backward linkages from multinational buyers brings productivity gain to local suppliers. Firm level tests provide convincing evidence that increase backward linkage of FDI will lead to productivity gains. This includes not only total factor productivity, but also labor productivity. Industry level tests, when conducted with and without time dummy variables, give different results: estimations with time dummy variables give little or sometimes negative results on the coefficients of backward linkage, while those without time dummy variables give positive and significant findings. Our estimation results also suggest positive effects of horizontal spillovers for both tests. Forward linkage is found to be negative in general. In sum, among the three spillover channels, backward linkage and horizontal spillovers are found to be beneficial to local industries, which is consistent with previous studies and the Chinese government's incentives to attract more foreign direct investment.

Keywords: FDI, backward linkages, technology transfer

I declare that this is an original work based primarily on my own research, and I warrant that all citations of previous research, published or unpublished, have been duly acknowledge.

(Liu Zhuomin)
April 29, 2005

CERTIFICATE OF APPROVAL OF THESIS

TESTING BACKWARD LINKAGE OF FDI IN CHINA

by

LIU Zhuomin

Master of Philosophy

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INTRODUCTION

There exists a long tradition in development economics that takes an optimistic view of the effect that foreign direct investment (FDI) has on industrial development of the host country. In this tradition, multinationals are seen as agents that increase competition in the host economy, transfer modern technology, and help achieve a more efficient allocation of resources. Furthermore, it is argued that inward FDI pushes forward the process of industrial development by creating linkages with, or spillovers to, the rest of the economy.¹ In pursuit of such benefits, China, for instance, adopted several favorable policies to attract foreign firms and foster relationships between multinationals and local firms. These preferential treatments include the freedom to import inputs, the right to retain and swap foreign exchange with each other and simpler licensing procedures. To enhance the transfer of technology, additional tax benefits are offered to those employing advanced technology.

However, theoretical and empirical literature has argued that not all kinds of spillovers from FDI are equally beneficial to host industry productivity. When we look into the nature of FDI externalities, we find that potential spillovers effects of FDI to the host country can be horizontal or vertical. Horizontal spillovers refer to the technology leakage from multinationals to local firms in the same industry. The effects of spillovers can be two-fold: Such spillovers may provide positive externalities through a number of channels. First, local firms may be able to learn by observing and imitating foreign technology. Second, employees may leave multinationals to join local firms, bringing along new technology and management know-how. Third, multinational may provide public goods which can also be enjoyed by domestic firms. On the other hand, entry of multinationals may hurt local firm. First, foreign firms may hire talent away from local firms, thereby creating a “brain drain” (Blalock 2001). Second, foreign firms may raise wages for all firms

¹ The concept of linkages is due to Hirschmann (1958). See Moran (1998 and 2001) for recent comprehensive surveys of the effects of FDI on economic development of host countries.

in competitive labor (Aitken, Harrison and Lipsey 1996). Finally, entry of multinationals can grab market shares of domestic firms, generating competition effects.

There has been a large literature which tries to measure the spillovers effects of FDI on the host economy. However, most of the recent studies found negative, rather than positive, horizontal spillovers effects from FDI. For instance, Kokko et al (1996), Aitken and Harrison (1999), Djankow and Hoekman (2000) and several others using firm level data find negative or insignificant evidence of horizontal spillovers. The explanation for little or even negative horizontal spillover effect is, as Blalock (2001) writes, “when one considers the incentive of foreign firms and the nature of markets they enter, however, it is not surprising that evidence of technology spillovers is weak at best. Multinationals will attempt to minimize technology leakage to competitors by limiting the mechanisms, such as labor mobility and imitation, through which spillover occur. Further, multinationals with non- protectable technology will likely choose not to enter overseas markets at all. Even if local firms can observe the technology brought with FDI, they may lack the absorptive capacity to adopt it because of the often wide gap in human capital and product development capabilities between multinational and local firms.”

On the other hand, regarding vertical linkages, theoretical and empirical work shows the effects are more likely to be positive in nature because they confer private benefits to multinationals buyers. In particular, multinationals might want to transfer technology to their local suppliers, in order to enjoy lower production costs, increased specialization and better adaptation of technologies and products to local environments. Thus, multinationals may help their local suppliers in improving technology, staff training, quality control, and inventory management (*World Investment Report 2001: Promoting Linkages*). Backward linkages from FDI are beneficial to local suppliers in forms of increased output and employment, improved production efficiency, technological, managerial capabilities and market diversification. Similarly, domestic firms may become more productive as a result of gaining access to new, improved, or less costly intermediate inputs produced by multinationals in upstream sectors, that is, through forward linkage channels. Sales of these inputs by multinationals may also be accompanied by provision of complementary services.

However, the effects of backward linkages are not attended until recent papers by Blalock (2001) on Indonesia and Smarzynska (2002) on Lithuania. The testing of backward linkages from FDI in China, one of the largest FDI recipients among developing countries, is not currently available to the best of our knowledge. This paper, thus, partially serves to fill in such gap. In this paper we extend the recent empirical literature on backward linkages effects of FDI, by studying the case of China. Following the approaches of Blalock (2001) and Javorcik (2004) and using an industry level dataset (1994-2003), as well as a firm level dataset (1999-2002), we find evidence of positive backward linkages effects of FDI on both total factor productivity (TFP) and labor productivity in Chinese manufacturing industries. This is true under cluster tests of firm level data and industry tests when time dummy variables are eliminated. Overall, the results suggest that linkages with multinational clients bring about technology and human capital upgrading to upstream industry in China.

This paper proceeds as follows: Chapter 2 reviews the recent literature on FDI spillovers and linkages, including case studies, theoretical work and empirical investigations. Although the findings on horizontal spillover effects are ambiguous, the evidence on backward linkages is convincingly positive for most literatures. Chapter 3 reviews China's industry (mainly manufacturing) structure and FDI policies. In this chapter, we take a look at the contributions of industrial sectors to economic development in China, how ownership structure evolves over time since China's opening up, and finally, how China's FDI policies have undergone several changes from gradually and limited opening to active linking to domestic industry interests. Chapter 4 contains some discussions on the incentives why foreign firms in host country want to transfer technology to suppliers through backward linkages, channels of backward linkages, and positive and negative sides of backward linkages. It also provides several examples of how local firms benefit from linking up to multinational clients in different places around the world, followed by discussions of the theoretical base of why it is meaningful to test backward linkages of FDI in China by adopting Javorcik (2004)'s model to test backward linkage (local sourcing) ratio on total factor productivity (TFP).

Chapter 5 presents the key findings. In this chapter, we test whether backward linkages from FDI bring productivity gains to upstream local suppliers in China. In our model, we regress value added on capital and labor (to capture the total factor productivity), together

with backward linkage, forward linkage and horizontal FDI ratios. The key variable of our interest, backward linkage ratio, is defined as the share of an industry's output purchased by downstream foreign funded enterprises in the host country. We use both the data from China's statistical yearbooks and Input-output Tables of 1992 & 1997 (the latest version 2003 is not yet published) to calculate the ratios for each of the 28 manufacturing sectors in China. We performed types of two tests: robust cluster test on firm level pooled data (1999~2002), and industry test- pooled, random effect and fixed effect models on industry panel dataset (1994~2003). In our firm level analysis, we use the same approach as in Blalock (2001) and Javorcik (2004) by regressing firm level productivity on sectoral backward linkage ratios, but utilize robust cluster test to adjust for the upward bias of t statistics when using aggregate variables on micro units. Firm level tests provide convincing evidence that increase backward linkage of FDI will lead to productivity raise. This includes not only total factor productivity, but also labor productivity. Industry tests, when tested with and without time dummy variables, give different results: estimations with time dummy variables give little or sometimes negative results on the coefficients of backward linkage, while those without time dummy variables give positive and significant findings. Our estimation results also suggest positive effects of horizontal spillovers for both tests. Forward linkage is found to be negative in general. In sum, among the three spillover channels, backward linkage and horizontal spillovers are found to be beneficial to local industries, which is consistent with previous literatures and the Chinese government's incentives to attract more foreign direct investment.

Chapter 6 discusses research limitations, including data limitations and methodology limitations. Chapter 7 concludes and suggests some ways to enhance the magnitude of backward linkages of FDI in China. These ways include self-technology upgrading to increase multinationals' incentives to source locally, organizing special programs to connect local and multinationals firms, and allowing multinationals to choose promising suppliers and provide them assistance.

REVIEW OF LITERATURE

The existing literature on spillovers and linkages is of three kinds: case studies, theoretical work and empirical investigation. We review each type accordingly in the remaining chapter, focusing on empirical studies.

2.1 Case Studies

Case studies present mixed evidence on the role of foreign investment in generating technology transfer to domestic firms. One case study in Mauritius and Bangladesh suggests that the entry of several foreign firms led to the creation of a booming, domestically owned export industry for textiles (Rhee and Belot 1989). Mansfield and Rorneo (1980), however, found that only a few on the 15 multinationals in their survey helped domestic firms acquire new technology. In a study of 65 subsidiaries in 12 developing countries, Germidis (1977) found almost no evidence of technology transfer to local competitors. Moran (1998) notes that the performance of the Mexican auto parts industry was improved due to the readiness of multinationals to invest in high- quality vertical relationships. Given such ambiguous findings on FDI spillovers, researchers start to investigate the impact of FDI on local welfare theoretically and empirically.

2.2 Theoretical Work

The pioneering work concerning backward linkages is by Hirschmann, the first to raise that FDI may benefit developing countries by transfer of technology through backward linkages. Later, Rodriguez-Clare (1996), the main concept of which is that backward linkages bring a greater variety of specialized input, thus generating a positive externality to other final-good producers, uses a two-country model- one headquarter (developed country) and the other FDI recipient (developing country), and shows that entry of multinationals may or may not benefit host countries, depending on the sophistication or large variety of intermediate goods. Markusen and Venables (1999) note that the entry of multinationals can have profound effects on local firms: competition in the product and

factor markets tends to reduce profits of local firms, but linkage effects to supplier industries may create demand for local suppliers and improve their quality, productivity and product diversity. They also show that FDI may lead to the establishment of local industrial sectors, and act as a catalyst leading to the development of local industry which may in turn become so strong the reduce both the relative and absolute position of multinationals in the industry. The heart of these two models is “love-of-variety production function” proposed by Ethier (1982).

These two analytical papers emphasize on the demand side effects of multinationals’ entry. Pack and Saggi (2001) focuses on the benefits of both importer in the developed country and suppliers in the less developed country. It shows that, although distributing the technology widely to multiple suppliers would encourage entry (competition), if new competition is not too great, the benefits of a competitive supply base to the multinational buyer outweigh the rents lost of free-loading rivals. Following Pack and Saggi (2001), Lin and Saggi (2003) develops a two-tier oligopoly model in which the entry of a multinational firm results in technology transfer to its local suppliers and the impact of backward linkages on the local industry. It also focuses on multinational’s decision on exclusivity and how invited suppliers respond, suggesting exclusivity may cause suppliers’ output to shrink.

It is also natural to relate backward linkages with local content requirements (LCR) policy. As is general believed, LCRs enhance the magnitude of backward linkages. Hence, the governments of the developing countries have incentives to set up optimal LCR policies to attract and benefit from FDI. Qiu and Tao (2001) explore various aspects of LCP policies by assuming a two-multinational-firm (one more cost-efficient than the other) model and show that properly set LCP policy induces both firms to undertake FDI. Under discriminatory LCR, if employment is the main source of FDI benefit, then the optimal LCR for the more cost-efficient firm is lower. The opposite is true when the government concerns most about technological upgrading. Under uniform LCR, a less efficient firm is more likely to adopt the FDI most than a more efficient firm.

On the other hand, Moran (2002) criticized the role of LCR on technology transfer. According this paper, the foreign affiliates may not achieve full economics, not utilize the most advanced production techniques when they have to integrate or cooperate with local

firms whose technology is not only older but different from what is found in world class production sites, pointing out that technological sophistication is the key factor to capture backward linkages.

2.3 Empirical Studies

Concerning empirical studies, Alfaro and Rodriguez-Clare (2003) provided a thorough review of recent literature regarding horizontal and vertical spillovers. According to their point of view, the empirical investigation on spillovers and linkages can be divided into three generations. The first generation is characterized by using industry-level or cross-sectional studies to test for horizontal spillovers from FDI. These studies generally found a positive correlation between foreign presence and sectoral productivity. For instance, the pioneering work of Caves (1974) finds positive FDI spillovers in Australia. Blomstrom (1983) and Blomstrom and Wolff (1994) find positive effects for Mexico, and Sjöholm (1999) for Indonesia. Cross-sectional empirical work by Borensztein, De Gregorio and Lee (1998), Carkovic and Levine (2000) and Alfaro, Chandra, Kalemli-Ozcan and Sayek (2003) finds little support that FDI has a positive effect on economic growth. However, their evidence suggests that local conditions such as education level and the development of local financial markets play an important role in allowing the positive effects of FDI to materialize. Carkovic and Levine (2002) also cast doubt on the findings on growth and FDI. When accounting for simultaneity bias and country-specific effects, they find that the exogenous component of FDI does not exert a robust positive influence on growth.

