CHIECO-00399; No of Pages 15

China Economic Review xxx (2009) xxx–xxx

Contents lists available at ScienceDirect

China Economic Review

Do Chinese domestic firms benefit from FDI inflow? Evidence of horizontal and vertical spillovers ☆

Ping LIN [a,*], Zhuomin LIU [b], Yifan ZHANG [a]

[a] Department of Economics, Lingnan University, Tuen Mun, N.T., Hong Kong Q1
[b] Department of Economics, University of Pittsburgh, Pittsburgh, PA 15260, United States Q2

ARTICLE INFO

Article history:
Received 21 March 2006
Accepted 20 May 2009
Available online xxxx

JEL classification:
F21
L14
O53

Keywords:
Foreign direct investment
Spillovers
China

ABSTRACT

Using a large panel dataset covering all manufacturing firms (above a minimum scale) in China from 1998 to 2005, this paper examines whether there exist productivity spillovers from foreign direct investment (FDI) to domestic firms. In estimating productivity, we control for a possible simultaneity bias by using semi-parametric estimation techniques. We find that Hong Kong, Macao and Taiwan (HMT) invested firms generate negative horizontal spillovers, while Non-HMT foreign invested firms (mostly from OECD countries) tend to bring positive horizontal spillovers in China. These two opposing horizontal effects seem to cancel out at the aggregate level. We also find strong and robust vertical spillover effects on both state-owned firms and non-state firms. However, vertical spillover effects from export-oriented FDI are weaker than those from domestic-market-oriented FDI.

1. Introduction

It is by now well recognized that inward foreign direct investment (FDI) can benefit the host country by generating spillovers to the rest of the economy, in addition to bringing in capital.[1] In fact, one of the primary motivations for governments around the world to attract foreign direct investment is the belief that the presence of FDI will benefit domestic firms. World Bank (1993) writes that “FDI brings with it considerable benefits: technology transfer, management know-how, and export marketing access. Many developing countries will need to be more effective in attracting FDI flows if they are to close the technology gap with high-income countries, upgrade managerial skills, and develop their export markets.” These claims have encouraged developing countries as well as developed countries to create costly programs, such as tax breaks, subsidized industrial infrastructure, and duty exemptions, in order to attract FDI. From 1991 to 2002, developing countries made over 1500 regulatory changes favorable to FDI (UNCTAD, 2003, p.21). Despite its importance to policy choices, recent empirical studies on FDI spillovers find mixed results. In a summary of the existing evidence, Rodrik (1999, p.37) concludes, “today's policy literature is filled with extravagant claims about positive spillovers from FDI, but the hard evidence is sobering.”

☆ We would like to thank co-editor Jeffrey Zax and an anonymous referee for their useful suggestions which improved the quality of the paper substantially. We would also like to thank Daniel Berkowitz, Loren Brandt, K. Y. Cheung, Deborah Davis, Simon Fan, Ying Fang, Lok-Sang Ho, Chang-Tai Hsieh, Yasheng Huang, W. L. Lai, Thomas Rawski, Christopher Udry, Thomas Voon, and Xiangdong Wei, and seminar participants at Lingnan University, University of Pittsburgh and Yale University for their helpful comments and discussions. Financial support from Lingnan University is acknowledged (Funding # DR07B4).
* Corresponding author.
E-mail address: plin@ln.edu.hk (P. Lin).
[1] See Moran (1998) for a comprehensive survey of the effects of FDI on economic development of host countries.

1043-951X/$ – see front matter © 2009 Published by Elsevier Inc.
doi:10.1016/j.chieco.2009.05.010

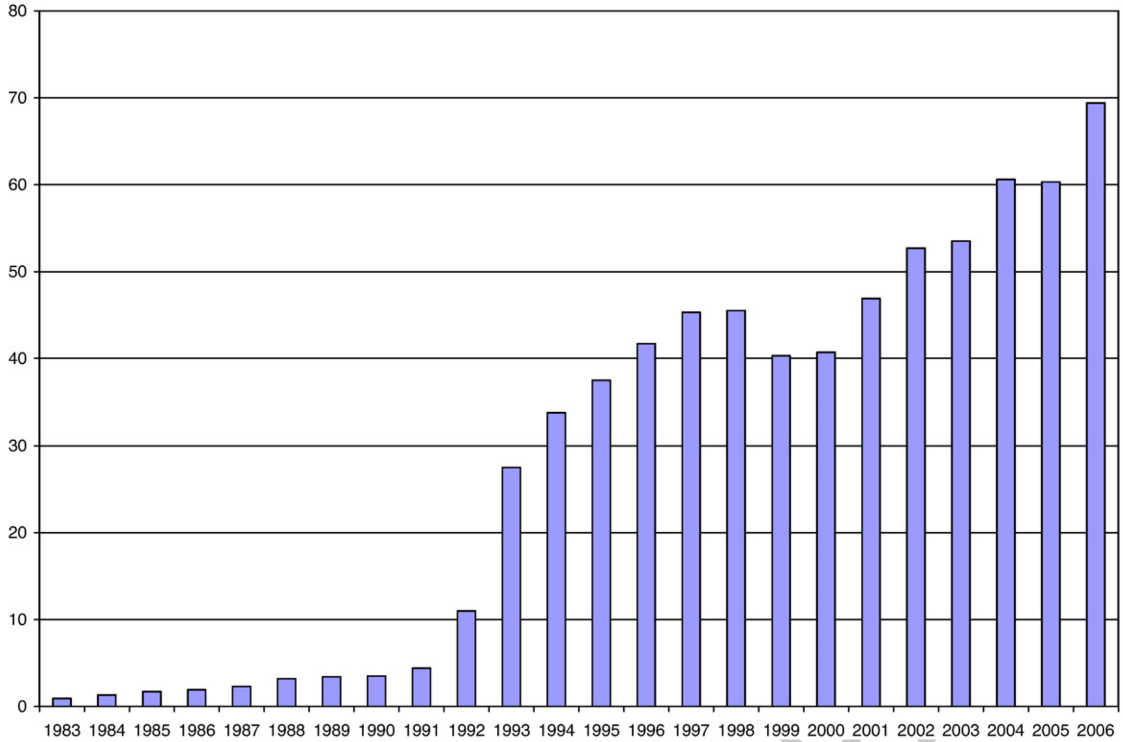

Fig. 1. FDI inflow into China (1983–2006). Source: Table 18-14 of China Statistical Yearbook (2006) and Statistical Communiqué of the People's Republic of China on the 2006 National Economic and Social Development. Q3

According to the theories, FDI spillovers can work through a number of channels. First, domestic firms can benefit from the presence of FDI in the same industry, leading to intra-industry or horizontal spillovers, through labor turnover, demonstration effects and competition effects. Second, there may be spillovers from foreign invested firms operating in other industries, leading to inter-industry or vertical spillovers. This type of spillover effect is often attributed to buyer–supplier linkages and therefore may be towards upstream (backward spillovers) or downstream industries (forward spillovers).

This paper examines the extent of FDI spillovers using firm-level panel data from China's manufacturing sector. Our dataset covers all state-owned firms and all non-state firms with sales above 5 million Yuan from 1998 through 2005. The number of firms in our dataset ranges from 124,944 in 1998 to 243,974 in 2005. China is of particular interest because it is the largest economy among developing countries, and more importantly one of the largest recipients of FDI in the world. Guided by FDI-oriented philosophy, Chinese governments at all levels compete aggressively with each other to offer tax breaks and other incentives to foreign investors. Fig. 1 shows the basic trend of FDI inflow into China between 1983 and 2006.

The general approach in this paper is to regress firm-level total factor productivity (TFP) on measures of foreign presence in the firm's related industries. We use panel data models to remove the effects of unobservable firm-specific variables. In line with previous studies such as Pavcnik (2002) and Javorcik (2004), we employ a semi-parametric estimation technique following Levinsohn and Petrin (2003) to get consistent estimates of TFP. We use China's 2002 Input–Output Table to calculate the measures of vertical linkages of Chinese industries.

In the paper, we examine both the horizontal and vertical spillovers of FDI, as well analyzing the market orientation of FDI, the geographic/cultural origin of FDI, and the ownership of domestic firms. We find that export-oriented FDI is not very different from domestic-market-oriented FDI in that we find the same positive backward and forward spillovers. In addition, Chinese statistics identify two types of foreign invested firms in China: those invested from Hong Kong, Macao and Taiwan (HMT), and those invested by foreign investors from countries in other regions (mainly from the OECD countries). We find that HMT firms bring negative horizontal spillovers, whereas Non-HMT firms tend to generate positive horizontal spillovers. We believe this is because many of the HMT firms are labor intensive and compete more intensively with domestic firms, compared with foreign invested firms from the OECD countries. We find strong and consistent positive forward spillovers of FDI on Chinese firms, in all estimation specifications. Backward spillovers can only be found from Non-HMT invested firms, however. When we compare the state-owned enterprises (SOEs) and non-state enterprises (Non-SOEs), we find consistent evidence of vertical FDI spillovers on both types of firms, although the magnitude of the vertical spillover effects is larger for SOEs.

The rest of the paper is organized as follows. Section 2 provides an overview of the literature. Section 3 describes the evolution of FDI in China. Section 4 discusses the data and the measurement issues. Estimation strategy is presented in Section 5. In Section 6, we report the results of the econometric tests and compare our results with those of previous studies. The paper concludes with Section 7.