However, a widely cited paper by Aitken and Harrison (1999), which is considered as the starting point of the second generation of empirical studies, first raises the question of “selection bias” when using industrial data in measuring foreign presence on sectoral productivity. In their paper, using firm level panel data on Venezuelan plants, they find that spillovers from within sector joint ventures negatively affected the productivity of domestically owned plants. Although they do find positive evidence of foreign-equity participation on plant productivity (direct effect of FDI) for small enterprises with less than 50 employees, the net impact, as they argue, taking into these two offsetting effects, is quite small. The gains from FDI appear to be entirely captured by joint ventures. Such finding of large, negative spillovers from foreign investment to domestic firms is in sharp contrast with previous studies. The reason, as they noted, is that using data aggregated at

the sectoral level, these studies were unable to control for differences in productivity across sectors which might be correlated with, but not caused by, foreign presence. Foreign firms may be located in high productivity industries as opposed to causing productivity externalities. Furthermore, high growth countries may attract more FDI as opposed to FDI causing this high growth. In such case, the coefficients on industrial level estimates are likely to overstate the positive impact of foreign investment. As a result, one could find evidence of positive foreign presence on industrial productivity, but not necessarily indicating horizontal externalities.

Following Aitken and Harrison (1999), Djankov and Hoekman (2000) on the Czech Republic, and Kongings (2001) on Bulgaria, Romania, and Poland, also find little or negative evidence of spillovers from FDI in developing countries. On the other hand, the case seems to be different in industrialized countries, as recent work by Haskel et al. (2002) and Keller and Yeaple (2003) provide evidence of positive FDI spillovers in the United Kingdom and the United States, respectively. Such differences, as Kongings (2001) says, are reasonable because a number of recent theoretical and empirical papers show that the degree to which domestic firms may benefit from such spillovers depends on the absorptive capacity of domestic firms. This is more likely achieved in sectors characterized by intensive R&D by firms which have a sufficient amount of knowledge to start with. Later, Grog and Greenway's (2002) survey of studies using panel dataset finds that only the two studies for industrialized countries mentioned above and none for developing countries report positive evidence for within industry externalities, and conclude that the effects are mostly negative.

Nevertheless, there are not many empirical papers on FDI spillovers in China. Cheung and Lin (2003) using provincial data from 1995 to 2000 find positive effects of FDI on innovations (the number of patent application) in China. They also find that the effects are strongest for minor innovations such as external design patent, highlighting a "demonstration effect" of FDI. Hu and Jefferson (2001, 2002) use data for large-and medium-size enterprises to examine the spillover effects of FDI in manufacturing industries in China. They found that inward FDI has a positive effect on introduction of new products in China.

Given these findings, economists recently turned to examining vertical spillovers effects of FDI. Especially after a report by UNCTAD (2001) “Promoting Linkages” discussing the benefits of backward linkages from FDI to domestic suppliers, a new group of papers- the third generation papers as classified by Alfaro and Rodriguez-Clare (2003)- has explored the existence of positive externalities from FDI towards local firms in upstream industries. Here the findings are more encouraging. A rare large sample empirical study is by Kugler (2000), which shows that FDI in one sector of Colombian manufacturing can cause productivity gains in another. Kugler, however, does not identify backward linkages or any particular causal mechanisms for the inter-sector spillover (Blalock and Gertler 2004). Blalock (2001) filled this gap in the literature by defining horizontal FDI as the proportion of output produced by foreign firms in each sector $horizontal_{jt} = (\sum_i FDI_{ijt} * output_{ijt}) / \sum_i output_{ijt}$, and backward linkage as the share of an industry’s output purchased by downstream foreign funded enterprises in the host country $Vertical_FDI_{jrt} = \sum_k \alpha_{jkt} * horizontal_FDI_{krt}$. Then in his latest revised version, Blalock and Gertler (2004) use a panel dataset of Indonesian manufacturing establishments from 1988 to 1996 to test whether the productivity of firms in a particular market increased when the share of their output sold to foreign- owned firms increased, and find strong evidence of productivity gains, greater competition, and lower prices amongst local firms upstream from foreign entrants. Javorcik (2004) conducts similar test on a panel firm level dataset on Lithuanian manufacturing sectors over the period 1996-2000 and also finds for backward linkages. However, she modified the measurement for backward linkages ratio by deleting inputs supplied within the sector $Backward_FDI_{jt} = \sum_{k \text{ if } k \neq j} \alpha_{jk} * horizontal_{kt}$, for she argued that this effect has been captured by horizontal FDI, and for the same principle defined forward linkages as the share of output in upstream sectors produced by firms with foreign capital participation (excluding exports). She also adjusts for the upward bias of t statistics caused by regressing firm level data on industry level backward linkages. Javorcik (2004) further tests on horizontal externalities and forward linkages and concludes that it is difficult to find robust evidence of positive externalities from multinationals to local firms in the same sector and to downstream buyers. A number of other studies focusing on vertical linkages provide mixed findings. Smarzynska and Spatareanu (2002) testing on data from

Romania find negative results of backward linkages, while Cordova (2003) finds that foreign capital improves total factor productivity (TFP), with positive inter-industry externalities prevailing over a negative intra-industry effect.

The only empirical study of vertical linkages on China, to the best of our knowledge, comes from Kinoshita (1998). Using a sample firm data taken from a survey conducted by the World Bank in eight cities in China IN 1992, the author defined foreign linkages as answer “yes” to the question “Do you currently have foreign buyers or suppliers? (=1 if yes; =0 if no). Then samples are tested separately in terms of whether a firm has any foreign linkages or not. The paper finds the existence of “foreign joint venture” is effective in raising TFP growth is firms have foreign suppliers or buyers and concludes foreign joint ventures and foreign linkages are complements in increasing a firm’s productivity. However, as we know, FDI inflow started to boom after 1993, hence, a study using more recent data is needed.

To summarize the major empirical findings, we list the recent evidence concerning FDI spillovers and linkages in table 1.

Table 1. Overview of Evidence on Spillovers or Linkages from Foreign to Local firms in Developing Countries

Author(s)	Sample	Results
<u>Cross-sectional</u>		
Blomstrom and Wolff (1994)	Mexico, 1970	Higher foreign shares in industry in 1970 led to higher rates of productivity growth in locally owned firms over the next five years
Kokko, Tansini and Zejan (1994)	Uruguay, 1988	Positive spillovers from FDI to a sub-sample of locally-owned manufacturing plants with moderate technology gaps vis-à-vis foreign firms
Sjoholm (1999)	Indonesia, 1980-1991	Positive effects from FDI to locally -owned establishments
<u>SUR estimation</u>		
Borensztei, De Gregorio and Lee (1998)	FDI flows to 69 LDC, 1979; 1980-1989	FDI contributes to growth only when the host country has a minimum threshold stock of human capital
<u>Panel</u>		
Haddad and Harrison (1994)	Morocco, 1985-1989	Reject the hypothesis that foreign presence accelerated productivity growth in domestic firms
Aitken and Harrison (1999)	Venezuela, 1976-1989	Small net impact of foreign investment. Positive effect of foreign equity participation on plant productivity robust only for small firms. Negative effect foreign investment on domestically owned plants
Djankov and Hoekman (2000)	Czech Republic, 1992-1996	Joint ventures and foreign direct investment have a negative spillover effects on firms that do not have foreign partnerships
<u>Panel-Olley-Pakes</u>		
Lopez- Cordova	Mexico, 1993-	Foreign capital improve TFP, positive inter-industry spillovers

(2003)	2000	from FDI prevail over a negative intra-industry effect
Javorcik (2004)	Lithuania, 1996-2000	No evidence of horizontal spillovers and some evidence of backward linkages
Blalock and Gertler (2003)	Indonesia, 1988-1996	Strong evidence for backward linkages
<u>GMM</u>		
Carkovic and Levine (2002)	72 countries 1990-1995, 5 year periods	Exogenous components of FDI does not exert a robust, positive influence on economic growth

Source: modified from Alfaro and Rodriguez-Clare (2003)

One general implication drawn from the existing literature- case studies, empirical test or theoretical work, is that backward linkage serves as an important channel for developing countries to absorb advanced technology from international market. In the next chapters, we are to explore the impact of backward linkages in China, one of the largest FDI recipients among developing countries.

INDUSTRY STRUCTURE AND FDI IN CHINA

This chapter provides some background information on China's industry structure and development, as well as China's policies toward foreign direct investment.

3.1. Industry Structure

GDP in China has experienced fast development since China's opening up to the world, growing rapidly from 362 (in 1978) to 11725 billion yuan in 2003 (figure 1). GDP per capita is also increasing over the years, from 379 (in 1978) to 9101 yuan per person in 2003.

Figure1. GDP (100 million yuan) 1978~2003

Source: Statistical Yearbook of China 1979~2004

Among all the sectors, industries contribute most to this fast economic growth. From 1979 to 1999, the average growth rate of industrial value added is 11.7%, significantly higher than other sectors, i.e. primary and tertiary sectors. From table 2, we learn that value added growth of industrial sectors has always been an important component of economic growth. If we divide the year 1979 to 1999 into 6 periods, we find that the fast

growth periods are period 84~88, 92~94 and 95~97, which follows a similar pattern to GDP growth (Zhou and Guo (2000)).

Table 2. Change of industry growth rate in comparison with other sectors

year	Average Annual Growth of Value Added (%)				
	Industry	Construction	Primary	Tertiary	GDP
1979~1983	7.6	10.4	6.2	10.4	8.1
1984~1988	14.2	14.8	5.0	15.4	12.0
1989~1991	7.5	0.5	4.2	5.5	5.7
1992~1994	20.1	17.5	4.5	10.9	13.5
1995~1997	12.6	7.8	4.5	8.5	9.6
1998~1999	8.7	8.1	3.1	7.5	7.4
1979~1999	11.7	10.3	4.9	10.4	9.6

Source: Zhou and Guo (2000)

Since China opened up to foreign direct investment in early 90s, the industry structure has also changed tremendously over the time: state owned and collective owned enterprises have gradually lost their leading roles in the market in terms of decreasing number share, market share, value added and fixed capital share (table 3a, b, c and d)². On the other hand, the number of foreign funded enterprises has increased from 8434 in 1992 to 17429 in 2003, growing by more than twice. The market share and capital share have also doubled or tripled their sizes in ten years' time. For instance, in 1993, the year FDI inflow started to boom, the output of foreign funded enterprises and those with funds from greater China areas (GCAs) including Hong Kong, Taiwan and Macau together accounted for 9% of industry total, while in 2003, the output of these two types accounts for 31% of industry total output, far dominating collective owned and being close to state owned enterprises.

² Please note that there is a change of standard for data reporting in year 1998, and that's why we observe a sudden jump for all the ratios concerning 1998, but the same pattern follows afterwards.

Table 3a. Number share of industrial enterprises by ownership

Year	State Owned	Collective Owned	Share-Holding Corporation	Foreign Funded	Enterprises with Funds from GCAs
1992	0.18	0.79		0.03	
1993	0.18	0.76	0.01	0.02	0.03
1994	0.17	0.74	0.01	0.03	0.04
1995	0.17	0.71	0.01	0.03	0.05
1996	0.17	0.00	0.02	0.04	0.05
1997	0.16	0.68	0.03	0.04	0.05
1998	0.39	0.29	0.02	0.06	0.10
1999	0.38	0.26	0.03	0.07	0.10
2000	0.33	0.23	0.03	0.07	0.10
2001	0.27	0.18	0.03	0.08	0.11
2002	0.23	0.15	0.03	0.08	0.11
2003	0.17	0.11	0.03	0.09	0.11

Table 3b. Output share of industrial enterprises by ownership

Year	State Owned	Collective Owned	Share-Holding Corporation	Foreign Funded	Enterprises with Funds from GCAs
1992	0.62	0.29		0.09	
1993	0.56	0.30	0.04	0.05	0.04
1994	0.49	0.31	0.06	0.07	0.06
1995	0.47	0.29	0.05	0.09	0.09
1996	0.43	0.30	0.05	0.10	0.09
1997	0.41	0.29	0.07	0.12	0.09
1998	0.50	0.19	0.06	0.12	0.12
1999	0.49	0.17	0.07	0.14	0.12
2000	0.47	0.14	0.12	0.15	0.12
2001	0.44	0.11	0.13	0.16	0.12
2002	0.41	0.09	0.13	0.17	0.12
2003	0.38	0.07	0.13	0.19	0.12

Table 3c. Value added share of industrial enterprises by ownership

Year	State Owned	Collective Owned	Share-Holding Corporation	Foreign Funded	Enterprises with Funds from GCAs
1992	0.68	0.25		0.07	
1993	0.57	0.30	0.04	0.04	0.04
1994	0.54	0.28	0.06	0.06	0.05
1995	0.54	0.25	0.05	0.08	0.07
1996	0.48	0.29	0.05	0.09	0.07
1997	0.46	0.26	0.07	0.10	0.08
1998	0.57	0.17	0.03	0.10	0.11
1999	0.56	0.15	0.08	0.12	0.11
2000	0.54	0.12	0.14	0.13	0.11
2001	0.52	0.09	0.16	0.14	0.11
2002	0.48	0.08	0.15	0.15	0.11
2003	0.45	0.06	0.15	0.16	0.11

Table 3d. Fixed Investment Share of industrial enterprises by ownership

Year	State Owned	Collective Owned	Share-Holding Corporation	Foreign Funded	Enterprises with Funds from GCAs
1992	0.78	0.16		0.06	
1993	0.72	0.16	0.03	0.04	0.04
1994	0.65	0.17	0.05	0.07	0.05
1995	0.64	0.16	0.05	0.07	0.08
1996	0.64	0.15	0.05	0.08	0.08
1997	0.62	0.14	0.07	0.09	0.08
1998	0.72	0.09	0.02	0.09	0.09
1999	0.72	0.08	0.07	0.10	0.09
2000	0.71	0.06	0.12	0.10	0.09
2001	0.70	0.05	0.15	0.11	0.09
2002	0.67	0.04	0.15	0.12	0.09
2003	0.64	0.03	0.14	0.12	0.09

Source: Statistical Yearbook of China, multiple years

Note: Before 1998, national total refers to enterprises with independent accounting system. Starting from 1998, only enterprises with an annual sales income of over 5 million yuan are reported.

Foreign direct investment (FDI) thus constitutes an important part of China's industrial structure. More importantly, foreign enterprises are usually more efficient in production. Table 4 lists the comparison of labor productivity between overall and foreign funded enterprises.

Table 4. Comparison of average industrial labor productivity (1999~2003) between foreign and industrial average (yuan/person)

Industries (1999~2003)	Average Foreign Productivity	Average Industry Productivity	gap
Food Processing	88777	58676	1.51
Food Manufacturing	84290	50657	1.66
Beverage Manufacturing	119516	70147	1.70
Tobacco Processing	206851	489607	0.42
Textile Industry	44273	29592	1.50
Garments and Other Fiber Products	27901	28243	0.99
Leather, Furs, Down and Related Products	26853	30707	0.87
Timber Processing, Bamboo, Cane and Palm Fiber	43555	35957	1.21
Furniture Manufacturing	41051	37659	1.09
Papermaking and Paper Products	85803	43474	1.97
Printing and Record Medium Reproduction	72506	44035	1.65
Cultural, Educational and Sports Goods	24833	25662	0.97
Petroleum Processing and Coking	364398	150179	2.43
Raw Chemical Materials and Chemical Products	145159	52629	2.76
Medical and Pharmaceutical Products	135036	70655	1.91
Chemical Fiber	126953	66182	1.92
Rubber Products	57687	41639	1.39
Plastic Products	53045	45438	1.17
Nonmetal Mineral Products	59931	32152	1.86
Smelting and Pressing of Ferrous Metals	120506	67122	1.80
Smelting and Pressing of Nonferrous Metals	94945	57159	1.66
Metal Products	61570	43664	1.41
Ordinary Machinery	87645	37904	2.31
Special Purpose Equipment	81988	35802	2.29
Transport Equipment	170919	60456	2.83
Electric Equipment and Machinery	71542	60271	1.19
Electronic and Telecommunications Equipment	124494	100366	1.24
Instruments, Meters, Cultural and Office Machinery	57451	41525	1.38

Source: Statistical Yearbook of China 2000~2004

Table 4 shows the average labor productivity in foreign funded enterprises is significantly higher than industry average for most of the sectors. In the next section, we are going to explore the government's policies in attracting FDI and enhance technology transfer to less-productive local industries.

3.2 China's FDI Policy

Since the early 1990s, China has been the world's largest FDI recipient among developing countries, accounting for over one fourth of total FDI inflow (table 5). Ever since the opening up of China to the outside world, the amount of FDI inflow to China has

increased dramatically from \$3.38 billion (in nominal value) in 1980 to \$56.14 billion in 2002, with the peak at \$64.408 billion in 1997 (figure 2).

Table 5. FDI inflows to China: in comparison with other developing countries

	1998-93 (average)	1997	1998	1999
FDI inflows (US billions)				
China	8.8	44.2	43.75	40.4
All developing countries	46.9	178.8	179.5	207.6
Average South Asia, East Asia and South East Asia	27.1	93.5	87.2	96.1
FDI/gross fixed capital formation (%)				
China	6.4	14.6	12.9	--
Average developing countries	4.6	10.8	11.5	--
Average South Asia, East Asia and South East Asia	5.5	9.8	10.5	--

Source: UNCTAD (2000b)

Figure 2. Actual usage of foreign capital 1979~2003

Source: Statistical Yearbook of China 1980~2004

One of the key elements of China economic reform process has been the encouragement of foreign direct investment. Since 1970s, China has gradually opened its economy for foreign business. At the same time, China's policies toward FDI have also experience various changes.

According to Fung, Iizaka and Tong (2002), in the late 1970s and early 1980s, government policies are characterized by setting new regulations to permit joint ventures using foreign capital and setting up Special Economic Zones (SEZs) and “open cities”. At the second session of the fifth National People’s Congress in July 1979, *The Law of the People’s Republic of China on Joint Ventures using Chinese and Foreign Investment* was adopted, granting foreign investment a legal status in China. The State Council also awarded rights of autonomy in foreign trade to Guangdong and Fujian provinces and in 1980, setting up four SEZs in Shenzhen, Zhuhai, Shantou, and Xiamen. In December 1982, the decision to open up China to the world economy was formally included in the 1982 State Constitution adopted by the Sixth National People’s Congress. Later in 1983, *Regulations for the implementation of the law of the People’s Republic of China on Joint Ventures using Chinese and Foreign Investment* was formulated in 1983 to further liberalize the domestic market.

In 1984, the concept of SEZs was extended to another fourteen coastal cities and Hainan Island. Twelve of the fourteen cities were designated Technology Promotion Zones in 1985 to expedite the transfer of technology, indicating China has paid more attention to the technology transfer from foreign firms rather than just foreign capitals. In 1985, “development triangles”- the Yangtze River delta, the Pearl River delta in Guangdong, and the Min Nan region in Fujian, Liaodong and Shandong Peninsulas and the Bohai Sea Coastal Region-were also opened to foreign investors. In 1990, the Pudong district of Shanghai was designated as a new development zone.

In 1986, more favorable regulations and provisions are used to encourage FDI inflow, especially export-oriented joint ventures and joint ventures using advanced technologies. Wholly foreign owned enterprises were also allowed. On October 11, 1986, the state Council promulgated the *Provision of the State Council of the People’s Republic of China for the Encouragement of Foreign Investment*. These provisions provided foreign joint ventures with preferential treatment, the freedom to import input such as materials and equipment, the right to retain and swap foreign exchange with each other, and simpler licensing procedures. Additional tax benefits were offered to export-oriented joint ventures and those employing advanced technology. The importance of the 1986 provisions is that it provided incentives for FDI rather than merely permitting it.

China's proactive policies toward FDI result in increasing inflow of foreign capital in the late 1980s and early 1990s. From mid 1990s, while maintaining favorable environment for foreign business, government policies began to focus more on linking FDI promotion to domestic industrial objectives. For instance, the *Provisional Guidelines for foreign Investment Projects* took effect on June 27, 1995. Priority was given to FDI in the agriculture, energy, transportation, telecommunications, basic raw materials, and high-tech industries, and FDI projects which could take advantage of the rich natural resources and relatively low labor costs in the central and northwest regions were to be vigorously encouraged.

Later, *Guiding Catalogue of Foreign Investment Projects* provided the basis for the examination and approval of FDI projects, which were to be classified to one of four categories: encouraged, restricted, prohibited and permitted. Included in the encouraged projects were those in infrastructure or underdeveloped agriculture; those with new/advanced technology which could upgrade product function, save energy and raw material, improve economic efficiency, or manufacture under supplied new equipment/material to satisfy market demand; those which were export-oriented; those which involved new technology/equipment which made use of natural/regenerative resources and prevented/controlled pollution and so on. Some projects were classified as restricted such as those whose technologies had been developed or transferred, and those were production exceeded domestic demand; and those under experiment or monopolized by the state, and those engaged in the exploration of rare and valuable mineral resources. Prohibited are those that harmed public interest and national security damaged the environment, natural resources or human health. Those that are not in any the above groups are classified as "permitted".

Generally speaking, China's policies toward FDI have experienced three stages: gradually and limited opening, active promoting, and promoting in accordance with domestic interest (Fung, Iizaka and Tong 2002). To conclude, perhaps the address by Planning Minister Zeng Peiyan best describes the current Chinese FDI policy, "...effects will be stepped up to attract investment from multinational corporations. Meanwhile, vigorous effects will be made to attract foreign investment in a variety of forms for the reorganization and technological upgrading of state-owned enterprises. We will attract foreign investment to fields encouraged by the government, such as high technology and environmental protection, as well as to the central and western regions. We need to

improve the management of foreign-funded enterprises, provide better service to them and protect the legitimate rights and interests of foreign investors” (Xinhua News Agency March 16, 2000).

3.3 Local Content Requirement

A policy designed specifically to promote backward linkage effect of FDI is the so-called local content requirement, which requires a foreign investor to purchase a certain amount of intermediate input from local suppliers as opposed to from international markets. Under such requirement, the government regulates the names of related products, the number or the value of domestic products that multinational firms must purchase or utilize in the production of final goods.³ In China, ‘The Law of the People’s Republic of China on Chinese and Foreign Equity Joint Ventures (the ninth term), the Law of the People’s Republic of China on Chinese and Foreign Contractual Cooperative Enterprises (the nineteenth term), and the Law of the People’s Republic of China Enterprises with Foreign Capital (the fifteenth term) require that foreign invested (joint venture, wholly owned and those with foreign capital participation should source their intermediate locally in China, if possible.

For instance, during the 1990s China required that the local content rate of all cars made in China be at least 40 percent and must increase to 60 percent in a year and to 80 percent in two years after operation of a project (China Daily July 15, 2004). In the mobile phone industry, to protect domestic mobile phone producers, China has banned new foreign investment in the mobile phone manufacturing industry. Besides, a quota system was introduced on the percentage of local content allowed for mobile phones made by foreign-invested manufacturers for export and local consumption. Existing foreign joint ventures must export at least 60% and by the end of year 2001 must reach a local content rate, by value, of at least 50% (Chinanetnews November 7, 2000).

However, upon China’s accession to the World Trade Organization (WTO), Chinese laws and policies have been amended. For instance, in terms of the operations of foreign investment, China has repealed the performance requirements that are prohibited by the

³ See Qiu and Tao (2001) for an analysis of optimal design of local content requirement policy.

Trade Related Investment Measures (TRIMS) agreement, such as the requirements for local content and the requirements of foreign exchanges. Thus, foreign-invested enterprises basically enjoy the same treatment as that of the domestic-invested enterprises. However, China is still at the stage of economic transformation and there is a certain gap between some measures requirements of the principles the market economy and the WTO rules. Relaxation of local content requirement and foreign exchange requirement implies that foreign invested firms in China will import more intermediate inputs from overseas in a more convenient way. Thus, the strategy for technology transfer through backward linkages will be less effective, and domestic market will face the pressures of foreign firms in terms of higher technology and lower price. Thus, as Wu Jinglian, one Chinese economist, pointed out, before challenges and the new rules, domestic enterprises have to actively upgrade their technology and management structure to enhance foreign firms' incentives to source locally.

Chapter 4

MULTINATIONALS, BACKWARD LINKAGES AND TECHNOLOGY TRANSFER

In this chapter, we discuss some possible benefits of backward linkages from FDI to local industries and the factors that may affect multinational's decision to transfer technology to local suppliers.

4.1 General Dissuasions

With the growing importance of FDI in economic life, host countries seek not just more such investment, but are also increasingly interested in its quality, in terms of benefits for sustainable economic development. Perhaps the most important way to tap these benefits is through production linkages between foreign affiliates and domestic firms. Such linkages can take several forms: *backward, forward or horizontal*. Backward linkages exist when foreign affiliates acquire goods or services to domestic firms. It is often argued that backward linkage is the most important conduit for technology transfer among the three because, although multinationals seek to minimize technology leakage to competitors, they have every incentive to improve the productivity of their suppliers through training, quality control, and inventory management. To reduce dependency on a single supplier, the multinational may establish such relationship with multiple vendors, which benefit firms which purchase these vendors' output (Blalock and Gentlet 2004). Backward linkages are of significant importance to developing countries because domestic firms in developing countries are generally behind foreign firms as regards to technology, human resources and other competitiveness-related factors. Thus, integration with FDI places a host country industry along the frontier of best practices in the international industry (Romer 1994).

As *World Investment Report: Promoting Linkages (2001)* indicates, backward linkages are important to both foreign affiliates and domestic enterprises. Starting with affiliates, most productive enterprises buy a large proportion of inputs from other firms. If foreign

affiliates can procure input locally, particularly in host economies in which labor costs are low, they can lower production costs (some service input, for example, may be very expensive to import). If they can subcontract directly to local suppliers, they can increase their specialization and flexibility, and adapt technologies and products better and faster to local conditions. Domestic suppliers can also benefit from linkages with foreign affiliates. First, linkages raise output and employment in linked suppliers. Linkages can be powerful channels for diffusing knowledge and skills, and exchanging information between firms. Under the right conditions, domestic firms may develop to become global suppliers. The strengthening of suppliers can in turn lead to various indirect effects and spillovers for the rest of the host economy.