Please cite this article as: Lin, P., et al., Do Chinese domestic firms benefit from FDI inflow? *China Economic Review* (2009), doi:10.1016/j.chieco.2009.05.010

2. Overview of FDI spillover channels

2.1. Horizontal spillovers

Horizontal spillovers of FDI take place when the presence of FDI increases the productivity of the domestic firms in the same industry. Teece (1977) argues that such spillovers can occur through various channels. The first channel is the demonstration effect. Domestic firms may be able to reduce the innovation costs simply by observing and imitating the foreign invested firms. The second channel is labor turnover. Workers employed and trained by foreign invested firms may join domestic firms or create their own firms. The third channel is the competition effect. The entry of foreign invested firms can force domestic firms to restructure and improve their production techniques and management. However, the increased intensity of competition may hurt domestic firms at least in the short run by reducing their market share and output. As shown by Aitken and Harrison (1999), the productivity of domestic firms would fall if they have to spread their fixed costs over smaller sales volume. This is usually interpreted as a crowding-out effect. Also, entry of foreign invested firms may also raise labor costs of domestic firms. Since foreign invested firms often pay higher wages, they may raise wages for all firms in competitive labor markets (Aitken, Harrison, & Lipsey, 1996). Theoretically, therefore the net horizontal effect of FDI on domestic firms is inconclusive; it depends on the relative magnitudes of the positive technological spillovers and the negative crowding-out effect.

There are two generations of empirical studies on horizontal effects. The first generation is characterized by industry-level studies. A partial list includes Caves (1974) for Australia, Globerman (1979) for Canada, and Blomstrom and Persson (1983) for Mexico. Most of the first generation studies find a positive correlation between FDI and industry productivity. Since most of them use cross-sectional data, it is difficult to distinguish whether FDI actually increases domestic firms' productivity, or whether foreign investors are simply attracted to the high-productivity industries.

The second generation of empirical studies is based on firm-level panel data. The advantage of the panel data approach is that it can control for foreign investor selection bias. These studies examine whether foreign presence increases the productivity of the firms in the same industry. The results, however, have been mixed. In a study of Venezuelan factories, Aitken and Harrison (1999) find net negative benefits to domestic firms, a result that they attribute to the crowding-out effect. Other studies that find negative spillovers include Haddad and Harrison (1993) for Morocco, Djankov and Hoekman (2000) for the Czech Republic, Konings (2001) for Bulgaria, Romania, and Poland, and Javorcik (2004) for Lithuania. In contrast, studies on developed countries often find evidence of positive spillovers. They include Castellani and Zanfei (2002) for Italy, Keller and Yeaple (2003) for the United States, Görg and Strobl (2003) for Ireland, and Haskel, Pereira, and Slaughter (2007) for the United Kingdom.

2.2. Vertical spillovers

In their review of the literature on productivity spillovers, Blomstrom and Kokko (1998) point out that "local firms may be able to improve their productivity as a result of forward or backward linkages with MNC affiliates." Backward spillovers of FDI refer to the technology transfer through supply chains from foreign invested firms to domestic suppliers. Similarly, forward spillovers occur when domestic firms gain access to new or less costly intermediate inputs as a result of the foreign investment in upstream industries. If foreign invested firms are successful at preventing the leakage of their firm-specific knowledge to domestic competitors in the same industry, there is no scope for intra-industry technology spillovers. It is possible, however, that foreign invested firms voluntarily or involuntarily help increase the productivity of domestic suppliers through backward linkages. Lall (1980) notes that technology transfer from multinationals to local suppliers can take place in several ways. A multinational might (1) help prospective suppliers set up production capacities; (2) provide technical assistance to raise the quality of suppliers' products and to facilitate innovations; and (3) provide training and help in management and organization (also see UNCTAD, 2001).

Several factors may affect multinationals' decisions to transfer technology to local suppliers and their effects on the degree of backward linkages. First, as Rodriguez-Clare (1996) points out, if a multinational can easily access international market and import intermediate goods from overseas, it will choose the channel that yields the highest profit. In particular, it may choose to import the intermediate goods for quality considerations for instance, instead of sourcing them locally. For example, in the 1990s, China's machine tool and aircraft industries suffered significant decline partly because their downstream customers insisted to source intermediate goods from overseas markets. Such displacement of pre-existing linkages, as emphasized in Rodriguez-Clare (1996), could be detrimental to the host country. Second, even if the foreign investors source locally, their local suppliers may fail to learn and absorb the technology to be transferred if they are far behind their foreign partners in productivity (Smarzynska, 2002). Finally, entry of foreign investors can also lower the degree of backward linkages with domestic suppliers if the foreign investors require its domestic suppliers to cease supplying other downstream firms as a condition for transferring its technology. Lin and Saggi (2007) show that such exclusive technology transfer arrangements can indeed emerge in equilibrium and hurt the domestic economy in terms of both vertical linkages and welfare.[2]

Evidence of technology transfer through vertical supply chains is well documented in case studies. For example, MacDuffe and Helper (1997) provide a rich description of technology transfer to U.S. parts suppliers following the entry of Japanese car makers. Driffield, Munday, and Roberts (2002) examine vertical spillovers with industry-level data from the UK. Blalock (2002) analyzes

[2] See Lin and Saggi (2005) for a survey of the theoretical literature on FDI and backward linkages.

Please cite this article as: Lin, P., et al., Do Chinese domestic firms benefit from FDI inflow? *China Economic Review* (2009), doi:10.1016/j.chieco.2009.05.010

Indonesian firms and Javorcik (2004) studies a panel dataset from Lithuanian industries, both of which find positive FDI spillovers through backward linkages. Gorodnicjenko, Svejnar, and Terrell (2007) use firm-level data from 17 former Eastern European countries to test both horizontal and vertical FDI spillovers. They find that backward spillovers are consistently positive; horizontal spillovers are mostly insignificant; and forward spillovers are positive only for old and service sector firms. They also find that lack of absorptive capability on the part of domestic firms tends to dampen spillovers. Most recently, Girma, Gorg, and Pisu (2007) studied FDI spillovers in the U.K. and find that both horizontal and vertical spillovers depend on export orientation of foreign invested firms.

3. Foreign direct investment in China

Since the late 1970s, China has aggressively pursued policies that encourage FDI inflow. It is not surprising that China developed its first law governing foreign investment in 1979, while the first law relevant to domestic firms was not enacted until 1988.[3] The amount of China's FDI inflow has increased dramatically from $6.33 billion in 1985 to $69.5 billion in 2006.[4] China's accumulative FDI reached $750 billion by the end of June in 2007.[5] Foreign invested firms accounted for 10.6% of total investment in fixed assets, 31.6% of total industrial output, and 58.9% of foreign trade in 2006.[6]

Hong Kong is the most important source of FDI in China. In 2006, Hong Kong invested 20.2 billion dollars in China, accounting for 32.1% of the total.[7] Other major sources of FDI include Japan, United States, South Korea, Taiwan and Virgin Islands.[8] In recent years, an increasing share of FDI came from global giants in OECD countries such as Motorola, Samsung and Siemens. As a result, the share of HMT investment in total foreign investment declined from 47% in 1998 to 35% in 2006.[9]

Nearly 70% of FDI in China was poured into the manufacturing sector. This is mainly due to the competitive edge of relatively low production cost in China for manufacturing. The other reason is that FDI in service sector until recently has not been fully liberalized (Branstetter & Lardy, 2008).

In the early 1980s, China's FDI policies were mainly characterized by setting up new regulations to permit joint ventures between foreign investors and local partners and setting up Special Economic Zones. During this period, FDI inflow was low and remained roughly constant. Since 1986, China started to further open up to FDI and adopted more favorable policies to encourage FDI inflow. Foreign investors were given preferential tax treatments, the freedom to import inputs, and simpler business licensing procedures. In the 1990s, Chinese government permitted wholly foreign-owned enterprise as a new entry mode of FDI. During the past few years, wholly foreign-owned enterprises have become the most popular form of entry mode FDI to China, representing 69 % of total FDI in 2006.[10] Most recently, the government started to allow, and in some cases even encourage, foreign investors to merge with or acquire domestic firms. As a result, more and more new FDI projects take the form of merger or acquisition. In many cases, the target firms are either state-owned enterprises or other leading and promising companies.[11]

One of the primary goals of China's FDI policies is to promote technology transfer to China, especially from multinational companies. Indeed, promotion of technology transfer is one of the key ingredients of the *Guiding Directory on Industries Open to Foreign Investment* first promulgated in 1995.[12] Since the mid-1990s, China has been encouraging FDI to flow into cutting-edge, technology-oriented industries such as electronic information, bioengineering, new materials, and aviation and aerospace, as well as establishing local R&D centers.[13] This should help generate horizontal spillovers via such channels as labor turnovers and demonstration effect, as well as vertical spillovers. 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. For instance, during the 1990s China required that the local content rate of all cars made in China be at least 40% and must increase to 60% in a year and to 80% in 2 years after operation of a project.[14] In 2007, China issued its new set of guidelines for FDI detailing sectors in which it will either promote, restrict or ban foreign investment. The National Development and Reform Commission and the Ministry of Commerce said that the new guidelines will help put FDI to better use to spur innovation, promote industrial restructuring and ease regional imbalance.[15]