Table 6. Backward Linkages and Other Relationships between foreign affiliated and local enterprises and organizations

Form	Relationship of foreign affiliate to local enterprises			Relationship of foreign affiliate to non-business institution
	Backward (sourcing)	Forward (distribution)	Horizontal	
“Pure” market transaction	“Off-the shelf” purchases	“Off-the shelf” sales		
Short-term linkage	Once-for-all intermittent purchases	Once-for-all intermittent sales		
Longer-term linkage	a. Longer-term (contractual) arrangement for the procurement of inputs for further process b. Subcontracting of the production of final or intermediate products	a. Longer-term (contractual) relationship with local distributor or end-customer b. Outsourcing from domestic firms to foreign affiliates	Joint projects with competing domestic firms	a. R&D contracts with local institutions such as universities and research centers b. Training programs for firms by universities c. Traineeships for students in firms
Equity relationship	a. Joint venture with supplier b. Establishment of new supplier-affiliate (by existing foreign affiliate)	a. Joint venture with distributor or end-customer b. Establishment of new distribution affiliate (by existing foreign affiliate)	a. Horizontal joint venture b. Establishment of new affiliate (by exiting foreign affiliate) for the production of same goods and services as it produces	Joint public-private R&D centers/training centers/universities
“Spillovers”	a. Demonstration effects in unrelated firms			

	-Spillover on process (technology) -Spillover on product design -Spillover on formal and tacit skills b. Effects due to mobility of trained human resources c. Enterprise spin-offs d. Competition effects	
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Source: World Investment Report: Promoting Linkage 2001

Note: The cell in **bold** letters is the focus of our research

However, not all linkages are equally beneficial for a host economy. For instance, as noted by *World Investment Report: Promoting Linkages (2001)*, firms may strike considerable linkages in protected industries in which there are inadequate incentive to invest in technological capabilities. Linkages may also involve excessive costs for a host economy. The reason lies in the size and market power of foreign affiliates. Exclusive linkages with large, monopolistic foreign affiliate can lead to anti-competitive practices and unfair terms and conditions for suppliers (Altenburg 2000). The distributing of benefits between buyers and sellers is subject to bargaining, much depending on the technological content of suppliers. Suppliers of high value-added and sophisticated products are generally better placed to benefit from linkages than those selling simple products, for the former have greater scope for enhancing their technological and organizational capabilities via linkages. Suppliers of simple price-sensitive inputs may, in addition, have to compete with each other by cutting costs, making it difficult to raise revenues and pay higher wages. Where affiliates are “footloose” and prone to shift to lower cost locations as wages rise, local suppliers may again be forced to bear a high risk. The risk comes from suppliers “locked in” to large buyers and their fortunes tied to those of their main customers (*World Investment Report: Promoting Linkages 2001*).

In sum, the impacts of backward linkages from FDI to developing host countries are two folded: They provide opportunities for production and employment by domestic suppliers. They constitute a direct channel for knowledge diffusion in upgrading domestic suppliers. However, the ability of multinationals’ linkages depends on the markets in which they operate and their incentives to do so. It also depends on the capabilities of domestic firms to learn.

4.2 Evidence of Backward Linkages around the World

Eng Teknologi Holdings Bhd (ENGTEK), headquartered in Penang, Malaysia, is a global supplier for the computer hard disk drive industries. This holding has nine companies in four countries (China, Malaysia, the Philippines and Thailand). Some 2000 employees generating a total revenue of about \$ 63 millions during 2000. However, some 25 years ago, the company started with a capital of \$200, as a tiny family run venture. One of the reasons for this tremendous change is through linkages with multinationals. ENGTEK has engaged in closely-knit supplier partnerships with world-class multinationals. For example, Intel provided financial as well as technical assistance needed for the company to produce semi-automated wire bonder in 1981. As a first-tier suppliers company, ENGTEK has been able to link up to the global production systems of its multinational clients, moving up the value chain over time. Partnership also helped ENGTEK to internationalize and to become a multinational on its own⁴.

Field research (conducted by UNCTAD in India in 2001) involved interviews with four leading foreign affiliate of multinationals in the food processing industry of India. It reveals that each firm on average sourced 93 percent of their raw material and 74 percent of other inputs. This high level was achieved in part as a result of comprehensive efforts by these companies to assist in the development of local suppliers, including collaboration in production development, technology transfer and training, introduction of contract farming and financial assistance. Technology transfer to local farmer has apparently had a positive impact. For example, prior to Pepsi's activities (in 1989), the tomato yields 16 ton/hectare; by 1999, the yield of its suppliers had increased to 52 ton/hectare.

Evidence also shows how firms in China, the country of primary interest to us, benefit from backward linkages. For example, Nestle operates 18 factories in China. In 1992, much of the company's supplies were imported. It decided in 1994 to engage in active supplier development, and by 1997, 98 percent of its needs were covered by local suppliers. The company worked with local suppliers to help them meet quality standards by providing information, technical assistance and sometimes also financial support. Nestlé's efforts to establish quality control procedures contributed to an improvement of the competitiveness of suppliers, and some of them subsequently exported to Russia,

⁴ *Source:* UNCTAD, based on ENGTEK's presentation at the workshop on technological and managerial upgrading of SMEs through linkages. August 2000.

Korea and elsewhere in Asia. So far, 109 of the 145 suppliers Nestle has dealt with are local.⁵

Similarly, working in full partnership with China's State Development and Planning Commission (SDPC), Motorola has established the *Center for Enterprises Excellence*, a program to provide high-level training to selected state-owned enterprises. The main objective of the program is to develop Motorola's supplier base by strengthening especially quality, production and productivity through classroom and on-site instruction. Recently the program was extended beyond Beijing to the interior of Western China. By 2001, 449 enterprises from 23 provinces, covering 1516 chief executive officers, middle level managers and technicians for 85 enterprises had participated in the program. The trainees come from a wide range of industries, including electronics, telecommunications, computer hardware, software, media and general trading or commercial enterprises. By 2000, the average percentage of locally manufactured parts and components in a cellular phone manufactured in a Motorola plant in China had reached 65 percent. It is expected that Motorola's local procurement will exceed \$1.5 billion, and the number of local suppliers will exceed 1000 by the end of 2001.⁶

One important thing to keep in mind is, although foreign affiliates may benefit local suppliers a great deal in terms of information, technology and global linkages, the technological advancement of local suppliers plays a major part in attract foreign clients. For instance, Nestlé's selection of suppliers in China are based on strict criteria, including the acceptance of Nestlé's specification, acceptance of audits and inspection, the existence of a well-structure quality assurance systems, technical competence in their field of activity, good quality record, reliability and economic viability. In Argentina, as another example, one supplier delivers a particulate product to all outlets of Carrefours or McDonalds, two of the world's most famous processed food retailers. Thus, suppliers need to operate in a sufficient scale to meet the demand of the entire network (Green and Tozanli 2001).

Discussed above are examples of how backward linkage has benefited suppliers. Here is some other evidence of backward linkages from FDI around the world. In some

⁵ *Source*: UNCTAD, based on Nestle 2001 and company interviews.

⁶ *Source*: UNCTAD, based on Motorola, 2001

developed countries, affiliates source between 10 and 20 percent of their inputs locally (i.e. supplied by domestic and foreign-owned suppliers). The average percentage of local sourcing observed in studies of various UK regions, for instance, ranges from 10 to 25 percent (UNCTAD 2001). Some evidence suggests that local procurement increases over time. In Ireland, raw material sourced locally as a percentage of total raw material inputs in non-food manufacturing increased from 16 percent in 1986 to 19 percent in 1994. And in a sample of affiliates in the electronics sector, the percentage of raw materials and components procured locally increased from 8 percent to 24 percent in the same period (Gorg and Ruane 1998).

In developing countries, the share of locally sourced input by foreign affiliates varies by industry and region. Local sourcing by foreign affiliates is particularly low in the garments industry-between 5 and 10 percent. (UNCTAD 2000A). In the Dominican Republic and Costa Rica, for example, very limited subcontracting was observed. In Morocco, similarly, the share of inputs from domestic and foreign-owned suppliers of the garment industry was estimated at only 10 percent in the late 1990s. In the electronics industry, for example, foreign affiliates in the color TV industry in Tijuana, Mexico, sourced 28 percent of their inputs locally, of which only 3 percent was supplied by Mexican-owned firms (Carrillo 2001). Meanwhile, in Malaysia, locally produced components by foreign affiliates in the electronic industries comprised 62 percent of exports in 1994. In the automobile industry, such as in Mexico, local content from Mexican-owned suppliers stood at 30 percent by 1995. In Brazil, local content in the automobile industry had been at a very high 85 percent in 1990. In China, a policy of “localization” stipulated that foreign affiliates in the automobile industry had to source 40 to 50 percent of inputs locally. Several foreign affiliates reached this target, many by inducing their foreign suppliers to invest in China. For example, the share of Shanghai Volkswagen Company’s local sourcing from affiliates stood at 26 percent in 2000, measured as purchases from foreign invested suppliers in total local purchases. (Xia and Lu 2001).

4.3 Theoretical Framework

When we refer to backward linkages, what we are really interested in is the technology transfer through backward linkages. Thus, we test if firms with stronger linkage with

multinational clients should enjoy higher productivity. This hypothesis is easily justified because with more intermediate goods demanded, a slight reduction in supplier price (or improvement in quality) will benefit multinational buyers more greatly. Hence, they may have greater incentives to transfer technology in order to reduce supplier costs (or improve quality).

We have to point out, however, that technology transfer to the home supplier creates a trade-off for the multinational. It benefits the multinational by lowering the price of home intermediate. On the other hand, such technology transfer also lowers the cost of production of the multinational by lowering the price of the home intermediate. For example, if local producers use intermediate input more intensively than multinationals, a slight decrease in input prices may induce a lot more output supply in the final product market, drag down market price and ultimately hurt multinationals. Multinationals will not transfer technology to suppliers if they cannot gain from it. Local suppliers, consequently, lose a channel for technology upgrading. Thus, we are going to test whether or not backward linkages bring productivity gain to local suppliers in Chapter 5.

Regarding backward linkage, there are many other theories and implications. For example, Pack and Saggi (2001) suggests that if technology diffusion to other upstream firms allows more capable suppliers to enter, then one would expect market concentration and input prices to fall. Further, there are impacts on downstream local competitors due to so-call “second round” diffusion. There are also creations of larger varieties of inputs brought about by backward linkage from FDI, as suggested by Rodriguez-Clare (1996). However, we cannot perform tests on each of these theories at this current stage due to data limitation. But still, tests of backward linkage on technology transfer provide us some valuable insides on the role of backward linkage effect in China.

TESTING THE EFFECTS OF TECHNOLOGY TRANSFER THROUGH BACKWARD LINKAGES IN CHINA

We follow the approach of Blalock and Gertler (2004) and Javorcik (2004) by assuming a Cobb-Douglas production function for both firm and industry level data estimations.

5.1 Firm Level Pooled Data Tests

The data⁷ used for firm level tests come from the Chinese Enterprises and Companies Database (CECDB), created by Wanfang Corporation in 1988. CECDB provides over 160, 000 pieces of firm information in 96 sectors, including the twenty- eight two- digit manufacturing sectors in accordance with China's Statistical Yearbook. The information includes firm geographical locations, total sales, fixed asset, number of workers and foreign ownership (joint ventures or wholly foreign owned). From the huge dataset, eighty firms are randomly selected by computer from each of the two- digit sectors, resulting in a sample of 1756 establishments spanning over the period 1999-2002, after missing values are eliminated.⁸

5.11. Testing Backward Linkage on Firm Level Total Factor Productivity (TFP)

We first adopt the same model as Javorcik (2004) as follows:

$$\ln Y_{ijrt} = \beta_0 + \beta_1 \ln K_{ijrt} + \beta_2 \ln L_{ijrt} + \beta_3 \ln M_{ijrt} + \beta_4 \text{Horizontal_FDI}_{jt} + \beta_5 \text{Backward_FDI}_{jt} + \text{FDI}_{ijrt} + d_j + d_t + \varepsilon_{ijrt} \quad (5.1)$$

where Y_{ijrt} , K_{ijrt} , L_{ijrt} , and M_{ijrt} are output, capital, labor and material input of firm i (located in region r) in sector j at time t . In this model, output is regressed against capital, labor and material to capture firm level total factor productivity (TFP), backward, forward

⁷ Please refer to A1 for detailed descriptions of firm data.

⁸ Firm information in CECDB is constantly updated, with old information replaced (rather than extended) over time. We thank the Chinese University of Hong Kong for allowing us to retrieve the firm data from the CECDB.

and horizontal FDI are added accordingly to see if any of these spillover variables will have effects on firm TFP. Equation (5.1) also contains 27 industry dummy variables noted by d_j and 3 time dummy variables noted by d_t . The FDI (dummy) variable takes the value of 0 if a firm has not foreign investment and 1 otherwise. Output takes the value of firm total revenue, capital takes the value of fixed assets and labor is defined as number of workers.

The CECDB unfortunately does not contain values of material input. We thus estimated a firm's materials by apportioning the regional and industrial total material inputs, which are available in China's Industrial Statistical Yearbooks and Statistical Yearbooks of each province, to each firm in the sample by its relative size. In particular,

$$M_{ijrt} = Y_{ijrt} \frac{M_{jrt}}{Y_{jrt}} \quad (5.2)$$

Moreover, to count on the technological and organizational differences between foreign companies (especially multinationals) and Chinese firms, we also distinguish foreign firms from domestic firms in our sample. Equation (5.2) thus becomes,

$$\begin{aligned} M_{ijrtd} &= Y_{ijrtd} \frac{M_{jrtd}}{Y_{jrtd}} \\ M_{ijrtf} &= Y_{ijrtf} \frac{M_{jrtf}}{Y_{jrtf}} \end{aligned} \quad (5.3)$$

where d refers to domestic firm and f, foreign firm.⁹

However, such approximation causes one variable (material input) to be highly correlated with the independent variable (output). In order to avoid the problem of multicollinearity, we test the equation again using value added, which is defined as output minus material input, to see if there is any structural change.

⁹ This is the most refined estimation we are able to obtain from data available. A drawback of such estimation is of course that it incurs a strong linear relationship between output and material input.

$$\ln VA_{ijrt} = \beta_0 + \beta_1 \ln K_{ijrt} + \beta_2 \ln L_{ijrt} + \beta_3 \text{Horizontal_FDI}_{jt} + \beta_4 \text{Backward_FDI}_{jt} + \text{FDI}_{ijrt} + d_j + d_t + \varepsilon_{ijrt} \quad (5.4)$$

where VA_{ijrt} , K_{ijrt} , and L_{ijrt} are value added, capital, and labor firm i (located in region r) in sector j at time t . d_j are industry dummy variables and d_t time dummy variables.

5.12. Calculation of Horizontal, Backward Linkage and Foreign Linkage Ratios

Turning to proxies for spillovers, horizontal FDI is measured by the proportion of an industry's output produced by foreign funded enterprises (both wholly foreign owned and joint ventures):

$$\text{Horizontal_FDI}_{jt} = \frac{\text{output of foreign funded enterprise}_{jt}}{\text{total output}_{jt}} \quad (5.5)$$

where j , t refers to upstream manufacturing sector j at time t .¹⁰ Therefore, horizontal FDI measures the presence of foreign investment in a given sectors. Table 7 lists the horizontal FDI ratio in the 28 two-digit Chinese manufacturing sectors in year 2003. From the table, we learn that foreign presence in 2003 is highest in Electronic and Telecommunications Equipments sectors, accounting for 77% of total output and lowest in Tobacco processing, where there is little foreign participation.

Backward linkage, in principle, should be defined as the share of a firm's output that is sold to foreign-owned firms. However, we would then have to worry about the endogeneity of a particular firm's decision to sell to multinationals customers. Moreover, since the firm-level dataset does not provide information about backward linkages of the firm concerned, we follow Javorcik (2004) to use the backward FDI values that are calculated as the share of an industry's output purchased by downstream foreign funded enterprises in the host country. The implication is that the stronger linkage a sector has with multinationals, the higher productivity firms in that sector should enjoy. In particular,

¹⁰ Our method of calculating horizontal FDI is modified from Blalock (2001), who estimated industry horizontal FDI by $\text{horizontal}_{jt} = (\sum_i \text{FDI}_{ijt} * \text{output}_{ijt}) / \sum_i \text{output}_{ijt}$, where i refers to firm i in sector j , and FDI is a dummy variable taking on the value of one if foreign capital accounts for at least ten percent of a firm's total output. Since the exact data of foreign output and total output of industries can be found in China's statistical yearbook, we simply calculate horizontal FDI by taking the ratio, which gives the same economic meaning.

it is the sum of output shares purchased by all downstream manufacturing sectors weighted by the share of foreign output in those sectors (horizontal FDI):

$$Backward_FDI_{jt} = \sum_{k \text{ if } k \neq j} \alpha_{jk} * Horizontal_{kt} \quad (5.6)$$

where α_{jk} is the proportion of upstream sector j 's output purchased by downstream sector k , which can be obtained from the input-output table. Inputs supplied within a sector are not included, since they are already included in the horizontal FDI variable. As an illustration, suppose that the textile sector sells 20% of its output to the furniture industry, 30% to papermaking, and 50% to garment, in which the shares of foreign output are 3%, 8% and 6%, respectively:

Then, we know that the approximately 0.6% of textile sector's output is purchased by foreign firms in the furniture sector. Since textile also sells its output to papermaking and Garment sectors, we simply sum up the ratios and obtain the linkage ratio for textile sector. $Backward_FDI_j = 0.2 * 0.03 + 0.3 * 0.08 + 0.4 * 0.06 = 0.054$, implying that approximately 6% of textile output is sold to foreign enterprises. In other words, the ratio of backward linkages generated by FDI related enterprises to its textile industry is 0.054.

The same principle applies to the forward linkage variable. It is defined as the weighted share of output in upstream sectors produced by firms with foreign capital participation (Javorcik 2004). As only intermediates sold in the domestic market are relevant to this study, goods produced by foreign firms for exports are excluded. Thus, the formula is defined as,

$$Forward_{jt} = \sum_{m \text{ if } m \neq j} \sigma_{mj} \frac{Foreign_{mt} - X_{mt}}{Total_{mt} - X_{mt}} \quad (5.7)$$

where σ_{mj} is the share of inputs purchased by industry j from industry m . X_{mt} is the value of export of industry m at time t . For the same reason as before, inputs purchased within the sectors are excluded. However, the data for sectoral export are only provided for the year 2001~2003, thus, they are assumed to be zero for the year 1999 and 2000. This is justified because 1) the observations in year 1999 and 2000 take only a minority of total sample size, which implies they cannot affect the result significantly, and 2) we are mainly testing the effects of backward linkage, while considering forward linkage, the same as horizontal spillovers, as control variables.

Table 7. Backward linkage (local sourcing rate), forward linkage and horizontal FDI (foreign presence) in year 2003

Industries	Backward Linkage 03	Horizontal FDI 03	Forward FDI 03
Food Processing	0.01	0.27	0.05
Food Manufacturing	0.08	0.39	0.01
Beverage Manufacturing	0.07	0.32	0.01
Tobacco Processing	0.04	0.01	0.00
Textile Industry	0.03	0.24	0.11
Garments and Other Fiber Products	0.13	0.46	0.01
Leather, Furs, Down and Related Products	0.08	0.51	0.02
Timber Processing, Bamboo, Cane and Palm Fiber	0.05	0.26	0.12
Furniture Manufacturing	0.14	0.50	0.02
Papermaking and Paper Products	0.05	0.31	0.14
Printing and Record Medium Reproduction	0.14	0.34	0.05
Cultural, Educational and Sports Goods	0.18	0.59	0.01
Petroleum Processing and Coking	0.02	0.10	0.07
Raw Chemical Materials and Chemical Products	0.05	0.24	0.12
Medical and Pharmaceutical Products	0.06	0.22	0.00
Chemical Fiber	0.12	0.20	0.19
Rubber Products	0.10	0.37	0.14
Plastic Products	0.11	0.43	0.16
Nonmetal Mineral Products	0.07	0.17	0.04
Smelting and Pressing of Ferrous Metals	0.04	0.09	0.15
Smelting and Pressing of Nonferrous Metals	0.03	0.13	0.17
Metal Products	0.06	0.35	0.09
Ordinary Machinery	0.08	0.25	0.08
Special Purpose Equipment	0.12	0.20	0.04
Transport Equipment	0.09	0.40	0.02
Electric Equipment and Machinery	0.15	0.35	0.08
Electronic and Telecommunications Equipment	0.08	0.77	0.04
Instruments, Meters, Cultural and Office Machinery	0.17	0.68	0.05
Average ratio	0.08	0.33	0.07

Source: Statistical Yearbook of China 2004 and IO table 1997

Table 7 lists the calculated linkage ratios in year 2003. From the information given, we know the sector in 2003 that has the highest backward linkage with downstream multinationals is cultural, educational, and sports goods, which sells 18% of its output to foreign clients. Food processing, other the other extreme, sells only 1% of its input to foreign clients. Foreign linkage is largest for chemical fiber, counting for 19% of its output and smallest for Tobacco processing, where it purchases nothing from multinational suppliers.

Two Input-Output (IO) Tables of China are used to calculate the backward linkage coefficients a_{jk} (as well as σ_{mj}): The values of a_{jk} (σ_{mj}) from 1994 to 1995 follow from the “direct input coefficients” 1992 IO table (which is not applicable for firm level test, but are used for industry level test in the next section), whereas the values for the years from 1996 to 2003 are based on the 1997 IO table.¹¹ ¹² In any event, while the coefficients taken from the IO table remain fixed for some years, horizontal FDI values do change over time so the resulting estimations for backward linkages are time- varying sector-specific variables (Javorcik 2004).

5.13. Regression Results for Robust Cluster Test on Firm Level TFP

We performed robust cluster test, instead of the traditional OLS estimation, because the dataset is unbalanced and that some several variables are also used in explaining firm level productivity. As Moulton (1990) illustrates, the OLS method is usually based upon the assumption of independent disturbances, which is not appropriate for disturbances with grouped structure¹³. As a result, OLS method can lead to standard errors that are seriously biased downward. This can in turn result in spurious findings of statistical significance for the aggregate variables of interest. Thus, we utilize robust cluster test techniques to cluster standard errors in the same industry and year, allowing disturbances to be correlated within groups.

¹¹ China revises its national Input-Output tables about every five years. The 2003 Table is still under progress.

¹² Sectors in the IO Tables are re-grouped so as to match the industry classifications for two-digit level industries in China’s Statistical Yearbook.

¹³ Such as in our model, sectoral variables horizontal and backward FDI are regressed to explain firm level productivity.

The regression results of equation (5.1) and (5.4) are shown in table 8a and b and 9a and b. We first perform regression on all firms (domestic and foreign) with FDI dummy added, and then test of effects on domestic firms and foreign firms separately. Suspecting that backward linkage may take some time to materialize, we also test equation (5.1) and (5.4) with backward and horizontal FDI one year lagged¹⁴.

Table 8a. Robust cluster test on backward, forward and horizontal FDI of current year (firm level pooled 1999~2002)

	Ln (Output)					
	All Firms		Domestic		Foreign	
Ln(Capital)	0.02** (2.12)	0.02** (2.11)	0.02* (1.67)	0.24* (1.67)	0.01*** (2.90)	0.10*** (2.88)
Ln(Labor)	0.02* (1.75)	0.02* (1.87)	0.02* (1.85)	0.02* (1.90)	0.01* (1.86)	0.01* (1.89)
Ln(Material)	0.94*** (33.64)	0.94*** (33.01)	0.93*** (25.44)	0.93*** (25.43)	0.97*** (68.58)	0.97*** (68.75)
Backward	3.46** (2.32)	4.10*** (3.15)	4.12*** (2.84)	4.97*** (3.81)	-5.36** (-2.01)	-6.89** (-2.49)
Horizontal		0.59* (1.75)		0.75* (1.95)		-0.43 (-1.04)
Forward		-0.65** (-2.17)		-0.66** (-2.04)		-0.86 (-1.32)
FDI Dummy		0.03** (2.17)				
Constant	-0.01 (-0.03)	-0.44 (-1.37)	-0.08 (-0.29)	-0.63* (-1.78)	1.30*** (3.14)	1.85*** (3.70)
27 Industry dummy	yes	yes	yes	yes	yes	yes
3 Time dummy	yes	yes	yes	yes	yes	yes
Number of Obs	1756	1756	1240	1240	516	516
Number of Groups	93	93	93	93	55	55
R ²	0.97	0.97	0.97	0.97	0.98	0.98

¹⁴ Forward linkage is not lagged because data for export, one variable in calculating forward linkage would be missing for year 1999, 2000, 2001, causing too much bias.

Table 8b. Robust cluster test on backward, forward, and horizontal FDI with one year lagged (firm level pooled 1999~2000)

	Ln (Output)					
	All Firms		Domestic		Foreign	
Ln(Capital)	0.02** (2.11)	0.02** (2.11)	0.02* (1.67)	0.23* (1.67)	0.01*** (2.92)	0.10*** (2.90)
Ln(Labor)	0.02* (1.77)	0.02* (1.85)	0.02* (1.87)	0.02* (1.87)	0.01* (1.82)	0.01* (1.83)
Ln(Material)	0.94*** (33.56)	0.94*** (32.89)	0.93*** (25.38)	0.93*** (25.37)	0.97*** (67.95)	0.97*** (67.75)
Backward _{t-1}	0.12 (0.16)	0.28 (0.35)	-0.30 (-0.28)	0.00 (0.00)	-1.86** (-2.34)	-1.52** (-2.03)
Horizontal _{t-1}		-0.08* (-0.30)		-0.10 (-0.32)		0.13 (0.29)
Forward		-0.73** (-2.23)		-0.77** (-2.08)		-0.78 (-1.17)
FDI Dummy		0.03** (2.12)				
Constant	0.52*** (4.00)	0.58*** (2.68)	0.62*** (3.48)	0.66** (2.23)	0.17 (1.32)	0.13 (0.54)
27 Industry dummy	yes	yes	yes	yes	yes	yes
3 Time dummy	yes	yes	yes	yes	yes	yes
Number of Obs	1756	1756	1240	1240	516	516
Number of Groups	93	93	93	93	55	55
R ²	0.97	0.97	0.97	0.97	0.98	0.98

Note: tests of backward and horizontal with two years lagged give similar results to one year lagged and thus not are reported here.

We observe without surprise that coefficients on capital and labor are positive and significant. The exceptional significance of material input is perhaps due to apportioning material inputs to each firm by its firm size, so is the usual large R-square. As can be seen in table 9a and b, if we use value added as the dependent variable and eliminate material from the right hand side, the R-square drops to below 0.6. Nonetheless, we argue here that although the inclusion of estimated material input does weaken the statistical significance of capital and labor to some extent, for capital, labor and material are known to be related, it does not affect much of backward linkage and horizontal FDI, since correlation between material and these two variables are no more than 0.1 in absolute value. FDI dummy, as consistent with all previous studies, is positive and significant, suggesting that firms with foreign fund participations outperform their domestic counterparts. For instance, the coefficient 0.03 represents given the same amount of capital and labor and other things the same, foreign firms generate 3 million yuan more than domestic firms.