There are a number of studies of FDI spillover effects in China in recent years. Cheung and Lin (2003) examine the spillover effects of FDI on innovation activity of domestic firms in China. The authors use the panel data for the 26 provinces and 4 administrative cities of China for the period from 1995 to 2000, and find that inward FDI has significant and positive effects on the number of patent applications filed by domestic firms in China. This is true for all three types of patent (invention, utility model, and external design), although the spillover effect is the strongest for minor innovations such as external design. Hu and Jefferson

[3] Source: Table 11.1, Clarke, Murrell, and Whiting (2008).
[4] Source: Table 18-1, China Statistical Yearbook (2007). Q7
[5] Source, "Cumulative FDI in China Exceeds 750 Billion US Dollars," People's Daily, August 28, 2007.
[6] Source: Table 6-14, Table 14-1 and Table 18-13 of China Statistical Yearbook (2007), respectively. Q8
[7] Source: Table 18-15, China Statistical Yearbook (2007). Q9
[8] Most of the FDI from tax havens such as Virgin Islands are actually redirected to China by investors from other parts of the world, including Hong Kong and Taiwan. See Naughton (2007), p. 413.
[9] Source: Table 18-15, China Statistical Yearbook (2007). Q10
[10] Source: Table 18-16, China Statistical Yearbook (2007). Q11
[11] Source: "Foreign M&As created problems," China Daily, November 12, 2007.
[12] Source: see http://www.fdi.gov.cn/pub/FDI/default.htm.
[13] See Long (2005) for a recent review of China's FDI policy.
[14] Source: *China Daily*, July 15, 2004.
[15] Source: *Wall Street Journal*, November 8, 2007, C2.

Please cite this article as: Lin, P., et al., Do Chinese domestic firms benefit from FDI inflow? *China Economic Review* (2009), doi:10.1016/j.chieco.2009.05.010

Table 1
Summary statistics of domestic firms.

	1998	1999	2000	2001	2002	2003	2004	2005
Number of domestic firms	103,102	109,126	104,467	116,646	124,997	136,706	194,815	189,809
Output	38,632	42,051	46,769	48,920	54,761	61,712	54,616	66,253
	(246,195)	(278,611)	(332,378)	(359,666)	(400,931)	(465,350)	(468,451)	(573,500)
Employment	358	347	329	290	278	260	200	209
	(1,326)	(1,308)	(1,295)	(1,126)	(1,088)	(975)	(751)	(832)
Capital	19,866	21,984	22,583	21,502	21,581	20,804	15,737	17,904
	(219,151)	(27,7172)	(257,137)	(258,206)	(262,462)	(243,931)	(191,838)	(191,838)
Intermediate input	29527	32,371	35,350	36,556	40,694	44,666	37,555	44,178
	(184,065)	(215,965)	(259,708)	(276,390)	(303,251)	(340,830)	(321,418)	(391,284)
Value added	10,574	11,646	12,769	13,353	15,155	17,116	15,048	18,199
	(92,929)	(96,057)	(105,259)	(109,908)	(127,883)	(155,127)	(164,654)	(180,161)
Backward	0.087	0.093	0.098	0.103	0.103	0.111	0.126	0.124
	(0.066)	(0.072)	(0.075)	(0.078)	(0.078)	(0.082)	(0.088)	(0.089)
Forward	0.053	0.062	0.067	0.069	0.069	0.075	0.080	0.083
	(0.026)	(0.031)	(0.034)	(0.034)	(0.035)	(0.039)	(0.041)	(0.043)
Horizontal	0.177	0.191	0.205	0.214	0.214	0.223	0.242	0.240
	(0.103)	(0.109)	(0.114)	(0.117)	(0.113)	(0.120)	(0.124)	(0.125)

Notes: China National Statistical Bureau Enterprise Database. This table shows the mean and standard deviation (in parentheses) of the variables. All financial variables are measured in 1998 constant price. The unit of all financial variables is 1000 Yuan.

(2002) focus on horizontal spillover effects of FDI in China's electronic and textile industries. Using the data of large and medium enterprises, the authors find that inward FDI has a positive effect on introduction of new products in China. Using data on 29 manufacturing industries from 1993 to 1998 in Shenzhen Special Economic Zone of China, Liu (2002) finds that FDI has large and positive spillover effects on productivity of manufacturing industries.

More recently, Abraham, Konings, and Slootmaekers (2006) use a panel of 17,645 plants in China to study FDI spillovers. They look at horizontal spillovers only and find that FDI from HMT firms generates positive spillovers whereas that from other countries/regions generates negative effects. Girma, Gong, and Gorg (2006) use a firm-level panel dataset and find that inward FDI has a negative effect on the innovative activity in China's state-owned enterprises. They also find that the FDI effect is positive for those state-owned enterprises that export, invest in human capital and R&D, or have prior innovation experience.

4. Measurement and data

4.1. Measuring horizontal spillovers

As in Javorcik (2004), the variable $Horizontal_{jt}$ measures the foreign presence in the firms' own industry j at time t. It is calculated as follows:

$$Horizontal_{jt} = \frac{\sum_{i \in j} Foreign\ Share_{it} \times Y_{it}}{\sum_{i \in j} Y_{it}}, \tag{1}$$

where $Foreign\ Share_{it}$ is define as the share of firm i's total equity owned by foreign investors, and Y_{it} is its output, for all firms in industry j. To be consistent with the definition of vertical spillover variables, instead of using four-digit industries, we use the manufacturing industries defined in the 2002 Input–Output Table for horizontal spillover variable.[16] There are in total 122 industries in the 2002 Input–Output Table (National Bureau of Statistics, 2006), of which 72 are in manufacturing. After excluding the industry of recycling and disposal of waste, we obtain 71 manufacturing industries for both horizontal and vertical spillover variables.

4.2. Measuring backward spillovers

$Backward_{jt}$ captures the foreign presence in the downstream industries that are supplied by industry j. Since our dataset does not provide information about backward linkage at firm level, we use backward linkage value of the firm's industry. In particular, we have

$$Backward_{jt} = \sum_{k \neq j} \theta_{jk} Horizontal_{kt}, \tag{2}$$

[16] China compiles its national input-output table every 5 years. The 1997 Input-Output table is before our sample period. We also run parallel regressions using the 1997 table for 1998-2000 and 2002 table for 2001-2005; the results are qualitatively similar to those reported in the paper.

Please cite this article as: Lin, P., et al., Do Chinese domestic firms benefit from FDI inflow? China Economic Review (2009), doi:10.1016/j.chieco.2009.05.010

Table 2
Number of firms in the database.

	1998	1999	2000	2001	2002	2003	2004	2005
Total number of firms	124,944	133,976	130,295	146,254	156,930	173,511	249,075	243,974
Total number of foreign invested firms	21,842	24,850	25,828	29,608	31,933	36,805	54,260	54,165
	(17%)	(19%)	(20%)	(20%)	(20%)	(21%)	(22%)	(22%)
– HMT firms	12,981	14,721	15,166	17,317	18,224	20,297	26,940	26,669
	(11%)	(12%)	(12%)	(12%)	(12%)	(12%)	(11%)	(11%)
– Non-HMT firms	8,861	10,129	10,662	12,291	13,709	16,508	27,320	27,496
	(7%)	(8%)	(8%)	(8%)	(9%)	(10%)	(11%)	(11%)

Notes: China National Statistical Bureau Enterprise Database. HMT firms are partly or fully funded by investors from Hong Kong, Macao and Taiwan. Non-HMT firms are partly or fully funded by investors from foreign countries. Numbers in parentheses are the percentages of all firms.

where θ_{jk} is the proportion of industry j's total intermediate use that is purchased by industry k.[17] We exclude the purchase by its own industry because we have already included $Horizontal_{jt}$ in the regression. We calculate θ_{jk} using Table 5.1 of the 2002 Input–Output Table.

4.3. Measuring forward spillovers

Similarly, $Forward_{jt}$ shows the foreign presence in the upstream industries from which industry j purchases its intermediate inputs. As only intermediates sold in the domestic market are relevant to this study, goods produced by foreign invested firms for exports are excluded. Thus, we calculate $Forward_{jt}$ in the following way:

$$Forward_{jt} = \sum_{m \neq j} \rho_{jm} \frac{\sum_{i \in m} ForeignShare_{it} \times (Y_{it} - EX_{it})}{\sum_{i \in m} (Y_{it} - EX_{it})} \tag{3}$$

where ρ_{jm} is the proportion of industry j's total intermediate input that is supplied by industry m, and EX_{it} is the exports of each firm i in industry m. As above, $Foreign\ Share_{it}$ is the share of firm i's total equity owned by foreign investors. Again the coefficient ρ_{jm} is computed based on Table 5.1 of 2002 Input–Output Table.

4.4. The data

This empirical study uses a large dataset of Chinese industrial firms built from cross-sectional data collected in regular surveys by China National Bureau of Statistics between 1998 and 2005. The surveys cover all state-owned firms and all non-state firms above designated scale. Only non-state firms with sales under 5 million Yuan are excluded. The number of firms covered by this dataset is 124,944 in 1998 and 243,974 in 2005, respectively. The industry section of *China Statistical Yearbook* is complied based on this dataset. *China Markets Yearbook* which reports the basic information of each four-digit industry is also based on this dataset. The dataset contains detailed information of about 100 variables, including ID number, address, ownership, output, value added, four-digit industry code, six-digit geographic code, exports, employment, capital stock, and intermediate inputs. The firms in our sample account for 57% of total industrial value added in 1998 and 94% in 2005.[18]

Since we only focus on manufacturing, we exclude mining and utilities industries. Moreover, we delete those observations with missing values and those that fail to satisfy some basic error checks. In addition, we trim top 1% and bottom 1% of TFP for each year to remove the effects of outliers. Summary statistics of domestic firms are reported in Table 1.