Table 9a. Robust cluster test on backward, forward, and horizontal FDI of current year (firm level pooled 1999~2002)

	Ln (Value Added)					
	All Firms		Domestic		Foreign	
Ln(Capital)	0.30*** (10.05)	0.29*** (10.39)	0.27*** (8.38)	0.27*** (8.36)	0.30*** (7.08)	0.30*** (7.10)
Ln(Labor)	0.31*** (8.24)	0.32*** (8.60)	0.35*** (8.17)	0.35*** (8.18)	0.22*** (4.32)	0.22*** (4.34)
Backward	10.54 (1.08)	16.18** (2.17)	12.72 (1.53)	19.41*** (2.97)	-23.68 (0.60)	-38.00 (-0.85)
Horizontal		5.72*** (3.91)		6.79*** (4.33)		-1.27 (-0.20)
Forward		-2.19 (-1.46)		-1.65 (-1.14)		-8.92 (-0.77)
FDI Dummy		0.22*** (2.26)				
Constant	2.11 (1.36)	-2.26 (-1.47)	1.52 (1.13)	-3.54** (-2.28)	8.24 (1.34)	11.71 (1.45)
27 Industry dummy	yes	yes	yes	yes	yes	yes
3 Time dummy	yes	yes	yes	yes	yes	yes
Number of Obs	1745	1745	1231	1231	514	514
Number of Groups	93	93	93	93	55	55
R ²	0.58	0.59	0.63	0.64	0.49	0.49

Table 9b. Robust cluster test on backward, forward, and horizontal FDI with one year lagged (firm level pooled 1999~2000)

	Ln (Value Added)					
	All Firms		Domestic		Foreign	
Ln(Capital)	0.30*** (9.79)	0.29*** (10.06)	0.26*** (8.05)	0.26*** (8.09)	0.30*** (6.93)	0.30*** (6.94)
Ln(Labor)	0.30*** (8.07)	0.32*** (8.60)	0.35*** (8.07)	0.36*** (8.21)	0.22*** (4.22)	0.22*** (4.23)
Backward	25.98** (2.08)	17.90* (1.96)	25.21** (2.04)	17.88* (1.76)	-19.05** (2.62)	-19.37** (2.60)
Horizontal		4.15* (1.89)		4.30* (1.82)		-0.52 (-0.13)
Forward		-7.30** (-2.80)		-7.26** (-2.49)		-6.75*** (-6.18)
FDI Dummy		0.22*** (3.59)				
Constant	-0.27 (-0.15)	-1.24 (-0.82)	-0.41 (-0.21)	-1.48 (-0.49)	1.49 (1.38)	5.06** (2.22)
27 Industry dummy	yes	yes	yes	yes	yes	yes
3 Time dummy	yes	yes	yes	yes	yes	yes
Number of Obs	1745	1745	1231	1231	514	514
Number of Groups	93	93	93	93	55	55
R ²	0.56	0.58	0.61	0.62	0.49	0.53

Note: tests of backward and horizontal FDI with two years lagged give similar results to one year lagged and thus are not reported here.

Backward linkage is found to be positive and significant for the cases of all firms and domestic suppliers, representing the productivity of firms in a sector increased when the share of their output sold to foreign-owned firms increase. The coefficient of backward linkage implies the rate of change in value added with respect to backward linkage ratio, given other things the same. Note that it is generally big because backward linkage ratio is very small, about 0.08 on average. This finding is similar to that in Javorcik (2004), indicating evidence of technology transfer through the channel of backward linkage to suppliers in host country. Backward linkage performs negative impact on foreign firms. We suspect this is due to, first, foreign firms are already technology-advanced and do not need these “spillovers”, and second, the improvement of domestic performance from backward linkage generate competition effect to foreign firms in upstream industries. Also note that horizontal FDI, after we control for differences in productivity across sectors, still gives positive and robust results, suggesting a horizontal spillover effect to domestic industry, but has no effect on foreign firms, possible because foreign firms are already technology-advanced, therefore do not need to learn from other foreign competitors. Forward linkage, surprisingly, appear to be negative and significant, the reason of which is not known yet. One can argue that the transfer of technology to local suppliers may take some time to materialize. To examine lagged effects of FDI, we conducted the above cluster test by using one year lagged values of FDI variables. However, the results for backward linkages with one year’s lagged are not significant for equation (5.1) when we use output as the dependent variable (table 8b), but remain robust for equation (5.4) when we take value added as the dependent variable (table 9b). The reason of this difference in robustness can be explained by that material input in table 8b take too much significance (about 95%) of the dependent variable, thus weaken the effects of others. When it is eliminated, we get the robust result for backward linkage in table 9b.

5.14. Testing the Effects of Backward Linkage on Firm Level Labor Productivity

As is also discussed in Chapter 4, staff training is another important way multinationals transfer technology to their suppliers. Hence, we intend to test the effects of backward linkages on labor productivity, which according to China’s Statistical Yearbook, is defined as value added per worker:

$$\ln Labor_productivity_{ijrt} = \beta_0 + \beta_1 Backward_FDI_{jt} + \beta_2 Horizontal_FDI_{jt} + FDI_{dummy}_{ijrt} + d_j + d_t + \varepsilon_{ijrt} \quad (5.9)$$

where labor productivity is the value added per worker at each firm i in sector j at time t .

Table 10. Robust cluster test of backward linkage on labor productivity (firm level pooled 1999~2002)

	Ln (labor productivity)					
	All Firms		Domestic		Foreign	
Backward	66.87 (1.64)	9.01* (1.98)	63.75* (1.66)	13.48** (2.43)	5.00 (0.08)	-51.98* (-1.71)
Horizontal		5.96*** (4.03)		6.47*** (3.71)		-1.93 (-0.39)
Forward		-4.07** (-2.31)		-2.77* (-1.69)		-11.77 (-1.35)
Ln(Capital)		-0.02 (-0.81)		-0.06* (-1.89)		0.06*** (1.49)
FDI Dummy		0.36*** (3.59)				
Constant	-8.81 (-1.37)	-2.72** (-2.34)	-8.37 (-1.44)	-3.67** (-2.46)	1.81 (1.09)	12.21** (2.26)
27 Industry dummy	yes	yes	yes	yes	yes	yes
3 Time dummy	yes	yes	yes	yes	yes	yes
Number of Obs	1745	1745	1231	1231	514	514
Number of Groups	93	93	93	93	55	55
R ²	0.13	0.26	0.13	0.30	0.49	0.22

Note: Tests of backward linkage with one and two years lagged gives similar results and thus are not reported here.

The regression results are presented in table 13. Similarly, we test the effect of backward linkage alone first, and then test the mixed effect of backward, forward and horizontal FDI. Finally, minding that capital might affect labor productivity, we add capital at the last column of each test. From the results, we see that backward linkages have a positive but not strong impact on firm-level labor productivity for the whole sample and domestic firms only. The results, nonetheless, still give evidence of backward linkage ratio increase is associated with labor productivity raise. We also observed that other FDI effects, such as horizontal and partnership effects, also positively contribute to the labor productivity of suppliers. Forward linkage, still gives negative effects, while the reason is unknown. The results remain unchanged when we lag backward linkage and horizontal FDI for one and two years. However, capital input displays little or even negative effect on labor productivity. We suspect this is due to the correlation between capital and labor is higher than between value added. When we observe these FDI effects on foreign firms, we find

that none of them suggest positive impact. This is not surprising to us because foreign firms are already advanced in technology and do not need these “spillovers”. In addition, increased labor productivity of local firms generates competition effects to foreign firms.

5.2 Industry Level Panel Data Tests

While firm level data provide us micro view on the spillover effects of FDI, we would also want to see the effects of backward linkage on industry performance over a longer period.

5.21. Test of Backward Linkage on Industrial Level TFP

In the model using industrial panel dataset, value added is regressed on capital and labor, all in logarithm, to capture industry level total factor productivity (TFP or technology)¹⁵

$$\ln VA_{jt} = \beta_0 + \beta_1 \ln K_{jt} + \beta_2 \ln L_{jt} + \beta_3 \text{Backward_FDI}_{jt} + \beta_4 \text{Horizontal_FDI}_{jt} + d_t + \varepsilon_{jt} \quad (5.1)$$

where VA_{jt} , K_{jt} , L_{jt} are value added, capital and labor for industry j at time t . Backward and horizontal FDI¹⁶ are added accordingly to test the effects of these two variables on industrial TFP. Finally, we add 8 time dummy variables to capture the productivity changes which are independent of the backward and horizontal linkages. The data used in industry level test come from the China’s Statistical Yearbook consisting of a balanced panel spanning over the period 1994-2002, excluding 1998 due to missing value of foreign output in calculating horizontal FDI. I also restrict my sample to the 28 manufacturing sectors¹⁷ classified by China’s Statistical Yearbook only, which then constitutes a sample of 224 observations. I defined value added as industry value added in money term. Capital as annual average of net value of fixed assets and labor as number of industrial workers.

¹⁵ In Aitken and Harrison (1999), Blalock and Gertler (2004 and Javorcik (2004), output is regressed on capital, labor and material input $\ln Y_{jt} = \beta_0 + \beta_1 \ln K_{jt} + \beta_2 \ln L_{jt} + \beta_3 \ln M_{jt} + \varepsilon_{jt}$ to capture productivity. However, from our data we find that material is highly correlated with labor (0.73) and capital (0.86). To avoid multicollinearity, we instead use value added, which equals output minus intermediate input, while eliminating material from the right hand side of the equation.

¹⁶ Forward linkage is not included due to missing data.

¹⁷ It is argued that backward linkage can be generalized mainly between manufacturing sectors. Please refer to World Investment Report: Promoting linkages (2001)

Both value added and capital are deflated by producer price index (PPI) to 1997 value, the year of input-output table¹⁸.

5.22. Industrial Panel (Pool vs. Random vs. Fixed Effect Models) Test Results (With Time Dummy variables vs. Without Time Dummy variables)

Table 11a and b show industry level results under both the pooled data OLS regression and panel data estimations (random effect vs. fixed effects). Pooled OLS put data of various years together as cross-sectional data. Random effect estimation assumes each variable to be independent of the disturbances term, while fixed effect allows the constant term to vary between industries, and it is equivalent to pooled OLS with 27 industry dummy variables. To test if the difference in coefficients between random and fixed effects are systematic or not, we use hausman test to tell which test (random vs. fixed) is more suited in this regression model. We first test the effects of backward linkages alone on industry-level productivity, and then horizontal effects are added. Forward linkage is not tested here due to missing data of sectoral exports during 1994 to 2000. Minding that technology transfer cannot take place immediately, we test backward linkages effects in the same year as well as for value lagged one year. Surprisingly, backward linkage, in spite of current year or one year lagged, performs little or even negative effects on industry productivity. Horizontal FDI are positive, as it should be since an industry with greater foreign presence should have higher TFP because foreign firms are known to be more productive, as we can see in table 4. However, when we run the regression again without time dummy variables, backward linkage effects of FDI become positive and significant except for the pooled data model (table 12a and 12b), suggesting higher local sourcing ratio is associated with higher TFP in the upstream sectors. The reason, as we suspect, is that we are using 1992 and 1997 (mainly 1997) input-output tables to calculate backward linkage ratio from year 1994 to 2003, spanning over a decade. Therefore, we might suspect the backward linkage ratio to be quite stable over the year and fails to capture the real change over this period when FDI is booming and industrial structures are changing dramatically in China. Thus, adding of time dummy variables may explain more of the productivity change and drag away the robustness of backward linkage. Horizontal FDI,

¹⁸ Please see A2 for detailed descriptions of industry data.

on the contrary, uses the real yearly value and captures the real change and therefore, is positive and significant for all cases. Finally, to see which model is better suited to our regression equations, we conduct Hausman test to tell if the difference in coefficients between random and fixed effects are systematic. Large Hausman value indicates fixed effects are better for this model. The Hausman test value is shown at the bottom of each table. Generally speaking, the Hausman tests show that fixed effects are better for the model, which is fairly reasonable since the nature of each industry varies and industry dummy variables can be used to filter other effects that are not explained by our variables. Nonetheless, the test results for backward linkage are similar for both random and fixed effects.