We construct a panel dataset by matching the firms in different years. In our dataset, each firm is assigned a unique numerical ID. However, a firm may change its ID if it went through restructuring, merger or acquisition. Therefore, in addition to matching by IDs, we also match the firms using a combination of firm name, founding year, geographic code, industry code and address.

Table 2 shows total number of foreign invested firms in each year. There is a jump in total number of firms between 2003 and 2004. This is because 2004 is a census year. Some firms that should be surveyed but were not surveyed in previous years were included in 2004 sample. In our dataset, the share of foreign invested firms increased steadily from 17% in 1998 to 22% in 2005. In fact, we can see that the share of HMT firms is relatively stable while that of Non-HMT firms has been rising during this eight-year period.

Appendix A reports backward, forward and horizontal spillover variables in 1998 and 2005 for all manufacturing sectors in 2002 Input–Output Table. As shown by the table, there is significant variation of all three spillover variables across sectors. For example, in 1998 *horizontal* ranges from 0 in tobacco products to 0.84 in stationary and office machinery. For all sectors, the values

[17] For example, suppose industry A sells 10% of its output to industry B, 30% to industry C and 60% to industry D, where *Foreign Share* is 30%, 20% and 25%, respectively. In this example, *Backward* of industry A = 0.1 × 0.3 + 0.3 × 0.2 + 0.6 × 0.25 = 0.24.
[18] This is calculated from dividing the total value added in the dataset by the industrial GDP in the China Statistical Yearbook.

Please cite this article as: Lin, P., et al., Do Chinese domestic firms benefit from FDI inflow? *China Economic Review* (2009), doi:10.1016/j.chieco.2009.05.010

Table 3
Differentials of characteristics between foreign and domestic firms.

	1998	1999	2000	2001	2002	2003	2004	2005
ln(Output)	0.85	0.78	0.80	0.69	0.65	0.63	0.62	0.61
ln(Value added per worker)	0.62	0.50	0.43	0.31	0.26	0.17	0.12	0.08
ln(Wage per worker)	0.54	0.49	0.45	0.41	0.38	0.35	0.30	0.29
ln(Captial per worker)	0.94	0.84	0.74	0.73	0.66	0.59	0.56	0.49

Notes: this table reports the coefficients of *foreign share* in Eq. (4) of Section 4.5. All coefficients are significant at the 1% level. All regressions include a full set of sector and provincial dummies.

of both *backward* and *forward* have increased during 1998–2005, whereas horizontal spillovers have increased for almost all the sectors except for six of the 71 sectors. These trends indicate an economy-wide increase in the presence of foreign direct investment and their linkages with domestic firms in China during the sample period. We would like to note that vertical linkages may not automatically rise simply because more and more FDI flows into China (i.e., as horizontal FDI increases). Foreign companies in the host country may choose to source their intermediate goods internationally, e.g. from their parent companies abroad, rather than buying them domestically in the host country. Similarly, these foreign companies may choose to sell products (as final products for consumption or intermediate goods) in the international markets. Therefore, it is conceivable that vertical linkages could become weakened as horizontal linkages enhance in the host country, at least for some industries. However, it is not the case in China, as Appendix A shows.[19]

4.5. A descriptive analysis: comparing domestic firms and foreign invested firms

To compare foreign invested firms with Chinese domestic firms, as preliminary exploration, we estimate the following equation:[20]

$$lnS_i = \alpha_0 + \alpha_1 * \text{Foreign Share}_i + \alpha_j + \alpha_r + \varepsilon_i, \quad (4)$$

where S_i refers to firm *i*'s characteristics, including output, labor productivity (defined as value added per worker), capital intensity, and wage. We estimate Eq. (4) separately for each year in our sample. In the regression, we include two-digit industry (α_j) and provincial dummies (α_r).

The estimation results reported in Table 3 suggest that foreign invested firms differ significantly from domestic firms. The percentage differential between a wholly foreign-owned firm (*Foreign Share* = 1) and a domestic firm (*Foreign Share* = 0) can be calculated from the estimated coefficient as $100*(\exp(\alpha_1) - 1)$. For example, in 1998, the labor productivity of a wholly foreign-owned firm is on average 86% (100*(exp(0.62) − 1)) higher than that of a domestic firm. In general, foreign invested firms are larger, more productive, more capital intensive, and pay higher wages. Such findings are consistent with previous studies on other countries. We also find that in our sample period these differences between foreign invested firms and domestic firms gradually decreased over time.

5. Empirical strategy

To investigate the relationship between FDI and the productivity of domestic firms, we follow an approach that is commonly used in the literature (e.g., Aitken & Harrison, 1999). We estimate a production function that includes spillovers measures and industry concentration as explanatory variables. Our starting point is the following equation:

$$\begin{aligned} lnY_{it} = {} & \beta_0 + \beta_1 lnL_{it} + \beta_2 lnK_{it} + \beta_3 lnM_{it} + \gamma_1 Horizontal_{jt} \\ & + \gamma_2 Backward_{jt} + \gamma_3 Forward_{jt} + \gamma_4 \text{CR8}_j + \varepsilon_{it} \end{aligned} \quad (5)$$

where Y_{it} is the real output of firm *i* at time *t*, which is deflated by industry-specific ex-factory price index. L_{it} is the number of employees. K_{it} stands for the net value of fixed assets deflated by investment price index. The deflators of output and capital stock are calculated based on the price information in Table 9-1 of *China Statistical Yearbook* (2006). **Q4**

As Javorcik (2004) points out, foreign entry could change industry concentration and indirectly affect firm productivity. Here we adopt an alternative approach, by including industry concentration as an independent variable parallel to FDI spillovers. Following the logic of the standard Structure–Conduct–Performance paradigm, we take the view that industry concentration is an

[19] Alfaro and Rodriguez-Clare (2004) propose to use the ratio of the value of inputs bought domestically by FDI firms to the total workers employed by the firm as an alternative indicator of vertical linkages. Our dataset does not provide firm-level information about vertical linkage.

[20] This is only a simple descriptive exercise for illustrative purposes.

Please cite this article as: Lin, P., et al., Do Chinese domestic firms benefit from FDI inflow? *China Economic Review* (2009), doi:10.1016/j.chieco.2009.05.010

Table 4
Baseline regression I.

	Dependent variable: ln*Y*			
	Fixed effect	Random effect	Fixed effect	Random effect
ln*K*	0.030***	0.029***	0.030***	0.029***
	(0.001)	(0.001)	(0.001)	(0.001)
ln*L*	0.071***	0.052***	0.071***	0.052***
	(0.001)	(0.002)	(0.001)	(0.002)
ln*M*	0.833***	0.884***	0.832***	0.884***
	(0.003)	(0.002)	(0.003)	(0.002)
Horizontal	−0.035	−0.025	−0.044	−0.032
	(0.031)	(0.043)	(0.031)	(0.042)
Forward	1.714***	0.664***	1.718***	0.702***
	(0.115)	(0.131)	(0.112)	(0.129)
Backward	0.513***	0.197***	0.474***	0.193***
	(0.039)	(0.052)	(0.038)	(0.052)
CR8			−0.134***	−0.066***
			(0.010)	(0.017)

Notes: this table reports the estimation results of Eq. (5). Numbers in parentheses are standard errors corrected for sector/year clustering. Total number of observations is 1,048,386. *Denotes statistical significance at the 0.10 level. **Denotes statistical significance at the 0.05 level. ***Denotes statistical significance at the 0.01 level.

important determinant of firm conduct, thus affecting the intensity of market competition, firm incentive for innovation and technological upgrading, and having a direct effect on firm TFP.

There are two econometric concerns with the estimation of Eq. (5). The first is the omission of unobservable firm-specific variables. These variables may affect the correlation between firm productivity and FDI presence. Examples include government subsidies and strong senior management team. Our solution to this problem is to use panel data models to control for firm fixed effects.

The second econometric problem is that OLS is biased when estimating the production function in Eq. (5) because labor and intermediate inputs are not exogenous. Griliches and Mairesse (1998) argue that inputs should be endogenous since they are chosen by firms after productivity is observed. If this is the case, the error term of the production function can influence factor inputs, which makes OLS estimates biased. To correct the endogeneity bias, Olley and Pakes (1996) propose using investment as a proxy for the unobservable productivity shock. The identifying assumption in Olley–Pakes estimation is that investment is monotonically increasing with respect to the shock, conditional on capital. Because capital responds to the shock only in a lagged fashion through contemporaneous investment, the return to the other inputs can be obtained by non-parametrically inverting investment and capital to proxy for the unobserved shock.

Since the Olley–Pakes procedure requires the information of investment which is not available in our dataset, we opt for the Levinsohn and Petrin (2003) procedure, which uses intermediate inputs rather than investment to address the underlying endogeneity issues.[21] There are two advantages for the Levinsohn–Petrin procedure. First, because there is substantial adjustment cost with capital stock, in many firm-level datasets, a large number of observations have zero investment. These observations must be deleted to satisfy the strict monotonicity condition. The Levinsohn–Petrin procedure can avoid this problem since the intermediate inputs must be positive. Second, intermediate inputs provide a better proxy for productivity shock than investment because investment does not respond to the productivity shock quickly enough due to the adjustment cost.

The Levinsohn–Petrin procedure is implemented in this paper using the Stata module "levpet" developed by Petrin, Poi, and Levinsohn (2004). To allow for different technologies across sectors, we perform the procedure for each industry separately. The measure of TFP is thus calculated as follows:

$$lnTFP_{it} = lnV_{it} - \hat{\beta}_l lnL_{it} + \hat{\beta}_k lnK_{it}, \qquad (6)$$

where V_{it} is the value added of firm i at time t, and β_l and β_k are the estimated coefficients of labor and capital from Levinsohn–Petrin procedure.

In summary, we estimate panel data models for the following equation:

$$lnTFP_{it} = \gamma_0 + \gamma_1 Horizontal_{jt} + \gamma_2 Backward_{jt} + \gamma_3 Forward_{jt} + \gamma_4 CR8_j + \alpha_i + \varepsilon_{it}, \qquad (7)$$

where $\ln TFP_{it}$ is obtained from Eq. (6), and α_i is the unobservable firm fixed effect.

As Moulton (1990) illustrates, the traditional OLS method is based upon the assumption of independent disturbances, which is not appropriate for disturbances with grouped structure. As a result, OLS method can lead to standard errors that are seriously

[21] Although semi-parametric method has been a more standard approach to the TFP estimation with firm panel data (see, for example, Pavcnik, 2002; Javorcik, 2004), it has been recently criticized by Ackerberg, Caves, and Frazer (2007). They investigate the identification strategy for the semiparametric estimator and argue that the first stage of both Olley-Pakes and Levinsohn-Petrin procedures suffers from a collinearity problem.

Please cite this article as: Lin, P., et al., Do Chinese domestic firms benefit from FDI inflow? *China Economic Review* (2009), doi:10.1016/j.chieco.2009.05.010

Table 5
Baseline regression II.

	Dependent variable: lnTFP			
	Fixed effect	Random effect	Fixed effect	Random effect
Horizontal	−0.086	−0.091	−0.106	−0.109
	(0.079)	(0.167)	(0.078)	(0.168)
Forward	4.560***	2.799***	4.563***	2.892***
	(0.305)	(0.484)	(0.300)	(0.482)
Backward	1.357***	1.329***	1.268***	1.305***
	(0.100)	(0.212)	(0.096)	(0.211)
CR8			−0.292***	−0.215***
			(0.027)	(0.064)

Notes: this table reports the estimation results of Eq. (7). Numbers in parentheses are standard errors corrected for sector/year clustering. Total number of observations is 1,048,386. *Denotes statistical significance at the 0.10 level. **Denotes statistical significance at the 0.05 level. ***Denotes statistical significance at the 0.01 level.

biased downward. This can in turn result in spurious findings of statistical significance for the aggregate variables of interest. To overcome this problem, throughout the paper we report standard errors that are corrected for sector–year clustering.[22]

6. Estimation results

6.1. Baseline specifications

To get a first feeling of the FDI spillover effects, we start with regression results in Eq. (5). Table 4 reports the estimation results with ln*Y* as the dependent variable. Although the Hausman test favors the random effect model, in all four cases, the coefficients on *backward* and *forward* are both positive and statistically significant at the 1% level. *Horizontal* coefficients are negative but not statistically significant. A possible explanation for this is that the potential positive spillover effect and the negative crowding-out effect on domestic competitors, as discussed in Section 2, are canceling out, leading to the non-significant result in our estimation. When we add industry concentration into Eq. (5), we find its effect is also negative, in both fixed effect and random effect models. Throughout the paper, we find negative and significant coefficients on CR8, which implies that competition (or lower industry concentration) tends to raise firms' TFP.

In Table 5, we report the estimation results of Eq. (7). The dependent variable is ln*TFP*, which is calculated through Levinsohn–Petrin procedure. Although we believe the estimation results of Eq. (5) in Table 4 are biased due to the endogeneity problem of firm's input decision, we find that the results of Eq. (7) are qualitatively similar to those of Eq. (5). Again, positive and significant coefficients on *backward* and *forward* are found for all models. *Horizontal* bears a negative sign and remains statistically insignificant. Industry concentration is negative and significant at the 1% level. A notable difference is that the coefficients of *backward* and *forward* in Table 5 are larger than those in Table 4.

The vertical spillover effects are also quantitatively significant. For example, if we use the results in the fourth column of Table 5, for backward spillover variable, a one-standard-deviation (10 percentage points) increase in the foreign presence in the downstream industries is associated with about 12% increase in TFP of the domestic firms in the supplying industry.

6.2. Export orientation

It has been suggested that the market orientation of the foreign invested firms is likely to affect both horizontal and vertical spillovers (Girma et al., 2007; Javorcik, 2004; Sgard, 2001). First, domestic-market-oriented foreign invested firms take market share directly from domestic firms, while export-oriented foreign invested firms that target international markets tend to put less pressure on domestic competitors. Second, export-oriented foreign invested firms are often part of global production network. They usually depend on the suppliers from their parent company or their affiliates in other countries. Therefore, export-oriented foreign invested firms may be more likely to generate (positive) horizontal spillovers but not vertical spillovers.

To test this hypothesis, we distinguish three types of foreign invested firms in each year: (1) domestic-market oriented foreign invested firms with export/sales ratio below 20%; (2) no orientation foreign invested firms with export/sales ratio between 20% and 80%; and (3) export-oriented foreign invested firms with export/sales ratio exceeding 80%. For each type of FDI, we recalculate spillover variables in Eqs. (1)–(3) using the new *Foreign Share* variable which includes the foreign invested firms of that type only. Then we re-estimate Eq. (7) with our newly constructed spillover variables.

The estimation results in Table 6 indicate that in terms of productivity spillovers, export-oriented foreign invested firms are not very different from domestic-market-oriented foreign invested firms in that we find the same positive backward and forward spillovers. However, in both the fixed effect and random effect models, the magnitude of such vertical spillovers becomes weaker as the export/sales ratio of foreign invested firms rises. This is consistent with the view that the availability of vertical linkages outside China tends to reduce the backward and forward spillover effects that FDI can generate to domestic suppliers or customers. Despite this, all foreign

[22] In addition to clustering, the error term may be heteroskedastic due to the two-sage nature of our method. Since the dependent variable, lnTFP, is based on TFP estimation regression, the error term in Eq. (7) may depend on the errors from TFP regression. See Maddala (2001, p.64) for more discussion.

Table 6
Export orientation of FDI.

	Export/sales ratio < 20%		Export/sales ratio between 20% and 80%		Export/sales ratio > 80%	
	Fixed effect	Random effect	Fixed effect	Random effect	Fixed effect	Random effect
Horizontal	−0.363	−0.191	−0.110	−0.026	−0.261	−0.125
	(0.205)	(0.412)	(0.142)	(0.260)	(0.151)	(0.271)
Forward	7.014***	6.452***	5.732***	4.114***	3.058***	2.229***
	(0.785)	(1.232)	(0.656)	(0.829)	(0.540)	(0.567)
Backward	5.723***	6.336***	3.745***	3.902***	1.042**	1.274***
	(0.545)	(1.147)	(0.480)	(0.368)	(0.494)	(0.391)
CR8	−0.353***	−0.182***	−0.313***	−0.238***	−0.342***	−0.210***
	(0.026)	(0.061)	(0.034)	(0.065)	(0.030)	(0.068)

Notes: this table reports the estimation results of Eq. (7) with three different measures of FDI. Numbers in parentheses are standard errors corrected for sector/year clustering. Total number of observations is 1,048,386. *Denotes statistical significance at the 0.10 level. **Denotes statistical significance at the 0.05 level. ***Denotes statistical significance at the 0.01 level.

invested firms with different export orientation still generate positive and significant vertical spillover effects in China. Regarding horizontal effects, the result is similar to that in the baseline regressions: the spillover is negative but not statistically significant.

6.3. Source of FDI

In a much cited paper, Sachs and Woo (1994), when comparing the economic experience of China and Russia, emphasized that investment from Hong Kong, Macao and Taiwan played a critical role in China's economic success. Hong Kong, Macao and Taiwan are among newly industrialized economies, and their investments in China account for about 40% of China's overall FDI during the sample period. The investors from these regions have additional advantages of same culture, same language, geographical proximity, and even family ties, which tend to facilitate FDI spillovers. Tong (2005) shows that ethnic Chinese networks play an important role in promoting cross-border investment. Compared with HMT firms, the advantages of Non-HMT firms lie in their more advanced technology, global production chain and internationally recognized brand names. Therefore, it is not clear a priori which type of foreign invested firms is more likely to generate spillovers to domestic firms in China.

To investigate whether there exist different impacts of HMT and Non-HMT invested firms, we estimate Eq. (7) with these two types of FDI. Spillover variables are constructed using a new modified *Foreign Share* variable, which is now defined as the share of firm's equity owned by HMT or Non-HMT firms.