Table 11a. Industry level panel data estimation of backward and horizontal FDI of current year on TFP (1994~2003, excluding 1998): Pooled vs. Random (RE) vs. Fixed (FE) effect models, with time trend

	Ln (Value Added)					
	Pooled		RE		FE	
Ln(Capital)	0.49*** (9.57)	0.53*** (9.66)	0.25*** (5.03)	0.24*** (4.87)	0.18*** (3.54)	0.15*** (2.74)
Ln(Labor)	0.31*** (6.18)	0.28*** (5.40)	0.60*** (9.80)	0.61*** (9.95)	0.64*** (9.12)	0.68*** (9.70)
Backward_FDI	-1.68** (-2.16)	-2.20** (-2.68)	-0.24 (-0.31)	-0.68 (-0.82)	0.52 (0.61)	-0.26 (-0.30)
Horizontal_FDI		0.54* (1.92)		0.43 (1.53)		0.99*** (2.94)
Time dummy	yes	yes	yes	yes	yes	yes
Constant	1.81*** (6.97)	1.61*** (5.78)	2.02*** (6.29)	1.89*** (5.67)		
Adj R-square	0.80	0.81	0.77	0.75	0.74	0.65
F	106.13	91.27			90.26	85.79
Prob>F	0.00	0.00			0.00	0.00
χ^2			974.32	938.08		
Prob> χ^2			0.00	0.00		
Number of obs	252	252	252	252	252	252
Number of Groups			28	28	28	28

Hausman specification test: $\chi^2 = 18.84$, prob > $\chi^2 = 0.06$

Table 11b. Industry level panel data estimation of backward and horizontal FDI with one year lagged (1994~2003, excluding 1998): Pooled vs. Random (RE) vs. Fixed (FE) effect models, with time trend

	Ln (Value Added)					
	Pooled		RE		FE	
Ln(Capital)	0.48*** (9.01)	0.54*** (9.46)	0.24*** (4.79)	0.24*** (4.86)	0.17*** (3.00)	0.13*** (2.43)
Ln(Labor)	0.31*** (5.87)	0.27*** (4.85)	0.58*** (9.09)	0.59*** (9.41)	0.61*** (8.19)	0.61*** (8.84)
Backward_FDI _{t-1}	-1.34 (-1.59)	-2.10** (-2.39)	0.71 (0.91)	-0.48 (-0.58)	1.70** (1.99)	0.05 (-0.30)
Horizontal_FDI _{t-1}		0.36*** (2.68)		1.01*** (3.63)		1.71*** (5.39)
Time dummy	yes	yes	yes	yes	yes	yes
Constant	1.77*** (6.62)	1.48*** (5.18)	2.03*** (6.22)	1.81*** (5.81)		
Adj R-square	0.80	0.81	0.75	0.70	0.71	0.52
F	97.97	91.27			75.36	80.89
Prob>F	0.00	0.00			0.00	0.00
χ^2			739.18	796.97		
Prob> χ^2			0.00	0.00		
Number of obs	224	224	224	224	224	224
Number of Groups			28	28	28	28

Hausman specification test: $\chi^2 = 609.20$, prob > $\chi^2 = 0.00$

Note: Tests of backward and horizontal FDI with two years lagged give similar results and thus are not reported here.

Table 12a. Industry level panel data estimation of backward and horizontal FDI of current year on TFP (1994~2003, excluding 1998): Pooled vs. Random (RE) vs. Fixed (FE) effect models, without time trend

	Ln (Value Added)					
	Pooled		RE		FE	
Ln(Capital)	0.61*** (18.82)	0.61*** (19.24)	0.52*** (16.39)	0.51*** (15.85)	0.40*** (10.04)	0.36*** (8.57)
Ln(Labor)	0.20*** (5.02)	0.20*** (4.89)	0.15*** (2.91)	0.17*** (3.20)	0.04 (0.61)	0.09 (1.42)
Backward_FDI	-0.17 (-0.80)	-1.39* (-1.69)	3.00*** (3.14)	2.17** (2.00)	5.71*** (5.07)	4.48*** (3.79)
Horizontal_FDI		0.52*** (2.68)		0.54* (1.69)		1.23*** (2.99)
Constant	1.37*** (6.40)	1.26*** (5.81)	1.89*** (5.50)	1.77*** (5.02)		
Adj R-square	0.76	0.77	0.73	0.73	0.53	0.36
F	268.07	207.88			95.37	76.34
Prob>F	0.00	0.00			0.00	0.00
χ^2			346.96	350.89		
Prob> χ^2			0.00	0.00		
Number of obs	252	252	252	252	252	252
Number of Groups			28	28	28	28

Hausman specification test: $\chi^2 = 36.74$, prob > $\chi^2 = 0.00$

Table 12b. Industry level panel data estimation of backward and horizontal FDI with one year lagged (1994~2003, excluding 1998): Pooled vs. Random (RE) vs. Fixed (FE) effect models, without time trend

	Ln (Value Added)					
	Pooled		RE		FE	
Ln(Capital)	0.58*** (16.17)	0.60*** (16.81)	0.49*** (14.37)	0.48*** (14.30)	0.35*** (8.75)	0.33*** (8.34)
Ln(Labor)	0.22*** (5.13)	0.20*** (4.89)	0.17*** (3.23)	0.20*** (3.71)	0.04 (0.65)	0.10 (1.64)
Backward _{t-1}	0.04 (0.05)	-1.48* (-1.66)	3.75*** (3.88)	2.06* (1.86)	6.53*** (6.00)	4.11*** (3.54)
Horizontal _{t-1}		0.67*** (3.21)		1.03*** (3.17)		1.78*** (4.60)
Constant	1.46*** (6.20)	1.29*** (5.44)	2.03*** (5.74)	1.80*** (4.98)		
Adj R-square	0.75	0.76	0.71	0.68	0.42	0.24
F	221.24	175.54			71.22	64.26
Prob>F	0.00	0.00			0.00	0.00
χ^2			261.49	278.91		
Prob> χ^2			0.00	0.00		
Number of obs	224	224	224	224	224	224
Number of Groups			28	28	28	28

Hausman specification test: $\chi^2 = 70.33$, prob > $\chi^2 = 0.00$

5.23. Testing Backward Linkage on Industrial Level Labor Productivity (With Time Dummy variables vs. Without Dummy variables)

The same as firm level test, we test if backward linkage will lead to labor productivity raise. We first test the effect of backward linkage alone, then adding horizontal FDI and capital stock as control variables.

$$\ln Labor_productivity_{jt} = \beta_0 + \beta_1 Backward_FDI_{jt} + \beta_2 Horizontal_FDI_{jt} + d_t + \varepsilon_{jt} \quad (5.4)$$

The results for equation 5.4 are presented in table 9. Taking account that capital may be affecting labor productivity, we also add capital in the last column of each model. The same as industry productivity test, we get quite little or even negative results for backward linkage. The positive evidence of horizontal FDI again is already predictable because foreign firms which are known to have higher labor productivity constitute a larger portion of the whole industry and push up the industry-level labor productivity. The hausman test this time suggests that random and fixed effects models are quite systematic.

However, when we run the regression again without time dummy, the coefficients and t statistics of backward linkage become positive and significant except for the pool analysis. We suspect the reason is the same as industry TFP test, we are using 1992 and 1997 (mainly 1997) input-output tables to calculate backward linkage ratio from year 1994 to 2003, which leads to stable backward linkage ratio over the years and cannot capture the real structural change over time. Thus, time dummy variables may explain more of the productivity change and drag away the robustness of backward linkage. Firm level test, on the other hand, span over only 4 years (and relatively stable years since FDI inflow starts to become stationary and the new statistical standards are in use) and that's why we obtain satisfactory results for firm level test.

Table 13a. Industry panel estimation of backward linkage and horizontal FDI on labor productivity (1994~2003, excluding 1998): Pooled vs. Random (RE) vs. Fixed (FE) effect models, with time trend

	Ln (Value Added)					
	Pooled		RE		FE	
Backward_FDI _{t-1}	-4.45*** (-5.58)	-4.65*** (-4.38)	-0.70 (-0.84)	-1.47* (-1.70)	-0.14 (-0.16)	-1.19 (-1.35)
Horizontal_FDI _{t-1}		-0.37 (-1.55)		0.90*** (2.99)		1.33*** (3.89)
Ln(Capital)		-0.08* (-1.94)		0.08* (1.67)		0.05*** (3.12)
Time dummy	yes	yes	yes	yes	yes	yes
Constant	2.13*** (23.33)	2.82*** (8.06)	1.84*** (16.27)	1.09*** (3.21)		
Adj R-square	0.52	0.53	0.50	0.44	0.48	0.37
F	35.84	29.52			244.14	211.90
Prob>F	0.00	0.00			0.00	0.00
χ^2				1941.43	211.90	
Prob> χ^2				0.00	0.00	
Number of obs	252	252	252	252	252	252
Number of Groups			28	28	28	28

Hausman specification test: $\chi^2 = 15.96$, prob > $\chi^2 = 0.11$

Table 13b. Industry panel estimation of backward linkage and horizontal FDI on labor productivity (1994~2003, excluding 1998): Pooled vs. Random (RE) vs. Fixed (FE) effect models, without time trend

	Ln (Labor Productivity)							
	Pooled		RE				FE	
Backward_FDI	-2.15*	1.14	12.83***	5.39***	18.07***	5.91***		
	(-1.84)	(0.80)	(8.93)	(3.86)	(12.43)	(4.08)		
Horizontal_FDI		-0.24		1.59***		2.51***		
		(-0.73)		(3.73)		(5.11)		
Ln(Capital)		0.28***		0.51***		0.45***		
		(5.87)		(11.72)		(8.93)		
Constant	10.60***	8.64***	9.56***	6.30***				
	(112.75)	(24.33)	(63.14)	(23.04)				
R-square	0.01	0.14	0.01	0.06	0.01	0.02		
χ^2			79.66	372.24		148.69		
Prob> χ^2			0.00	0.00		0.00		
F	3.38	13.62			71.22			
Prob>F	0.07	0.06	0.00		0.00	0.00		
Number of obs	252	252	252	252	252	252	252	252
No. of groups			28	28	28	28	28	28

Hausman specification test: $\chi^2 = 17.75$, prob > $\chi^2 = 0.00$

Note: Test of backward and horizontal FDI with one year and two year lags give similar results and thus are not reported here.

However, as a final note, Aitken and Harrison (1999) point out studies that using data aggregated at the sectoral level, were unable to control for differences in productivity across sectors which might be correlated with, but not caused by, foreign presence. The use of industry level data to test spillover effects on productivity may lead to selection bias in the sense that foreign investors may choose to invest in more productive sectors or tend to source their intermediate inputs from sectors with higher productivity. Therefore, we believe firm level test gives us more convincing conclusions because it controls the variation within each industry to implement the “selection bias” problem in the industry test.

5.3 Summaries

Table 14 provides us a summary of our test results,

Table 14. Summary of test results

Dependant Variable	Data description	Test	Effects of Backward Linkages
TFP (output regressed on capital, labor and material)	All firms pooled (99-02)	Robust Cluster	+, significant
	Domestic only pooled (99-02)	Robust Cluster	+, significant
	Foreign firms pooled (99-02)	Robust Cluster	-, significant
TFP (value added regressed on capital and labor)	All firms pooled (99-02)	Robust Cluster	+, significant
	Domestic only pooled (99-02)	Robust Cluster	+, significant
	Foreign firms pooled (99-02)	Robust Cluster	-, significant
Labor Productivity	All firms pooled (99-02)	Robust Cluster	+, significant
	Domestic only pooled (99-02)	Robust Cluster	+, significant
	Foreign firms pooled (99-02)	Robust Cluster	-, significant
TFP (value added regressed on capital and labor)	Industry-Level Panel 94-03, with time dummy variables	Pooled	-, significant
		Random	-, insignificant
		Fixed	-, insignificant
TFP (value added regressed on capital and labor)	Industry-Level Panel 94-03, without time dummy variables	Pooled	-, insignificant
		Random	+, significant
		Fixed	+, significant
Labor Productivity	Industry-Level Panel 94-03	Pooled	-, significant
		Random	-, significant
		Fixed	-, insignificant
Labor Productivity	Industry-Level Panel 94-03	Pooled	-, significant
		Random	+, significant
		Fixed	+, significant

To conclude, we test the effects of backward linkage on productivity using two datasets- firm and industry level data. Firm level data give us convincing evidence of the positive effects of backward linkage, indicating that increase backward linkage of FDI will lead to productivity gains of those firms in the upstream industries. This includes all firms, as well as domestic firms. Industry test, although does not provide evidence of backward linkage when time dummy variables are included, we suspect it may be caused by the lack of yearly input-output table to capture the real change in local sourcing from FDI. Thus, adding of time dummy variables may explain more of the productivity change and drag away the robustness of backward linkage. We are waiting for the more updated I-O table to revise our test and see if there are significant changes in our estimation results. Finally, our test results are consistent with other tests applying the same methodology and our theoretical hypothesis.

Appendix. Data Descriptions

A1. Firm Data

The data used for firm level test come from the Chinese Enterprises and Companies Database (CECDB), created by Wanfang Corporation in 1988. CECDB provides over 160, 000 pieces of firm information in 96 sectors, including the twenty- eight two- digit manufacturing sectors in accordance with China's Statistical Yearbook. The information includes firm geographical locations, total sales, fixed asset, number of workers and foreign ownership (joint ventures or wholly foreign owned). The data are classified by either the two-digit or three-digit industries they belong to. In each industry, the computer displays the firm information in a random order (generated by computer) and I was allowed to get the first 80 firms of each industry. After missing values are eliminated, we obtained a sample of 1756 establishments spanning over the period 1999-2002. Because the firm data are on updated-basis, and once the information is updated, the old information is gone. Thus, the information of year 2002 takes a majority of the sample with some unupdated data of year 99, 00 and 01 (table 14b).

Basic information about the firm dataset is given in table 14a, 14b and 14c. As can be seen, a majority of the data is for the year 2002 and over two-thirds of the firms are domestic. The sample represents a fairly balanced industry breakdown as give in table 10c.