The results from the regressions are reported in Panel A of Table 7. We find robust evidence of forward spillovers from both HMT and Non-HMT firms, which is consistent with our previous findings. However, it seems that the forward spillover effects are stronger for Non-HMT FDI since its coefficient is larger. The coefficient of backward spillover variable is statistically significant only for Non-HMT FDI. The most interesting finding is that the coefficient of *horizontal* is negative and significant for HMT FDI but positive and significant for FDI from other economies in both fixed effect and random effect models. That is, the negative competition effects dominate the positive technological spillovers for FDI originated from HMT, whereas the reverse is true for Non-HMT FDI. One possible explanation for this finding is that HMT firms tend to be more labor intensive and produce closer substitutes to products of Chinese domestic firms.[23] This implies a stronger crowding-out effect on Chinese firms by HMT firms, relative to Non-HMT firms. This finding is similar to that of Tong and Hu (2003) who used data from the Third National Industrial Census of China in 1995. These authors interpret the negative horizontal effects of HMT FDI as a result of direct competition with domestic firms.[24] We thus observe negative horizontal effects from HMT FDI and positive such effects from Non-HMT FDI. Once these two sources of FDI are lumped together, however, the aggregate horizontal effects of FDI turn out to be insignificant.

We further conduct formal tests (F-tests for fixed effects models and Wald tests for random effects models) to see if each of three HMT effects are statistically different from their corresponding Non-HMT effects. Panel B of Table 7 reports the F-statistics/Chi-Square statistics and p-values individually for each effect and jointly for all three. In all cases, we reject the null hypotheses and conclude that these three effects are statistically different between HMT FDI and Non-HMT FDI.

6.4. Ownership of domestic firms

Enterprise reform is arguably the central problem in the entire transition process (Naughton, 2007, Chapter 13). State-owned enterprises (SOEs) were the “commanding heights” of the old planned economy, and today even after several rounds of privatization SOEs are still far from extinct. Indeed, in our sample, the share of SOEs in total industrial output decreased only slightly from 44.3% in 1998 to 38.3% in 2005. Large state enterprises in particular still play an important role in today's Chinese economy. In our study of FDI spillovers, it would be interesting to know whether the ownership of domestic firms matters. First, according to recent study by Jefferson, Rawski, and Zhang (2008), SOEs are the least efficient firms in China in terms of

[23] HMT FDI tends to enter such labor intensive industries as garments, footwear, and light electronics in China. See Zhang (2005) for a detailed analysis of HMT FDI in China.
[24] These authors did not consider vertical spillovers (either backward or forward).

Please cite this article as: Lin, P., et al., Do Chinese domestic firms benefit from FDI inflow? *China Economic Review* (2009), doi:10.1016/j.chieco.2009.05.010

Table 7
Sources of FDI.

	Dependent variable: lnTFP			
	Fixed effect	Random effect	Fixed effect	Random effect
Panel A: regression results				
θ_1: Non-HMT	0.318**	0.550**	0.358***	0.626***
Horizontal	(0.126)	(0.241)	(0.122)	(0.234)
θ_2: Non-HMT	5.361***	3.288***	5.877***	3.412***
Forward	(0.527)	(0.865)	(0.519)	(0.859)
θ_3: Non-HMT	2.402***	1.993***	2.136***	1.901***
Backward	(0.302)	(0.551)	(0.291)	(0.537)
θ_4: HMT	−0.706***	−0.876***	−0.773***	−0.988***
Horizontal	(0.142)	(0.272)	(0.139)	(0.272)
θ_5: HMT	3.345***	2.454**	2.846***	2.559***
Forward	(0.754)	(0.969)	(0.845)	(0.952)
θ_6: HMT	−0.277	0.216	−0.134	0.376
Backward	(0.363)	(0.716)	(0.352)	(0.702)
CR8			−0.318***	−0.289***
			(0.026)	(0.064)
Panel B: testing linear restrictions				
Hypotheses	*F*-statistics	Chi-square statistics	*F*-statistics	Chi-square statistics
$\theta_1=\theta_4$	22.17	13.98	28.45	18.70
	[0.000]	[0.000]	[0.000]	[0.000]
$\theta_2=\theta_5$	7.19	11.23	11.08	4.56
	[0.008]	[0.000]	[0.000]	[0.033]
$\theta_3=\theta_6$	17.80	5.60	13.68	7.21
	[0.000]	[0.0180]	[0.000]	[0.0076]
$\theta_1=\theta_4$ & $\theta_2=\theta_5$ & $\theta_4=\theta_6$	18.64	26.16	22.43	33.55
	[0.000]	[0.000]	[0.000]	[0.000]

Notes: in Panel A, numbers in parentheses are standard errors corrected for sector/year clustering. In Panel B, numbers in parentheses are *p*-values. Total number of observations is 1,048,386. *Denotes statistical significance at the 0.10 level. **Denotes statistical significance at the 0.05 level. ***Denotes statistical significance at the 0.01 level.

productivity. If the technological gap between foreign firms and SOEs is too large, SOEs may lack the ability needed to learn from the foreign firms. Second, the entry of foreign firms often breaks the monopoly of SOEs, making them particularly vulnerable to the crowding-out effects brought by FDI. Third, a key motivation of China's FDI policy after reform is to improve the technological level of the SOEs by learning from FDI (Long, 2005).

To examine the issue, we divide all domestic firms into two sub-samples: SOEs and Non-SOEs.[25] We estimate Eq. (7) separately for each sub-sample. The first four columns of Table 8 report the estimation results for SOEs. In all models, *horizontal* appears negative but statistically insignificant. The coefficients on *backward* and *forward* have positive signs and are statistically significant at the 1% level. The regression results from the Non-SOEs sample in the last four columns show similar pattern. However, the coefficients of both vertical spillover variables are larger for SOEs sample, indicating that the SOEs do not lack the capacity to learn from foreign invested suppliers and customers.

6.5. Interpretation and comparison with existing studies

As mentioned earlier, there are a number of empirical studies of the spillover effects of FDI to China in recent years. All of these studies examine the FDI spillover effects without making distinguishing horizontal spillovers and vertical spillovers, with the exception of Girma, Gong, and Gorg (2006). We contribute to the literature in three ways. First, we explicitly separate horizontal spillovers and vertical spillovers, and backward linkages and forward linkages, by using the latest Input–Output Table of China. Second, we look at the spillover effects of FDI from different sources, namely FDI from HMT and FDI from other countries. The investments from HMT differ from the Non-HMT FDI not only in culture background, but also in terms of market orientation and technology background (Zhang, 2005). Third, we use the panel data set from the National Bureau of Statistics covering all the manufacturing firms in China with scales above the designated level. Specifically, most of the existing studies are based on much smaller data sets. For instance, Hu and Jefferson (2002) use data from electronic and textile industries, whereas Liu (2002) used data for firms in Shenzhen City in South China. While Cheung and Lin (2003) use data that cover the whole country, their data are at provincial level only.

By separating horizontal and vertical spillover effects, and HMT FDI from Non-HMT FDI, we are able to find much finer evidence of the FDI spillovers in China. Foreign investment in China has impacted Chinese domestic firms differently: Suppliers and customers of foreign invested firms in China have enjoyed positive spillovers via backward linkages and forward linkages, whereas

[25] The data report over 25 different ownership categories. We include the following categories as SOEs: 110, 141, 143, 151, 159, and 160.

Please cite this article as: Lin, P., et al., Do Chinese domestic firms benefit from FDI inflow? *China Economic Review* (2009), doi:10.1016/j.chieco.2009.05.010

Table 8
Ownership of domestic firms.

	SOEs				Non-SOEs			
	Fixed effect	Random effect	Fixed effect	Random effect	Fixed effect	Random effect	Fixed effect	Random effect
Horizontal	−0.069	−0.009	−0.086	−0.015	−0.124	−0.266**	−0.146	−0.267
	(0.101)	(0.234)	(0.156)	(0.234)	(0.075)	(0.136)	(0.074)	(0.139)
Forward	5.489***	4.088***	5.463***	4.424***	3.951***	1.831***	3.968***	1.836***
	(0.402)	(0.688)	(0.400)	(0.688)	(0.270)	(0.376)	(0.267)	(0.376)
Backward	1.468***	1.632***	1.336***	1.586***	1.271***	0.919***	1.204***	0.918***
	(0.132)	(0.307)	(0.131)	(0.304)	(0.095)	(0.166)	(0.093)	(0.167)
CR8			−0.344***	−0.327***			−0.241***	−0.012***
			(0.031)	(0.081)			(0.025)	(0.059)

Notes: this table reports the estimation results of Eq. (7) with two sub-samples: SOEs and Non-SOEs. Dependent variable is lnTFP. Numbers in parentheses are standard errors corrected for sector/year clustering. Total numbers of observations are 357,200 for SOEs regression and 691,186 for Non-SOEs. *Denotes statistical significance at the 0.10 level. **Denotes statistical significance at the 0.05 level. ***Denotes statistical significance at the 0.01 level.

direct competitors to foreign invested firms have suffered from negative (but not significant) competition effects. This is in contrast with the findings of Liu (2002) who lumped horizontal spillovers and vertical spillovers together and found positive spillovers on the aggregate.

Girma, Gong, and Gorg (2006) is the only existing study that examines the horizontal and vertical spillovers in China separately, to the best of our knowledge. They find negative horizontal spillovers and no vertical spillovers on the innovation activities of SOEs in China. The major difference is that we use firms' TFP as our dependent variable, while Girma, Gong, and Gorg (2006) use new product sales as a measure for R&D output of domestic firms. While product R&D is closely related to firm TFP, a firm can improve its productivity without its own R&D. For example, firms can purchase advanced technology and learn from foreign firms. Labor turnover is another important channel via which FDI spillovers can take place.[26] To further compare our results with Girma, Gong, and Gorg (2006), we also run regressions for the SOEs in our sample (see Section 6.4). Once again, we find that the horizontal effects of FDI on Chinese SOEs are negative (as in Girma, Gong, & Gorg, 2006) but not significant and that both backward and forward linkage effects on SOEs are positive and significant, similar to our findings for the full sample of both SOEs and non-SOE firms.

Once the origin of FDI is taken into consideration, we find that FDI from OECD has generated positive spillovers to China while HMT FDI brought negative spillovers. Our result is consistent with the findings of Tong and Hu (2003) as mentioned earlier. However, this is in contrast to the findings of Abraham, Konings, and Slootmaekers (2006) which find exactly the opposite evidence. An obvious difference between our study and Abraham, Konings, and Slootmaekers (2006) is the different datasets used.[27] The second major difference is that their study does not consider vertical spillovers. Their interpretation of their results is that HMT firms in China are mostly export-oriented, while Non-HMT firms engage in head-to-head competition with domestic firms. Our explanation of our findings is different. We believe the technological gap between Chinese firms and HMT firms is not as large as that with firms from OECD countries. As a result, competition between Chinese firms with HMT firms is much more intense than with OECD firms.

We also examine the spillover effects of FDI with different degree of exporting orientation, which have not been studied in the literature. As reported earlier, we find that both the backward and forward spillovers in China decline with the export orientation of foreign invested firms. This is not surprising because export-oriented foreign firms are more likely to source intermediate goods overseas and work with downstream customers in the international markets, thereby leading to weaker vertical linkages in the host country.

7. Conclusions

This paper is among the first to analyze productivity spillovers from foreign direct investment using firm-level panel data from China manufacturing industries and the most recent Input–Output Table of China. We investigate whether there are exit productivity spillovers from FDI to domestic firms through horizontal, backward and forward linkages. We apply the Levinsohn and Petrin (2003) method to the estimation of TFP, which allows us to control for the potential endogeneity of input factors.

Our estimation results produce robust findings that support forward spillovers from all types of FDI, regardless of the motivation of FDI (exported oriented vs. domestic-market oriented), the source of FDI (HMT vs. Non-HMT) and the ownership type of domestic firms (SOEs vs. non-SOEs). We find strong evidence of backward spillovers from Non-HMT foreign invested firms. Regarding horizontal effects, we find negative spillovers from FDI originated from Hong Kong, Macao or Taiwan, and generally positive spillovers from non-HMT firms (mostly the OECD countries). Domestic-market oriented FDI does not show much difference with export-oriented FDI in terms of spillover effects on Chinese firms.

26 Another difference is that we use the 2002 Input-Output Table of China whereas Girma, Gong, and Gorg (2006) use the 1997 Input-Output Table.

27 The data, drawn from the Oriana CD-Rom complied by Bureau van Dijk, covers firms that are either publicly listed or with turnovers of at least US$10 million or with more than 150 employees.

Please cite this article as: Lin, P., et al., Do Chinese domestic firms benefit from FDI inflow? *China Economic Review* (2009), doi:10.1016/j.chieco.2009.05.010

Overall, our findings represent strong evidence that FDI has generated beneficial vertical spillover effects to Chinese domestic firms. The horizontal spillovers depend on the origin of FDI, and tend to cancel out on the aggregate in our dataset. We also find that industry concentration has a negative effect on firm productivity, i.e., that market competition enhances technological progress. These findings suggest that China's policy of opening up to FDI and introducing market competition in its industries has indeed produced quantitatively measurable benefits in terms of total factor productivity.

8. Uncited references

Q6

Borenstein et al., 1998
Kokko et al., 1996

Appendix A. Spillover variables by sector

Sectors	Backward98	Backward05	Forward98	Forward05	Horizontal98	Horizontal05
Corn milling	0.08	0.09	0.01	0.01	0.05	0.04
Feed processing	0.00	0.00	0.04	0.05	0.27	0.17
Vegetable oil refining	0.11	0.13	0.01	0.01	0.20	0.31
Sugar refining	0.19	0.25	0.01	0.02	0.03	0.08
Animal slaughtering & meat processing	0.16	0.18	0.01	0.02	0.14	0.19
Seafood processing	0.09	0.07	0.02	0.02	0.17	0.20
Other food products	0.06	0.06	0.05	0.08	0.27	0.29
Wines, spirits and liquors	0.01	0.02	0.04	0.05	0.04	0.17
Non-alcoholic beverage	0.01	0.01	0.07	0.09	0.21	0.42
Tobacco products	0.00	0.00	0.03	0.05	0.00	0.00
Cotton and chemical fiber spinning	0.15	0.17	0.03	0.04	0.11	0.15
Wool spinning	0.24	0.25	0.04	0.05	0.20	0.23
Ramie, linen, hemp and silk processing	0.19	0.21	0.03	0.04	0.07	0.10
Textile product	0.25	0.28	0.06	0.10	0.14	0.26
Knit fabric, knitting and product processing	0.22	0.23	0.07	0.10	0.31	0.32
Apparel, shoes and hat Manufacturing	0.06	0.08	0.08	0.11	0.37	0.37
Leather, furs, down and related products	0.06	0.08	0.04	0.06	0.40	0.43
Wood processing and wood products	0.07	0.10	0.03	0.04	0.21	0.16
Furniture manufacturing	0.03	0.04	0.09	0.10	0.29	0.43
Paper making and paper products	0.12	0.15	0.03	0.04	0.18	0.26
Printing and record media reproducing	0.03	0.05	0.10	0.16	0.19	0.24
Stationery	0.03	0.05	0.11	0.16	0.28	0.40
Toys, sporting and recreation products	0.00	0.01	0.12	0.17	0.53	0.55
Petroleum refining	0.04	0.06	0.01	0.01	0.03	0.07
Coke melting	0.06	0.09	0.01	0.02	0.02	0.06
Raw chemical materials	0.14	0.20	0.02	0.04	0.05	0.10
Chemical fertilizer	0.00	0.01	0.05	0.07	0.02	0.03
Pesticide manufacturing	0.01	0.01	0.05	0.09	0.06	0.12
Coating, printing ink and dyeing materials	0.16	0.20	0.04	0.07	0.14	0.35
Synthetic materials	0.20	0.25	0.04	0.07	0.18	0.24
Special chemical products	0.15	0.20	0.05	0.08	0.12	0.20
Daily chemical products	0.06	0.08	0.06	0.10	0.33	0.53
Pharmaceutical products	0.00	0.00	0.04	0.06	0.15	0.18
Chemical fiber manufacturing	0.15	0.17	0.05	0.08	0.19	0.17
Rubber products	0.14	0.19	0.04	0.07	0.21	0.30
Plastic products	0.15	0.20	0.07	0.11	0.30	0.34
Cement, lime and gypsum	0.01	0.01	0.06	0.08	0.06	0.07
Glass products	0.21	0.31	0.04	0.07	0.13	0.20
Ceramic products	0.03	0.04	0.04	0.07	0.21	0.28
Fireproof products	0.03	0.05	0.04	0.07	0.06	0.07
Other nonmetal products	0.03	0.05	0.03	0.05	0.09	0.13
Iron smelting	0.10	0.15	0.02	0.03	0.07	0.03
Steel smelting	0.09	0.16	0.03	0.04	0.03	0.09
Steel rolling processing	0.09	0.13	0.03	0.05	0.05	0.13
Alloy iron smelting	0.08	0.14	0.02	0.03	0.05	0.05
Nonferrous metal smelting	0.13	0.19	0.01	0.02	0.06	0.05
Nonferrous metal processing	0.17	0.24	0.04	0.05	0.12	0.18
Metal products	0.09	0.13	0.04	0.07	0.23	0.26
Boiler and motor manufacturing	0.10	0.13	0.05	0.09	0.10	0.10
Metal processing machinery	0.13	0.19	0.07	0.12	0.09	0.13
Other general machinery	0.07	0.10	0.06	0.10	0.16	0.23
Agriculture, forestry and fishing machinery	0.00	0.00	0.07	0.10	0.02	0.07

(continued on next page)

Please cite this article as: Lin, P., et al., Do Chinese domestic firms benefit from FDI inflow? China Economic Review (2009), doi:10.1016/j.chieco.2009.05.010

Appendix A (*continued*)

Sectors	Backward98	Backward05	Forward98	Forward05	Horizontal98	Horizontal05
Other special machinery	0.04	0.06	0.07	0.12	0.13	0.22
Railroad transport equipment	0.01	0.01	0.06	0.10	0.01	0.04
Motor vehicles	0.03	0.05	0.08	0.15	0.21	0.22
Motor vehicles parts and components	0.09	0.09	0.05	0.08	0.15	0.31
Ship building	0.00	0.00	0.08	0.12	0.06	0.09
Other transport equipment machinery	0.03	0.04	0.07	0.10	0.15	0.20
Motors and generators	0.13	0.18	0.07	0.12	0.20	0.29
Household electronic appliance	0.06	0.09	0.10	0.15	0.25	0.32
Other electronic machinery	0.15	0.21	0.09	0.13	0.19	0.29
Communication equipment	0.06	0.08	0.13	0.25	0.46	0.64
Computer body	0.03	0.04	0.26	0.45	0.27	0.94
Computer accessories	0.16	0.51	0.20	0.36	0.73	0.88
Electronic device	0.39	0.59	0.07	0.10	0.48	0.75
Household video and audio equipment	0.02	0.03	0.19	0.35	0.42	0.59
Other communication and electronic equipment	0.15	0.22	0.16	0.28	0.46	0.49
Instruments and meters	0.06	0.08	0.11	0.18	0.27	0.40
Stationary and office machinery	0.02	0.02	0.16	0.30	0.84	0.90
Arts and crafts products	0.04	0.05	0.07	0.10	0.28	0.32
Other manufacturing products	0.12	0.16	0.06	0.09	0.21	0.30

References

Abraham, F., Konings, J., & Slootmaekers, V. (2006). *FDI spillovers, firm heterogeneity and degree of ownership: Evidence from Chinese manufacturingWorking Paper.* Katholieke Universiteit Leuven.