Table 15a. Summary statistics of firm level pooled data

Variable	Observations	Mean	Std. Dev.	Min	Max
Output	1756	37996	278993	100	7107038
Capital	1756	22712	177351	7.5	5000000
Labor	1756	1214	6562	15	128804

Table 15b. Year and ownership distributions of firm level pooled data

Year	Distribution	Ownership	Distribution
2002	1335	Domestic	1240
2001	111	Joint-venture	312
2000	289	Wholly foreign owned	204
1999	21		
Total	1756	Total	1756

Table 15c. Sectoral distributions of firm level pooled data (Total vs. Foreign)

	Industries	Number of obs		ratio
1	Food Processing	64	16	0.25
2	Food Manufacturing	66	25	0.38
3	Beverage Manufacturing	57	17	0.30
4	Tobacco Processing	50	2	0.04
5	Textile Industry	68	13	0.19
6	Garments and Other Fiber Products	66	31	0.47
7	Leather, Furs, Down and Related Products	65	29	0.45
8	Timber Processing, Bamboo, Cane and Palm Fiber	51	16	0.31
9	Furniture Manufacturing	51	26	0.51
10	Papermaking and Paper Products	64	18	0.28
11	Printing and Record Medium Reproduction	63	18	0.29
12	Cultural, Educational and Sports Goods	65	36	0.55
13	Petroleum Processing and Coking	63	10	0.16
14	Raw Chemical Materials and Chemical Products	69	14	0.20
15	Medical and Pharmaceutical Products	58	6	0.10
16	Chemical Fiber	58	15	0.26
17	Rubber Products	54	13	0.24
18	Plastic Products	67	24	0.35
19	Nonmetal Mineral Products	64	11	0.17
20	Smelting and Pressing of Ferrous Metals	68	8	0.12
21	Smelting and Pressing of Nonferrous Metals	61	8	0.13
22	Metal Products	67	20	0.30
23	Ordinary Machinery	62	10	0.16
24	Special Purpose Equipment	67	18	0.27
25	Transport Equipment	70	22	0.31
26	Electric Equipment and Machinery	70	24	0.34
27	Electronic and Telecommunications Equipment	74	47	0.63
28	Instruments, Meters, Cultural and Office Machinery	54	19	0.35
	Total	1756	516	0.29

A2. Industry Data

The data used in industry level test come from the China's Statistical Yearbook consisting of a balanced panel spanning over the period 1994-2002, excluding 1998 due to missing value of foreign output in calculating horizontal FDI. I also restrict my sample to the 28 manufacturing sectors¹⁹ classified by China's Statistical Yearbook only, which then constitutes a sample of 224 observations. I defined value added as industry value added in money term. Capital as annual average of net value of fixed assets, and labor as number of industrial workers. Both value added and capital are deflated by producer price index (PPI) to 1997 value. Here are the explanatory notes taken from China's Statistical Yearbook 2004.

Value-added of Industry refers to the final results of industrial production of industrial enterprises in money terms during the reference period.

Industrial value-added can be calculated by two approaches: the production approach, i.e. gross industrial output value minus intermediate input plus value-added tax, and the income approach, i.e. income for various factors used in the course of production, including depreciation of fixed assets, remuneration of laborers, net of production tax, and operating surplus. Value-added of industry in the Yearbook is calculated by production approach as following:

Value-added of industry = gross industrial output – industrial intermediate input + value-added tax

(1) Gross industrial output: refers to the total achievements of industrial production during a given period. Gross industrial output includes value of finished products, income from external processing, and value of change in semi-finished products at the end and at the beginning of the reference period. Since 1995, it was substituted by the gross industrial output value by new method.

(2) Industrial intermediate input: refers to purchased goods and paid services consumed

during the industrial production of enterprises. Fees paid for services include fees paid for the services provided by material production sectors (industry, agriculture, wholesale and retail trade, construction, transport, post and telecommunications) and by non-material production sectors (insurance, banking, culture, education, scientific research, health and medical care, public administration, etc.). The determination of industrial intermediate input follows the principle that the goods and services must be purchased from outside and included in the gross industrial output, and that the goods and services are inputted into production and consumed (include low-value consumables) during the reference period.

Annual Average of Net Value of Fixed Assets refer to average of the net value of fixed assets during the reference period, calculated with the following formula:

Annual Average of Net Value of Fixed Assets = sum of net value of fixed assets at the beginning and at the end of each month from January to December / 24.

Information on this indicator can be obtained from the beginning and ending figures of the original value of fixed assets and cumulative depreciation from the *Assets and Liability Table* of enterprises.

Net value of fixed assets refers to the original value of fixed assets minus depreciation over the years, i.e.:

Net value of fixed assets = original value of fixed assets – cumulative depreciation.

Average Annual Number of Employed Persons: Employed persons refer to all those who are employed in enterprises and receive remunerations there from, including currently working employees, retirees who are re-employed, teachers of local-run schools, as well as foreigners, staff from Hong Kong, Macao and Taiwan, part-time employees and persons with second job who are employed by the enterprise, and employees of other units temporarily working in the enterprises, but excluding former

¹⁹ It is argued that backward linkage can be generalized mainly between manufacturing sectors. Please refer to World Investment Report: Promoting linkages (2001)

employees who left the enterprise with their employment records still kept by the enterprises.

Average number of employed persons refers to the number of employees everyday during the reference period, calculated with the following formula:

Annual average number = sum of monthly average number in reference year/12.

A3. Input-Output Table(s)

Input-output (IO) tables are edited every 5 years. So far, there are four Chinese IO tables in total: 1982, 1987, 1992, and 1997 real value IO table. In the most recent table-1997 IO table of China, the entire Chinese economy is divided into 118*118 sectors, of which 90 are industrial sectors. The basic matrix displays the actual amount of goods (in money term) purchased or sold between industries. The column shows the amounts of each upstream sector's output purchased by various downstream sectors and rows displays the amounts of each downstream sector's input supplied by various upstream sectors. The "direct input coefficient" matrix is the share (ratio) of each upstream sector's output purchased by its downstream sectors, and each column sums up to unity. The basic matrix is combined horizontally and vertically into a 28 * 28 matrix in accordance with the manufacturing sectors in China's Statistical Yearbook and the way to calculate backward linkage has already been stated in equation (5.6).

LIMITATIONS OF RESEARCH

This paper shed some lights on various effects of backward linkage from FDI on the development of upstream industries. We find that higher backward linkage is associated with higher productivity for both industry level and firm level data. However, there are still several limitations of our research. These limitations are generally of two kinds: data limitations and methodology limitations.

6.1 Data Limitations

The major limitation comes from unavailability of data. For instance, the actual data for backward linkage from FDI, the variable of our primary interest, are not available for industries and firms. Thus, we have to estimate backward linkage for each industry as stated in equation (5.3). Also, the information provided by firm level dataset is limited: we would love to have a panel dataset of longer periods so that we can control for time variance. Panel firm data can also provide us more convincing evidence on upstream firm growth as discussed in chapter 6, and so far, we only perform such test on industry level panel data, which suffers the problem of “selection bias”. Moreover, in firm level data, the information for total output is not provided. Although total revenue is the closest substitute for total output, the existence of inventory is not adjusted. Also, we would prefer total wage to the number of workers because it takes into account those high-skilled and low skilled workers. Most importantly, one crucial variable in predicting total factor productivity – material input, is not available, and so that we have to estimate firm level material by assuming the input-output ratio in a certain industry at a certain region is uniform. Fortunately, the similar regressions results in equation (5.1) and (5.4) suggest that our estimation of material input is quite reasonable. Further, due to data limitation, i.e. data for investment are not provided, we cannot, like Blalock and Gentler (2004) and Javorcik (2004), to apply Olley and Pakes correction to control for the endogeneity of input selection and firm exit.

Finally, input-output table is available only up to 1997. Ideally we would like to have yearly input-output table up to most recent year of our test, which would give us backward linkage ratios with strong time variance effects. Since input-output tables are constructed in five-year intervals, the best thing we can do so far, is to wait until input-output table 2003 to be published to revise our tests.

6.2 Methodology Limitations

The major methodology limitation goes to the estimation of backward linkages (however, this is also due to data limitation because the actual data for backward linkages from FDI are not available). We made use of data from input-output table and China Statistical Yearbook to approximate the share of output purchased by multinational clients. However, such estimation carries the same weight for each industry. However, we know the backward linkage incentives of FDI differ among industries in nature. It is also likely that the share of input bought domestically by MNCs is lower than for local firms. We do not distinguish the backward linkage to local or multinational suppliers, either.

In addition, as Alfaro and Rodrigues-Clare (2003) pointed out, in differentiated product industries, sales revenue and input expenditures are not good proxies for physical output and input, leading to underestimation of productivity measures (although both measurement have their advantages and disadvantages). Further, regression of productivity on backward linkage may not be able to filter other effects rather than technology transfer. For instance, selling to multinationals may allow suppliers to operate at a more efficient scale. Thus, in the future we hope to adjust these limitations and expand the scope of our research.

CONCLUDING REMARKS

Our research looks into various aspects of backward linkage on upstream suppliers' performance, including total factor productivity and labor productivity for both the firm level and industry level test. Again, let us review the summary of our test results,

Table 16. Summary of test results

Dependant Variable	Data description	Test	Effects of Backward Linkages
TFP (output regressed on capital, labor and material)	All firms pooled (99-02)	Robust Cluster	+, significant
	Domestic only pooled (99-02)	Robust Cluster	+, significant
	Foreign firms pooled (99-02)	Robust Cluster	-, significant
TFP (value added regressed on capital and labor)	All firms pooled (99-02)	Robust Cluster	+, significant
	Domestic only pooled (99-02)	Robust Cluster	+, significant
	Foreign firms pooled (99-02)	Robust Cluster	-, significant
Labor Productivity	All firms pooled (99-02)	Robust Cluster	+, significant
	Domestic only pooled (99-02)	Robust Cluster	+, significant
	Foreign firms pooled (99-02)	Robust Cluster	-, significant
TFP (value added regressed on capital and labor)	Industry-Level Panel 94-03, with time dummy variables	Pooled	-, significant
		Random	-, insignificant
		Fixed	-, insignificant
TFP (value added regressed on capital and labor)	Industry-Level Panel 94-03, without time dummy variables	Pooled	-, insignificant
		Random	+, significant
		Fixed	+, significant
Labor Productivity	Industry-Level Panel 94-03	Pooled	-, significant

		Random	-, significant
		Fixed	-, insignificant
Labor Productivity	Industry-Level Panel 94-03	Pooled	-, significant
		Random	+, significant
		Fixed	+, significant

To test whether backward linkages bring productivity gain to local suppliers, we adopt Javorcik's (2004) model to examine the effects of backward linkages from FDI on performance of local suppliers using industry level panel and firm level pooled dataset in Chinese manufacturing sectors. Both tests we perform complement each other. While the industry-level data constitute a balanced panel sample from 1994-2002, the firm level data contain more accurate information about productivity gains at the micro level. The firm level tests provide robust evidence of the positive effects of backward linkage on firm productivity in the Chinese manufacturing sectors, which are consistent with previous studies using the same methodology. The industry tests, on the contrary, provide little evidence of such effects. However, we believe this is due to lack of multiple input-output tables to capture the real industry structural change over time, and that's why the test results are reversed when time dummy variables are eliminated.

Generally speaking, our test results are consistent with previous studies by providing positive evidence of backward linkage on industry and firm level productivity, and such productivity are not limited to production technology, but also labor productivity. Our study adds to the recent new empirical studies of backward linkages effects of FDI (as mentioned in the Introduction) and, to our knowledge, is the first attempt to examine such effects in China.

Policy Implications

The theoretical discussions and econometrical analysis show the strong evidence of technology transfer from FDI through backward linkage in the Chinese manufacturing sectors. Thus, it is for the government's interests to enhance the magnitude of backward linkage. Before Trade Related Investment Measures (TRIMS), the effective ways to do so

were mainly local content requirement and contractual technology transfer requirement. However, upon China's accession to the WTO, the restrictions on foreign investment in terms of investment fields, geographic regions, technology transfers, local content requirement and foreign exchange equilibrium were removed. Thus, under this new "game", the government needs to come up with alternative ways to strengthen backward linkage with FDI. Perhaps one meaningful way is to raise multinationals' incentives to purchase intermediate input locally in China after the requirement for local content were called to an end. Under profit maximization, multinationals will always choose the ways that give them the highest profit- if it is more expensive for multinationals to import intermediate input from overseas, they will choose to purchase raw material in host country. Thus, local suppliers can either reduce prices or improve quality for intermediate input to attract multinational clients away from imports. Both ways can be realized by self-technology upgrading. Actually, several literatures have pointed out that backward linkage depends on technology sophistication of local suppliers. Moran (2001) indicates that multinationals have incentives to build up supply chains with local suppliers only when such supply chain can assist them achieve full economics of scale. Therefore, self-upgrading is an effective way in enhancing backward linkage from FDI.

Besides, the Chinese government may want follow Singapore's example by setting up Local Industry Upgrading Program, in which the Economic Development Board reimbursed the salary of managers of each participating multinational investor if these managers would invite local companies to their quality and process training programs, and would help identify which of them showed promise of becoming internationally competitive suppliers. For example, the foreign affiliate would often recommend specific machinery for the local firms to buy to upgrade their own performance (Moran 2001). To sum, under the WTO rules, the key is to rely on foreign investors to point out promising suppliers and help them obtain the assistance they need to follow recommendations about equipment and training, without requiring the multinationals to by specific amounts of suppliers' output. This approach to vendor development has appeared to be transparent. The formula for success has been on the part of host authorities rather than mandatory controls and requirements.

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