Ackerberg, D. A., Caves, K. & Frazer, G. (2007). Structural identification of production functions, mimeo, University of California at Los Angeles.

Aitken, B., & Harrison, A. (1999). Do domestic firms benefit from direct foreign investment? Evidence from Venezuela. *American Economic Review*, *89*, 605—618.

Aitken, B., Harrison, A., & Lipsey, R. (1996). Wages and foreign ownership: A comparative study of Mexico, Venezuela, and the United States. *Journal of International Economics*, *40*, 345—371.

Alfaro, L., & Rodriguez-Clare, A. (2004). Multinationals and linkages: An empirical investigation. *Economica* Spring No.2.

Blalock, G. (2002). Technology from foreign direct investment: Strategic transfer though supplies chains, Dissertation at Haas School of Business, University of California, Berkeley.

Blomstrom, M., & Kokko, A. (1998). Multinational corporations and spillovers. *Journal of Economic Surveys*, *12*, 247—277.

Blomstrom, M., & Persson, H. (1983). Foreign investment and spillover efficiency in an underdeveloped economy: Evidence from the Mexican manufacturing industry. *World Development*, *11*, 493—501.

Borenstein, E., De Gregorio, J., & Lee, J.-W. (1998). How does foreign direct investment affect economic growth? *Journal of International Economics*, *45*, 115—135.

Branstetter, L., & Lardy, N. (2008). China's embrace of globalization. In L. Brandt, & T. G. Rawski (Eds.), *China's great economic transformation* (pp. 633—682). Cambridge University Press.

Castellani, D., & Zanfei, A. (2002). Technology gaps, absorptive capacity and the impact of inward investments on productivity of European firms, mimeo, University of Urbino, Italy.

Caves, R. (1974). Multinational firms, competition and productivity in host-country markets. *Economica*, *41*, 176—193.

Cheung, K. Y., & Lin, P. (2003). Spillover effects of FDI on innovation in China: Evidence from the provincial data. *China Economic Review*, *15*, 25—44.

Clarke, D., Murrell, P., & Whiting, S. (2008). The role of law in China's economic development. In L. Brandt, & T. G. Rawski (Eds.), *China's great economic transformation* (pp. 375—428). Cambridge University Press.

Djankov, S., & Hoekman, B. (2000). Foreign investment and productivity growth in Czech enterprises. *World Bank Economic Review*, *14*, 49—64.

Driffield, N. L., Munday, M., & Roberts, A. (2002). Foreign direct investment, transactions linkages, and the performance of the domestic sector. *International Journal of the Economics of Business*, *9*, 335—351.

Girma, S., Gong, Y., & Gorg, H. (2006). Can you teach the old dragon new tricks? FDI and innovation activity in Chinese state-owned enterprises. *CEPR Discussion Paper, 5838*.

Girma, S., Gorg, H., & Pisu, M. (2007). Exporting, linkages and productivity spillovers from foreign direct investment. *CEPR Discussion Paper, 6383*.

Globerman, S. (1979). Foreign direct investment and spillover efficiency benefits in Canadian manufacturing industries. *Canadian Journal of Economics*, *12*, 42—56.

Görg, H., & Strobl, E. (2003). Multinational companies, technology spillovers and plant survival. *Scandinavian Journal of Economics*, *105*, 581—595.

Gorodnicjenko, Y. J., Svejnar, & Terrell, K. (2007). When does FDI have positive spillovers? *Evidence from 17 emerging market economies, working paper* : University of Michigan.

Haddad, M., & Harrison, A. (1993). Are there positive spillovers from direct foreign investment? Evidence from panel data for Morocco. *Journal of Development Economics*, *42*, 51—74.

Haskel, J., Pereira, S., & Slaughter, M. (2007). Does inward foreign direct investment boost the productivity of domestic firms? *Review of Economics and Statistics*, *89*, 482—496.

Hu, A., & Jefferson, G. (2002). FDI impact of spillover: Evidence from China's electronic and textile industries. *The World Economy*, *25*, 1063—1076.

Javorcik, B. S. (2004). Does foreign direct investment increase the productivity of domestic firms? In search of spillovers through backward linkages. *American Economic Review*, *94*, 605—627.

Jefferson, G., Rawski, T., & Zhang, Y. (2008). Productivity growth and convergence across China's industrial economy. *Journal of Chinese Economics and Business Studies*, *6*, 121—140.

Keller, W., & Yeaple, S. (2003). Multinational enterprises, international trade, and productivity growth: firm-level evidence from the United States. *GEP research paper 03/03* : University of Nottingham.

Kokko, A., Tansini, R., & Zejan, M. (1996). Local technological capability and productivity spillovers from FDI in the Uruguayan manufacturing sector. *Journal of Development Studies*, *32*, 602—611.

Konings, J. (2001). The effects of foreign direct investment on domestic firms: Evidence from firm level panel data in emerging economies. *Economics of Transition*, *9*, 619—633.

Lall, S. (1980). Vertical inter-firm linkages in LDCs: An empirical study. *Oxford Bulletin of Economics and Statistics*, *42*, 203—226.

Levinsohn, J., & Petrin, A. (2003). Estimating production functions using inputs to control for unobservables. *Review of Economics Studies*, *70*, 317—342.

Lin, P., & Saggi, K. (2005). Multinationals and backward linkages: A critical survey and a simply model. In T. Moran, E. M. Graham, & M. Blomstrom (Eds.), *Does foreign direct investment promote development?* (pp. 159—174). Washington D.C.: Institute For International Economics, Centre for Global Development.

Lin, P., & Saggi, K. (2007). Multinationals, exclusivity, and the degree of backward linkages. *Journal of International Economics*, *71*, 206—220.

Liu, Z. Q. (2002). Foreign direct investment and technology spillover: Evidence from China. *Journal of Comparative Economics*, *30*, 579−602.

Long, G. (2005). China's policies on FDI: Review and evaluation. In T. H. Moran, E. M. Graham, & M. Blomstrom (Eds.), *Does foreign direct investment promote development?* (pp. 315−336). Washington D. C.: Institute for International Economics, Center for Global Development.

MacDuffe, J., & Helper, S. (1997). Creating lean suppliers: Diffusing lean production through the supply chain. *California Management Review*, *39*, 118−152.

Maddala, G. S. (2001). *Introduction to econometrics.* West Sussex: John Wiley and Sons.

Moran, T. (1998). *Foreign direct investment and development.* Washington D.C.: Institute for International Economics.

Moulton, B. (1990). An illustration of pitfall in estimating the effects of aggregate variables on micro units. *Review of Economics and Statistics*, *72*, 334−338.

National Bureau of Statistics (2006). *China's input–output table.* Beijing: China Statistics press.

Naughton, B. (2007). *The Chinese economy: Transition and growth.* MA: MIT Press.

Olley, G., & Pakes, A. (1996). The dynamics of productivity in the telecommunication equipment industry. *Econometrica*, *64*, 1263−1297.

Pavcnik, N. (2002). Trade liberalization, exit, and productivity improvements: Evidence from Chilean plants. *Review of Economic Studies*, *69*, 245−276.

Petrin, A., Poi, B. P., & Levinsohn, J. (2004). Production function estimation in Stata using inputs to control for unobservables. *Stata Journal*, *4*, 113−123.

Rodriguez-Clare, A. (1996). Multinationals, linkages, and economic development. *American Economic Review*, *86*, 852−873.

Rodrik, D. (1999). The new global economy and developing countries: Making openness work. Policy Essay 24, Overseas Development Council; Johns Hopkins University Press, Washington DC.

Sachs, J., & Woo, W. (1994). Structural factors in the economic reforms of China, Eastern Europe, and the former Soviet Union. *Economic Policy*, *18*, 102−145.

Sgard, J. (2001). *Direct foreign investments and productivity growth in Hungarian firms, 1992–1999. CEPII Working Paper.* (pp. 2001−2019).

Smarzynska, B. (2002). *FDI spillovers through backward linkages: Does technology gap matter?Working Paper.* World Bank.

Teece, D. (1977). Technology transfer by multinational firms: The resource cost of transferring technological know-how. *Economic Journal*, *87*, 242−261.

Tong, S. (2005). Ethnic networks in FDI and the impact of institutional development. *Review of Development Economics*, *9*, 563−580.

Tong, S. & Hu, A. Y. (2003). Do domestic firms benefit from foreign direct investment? Initial evidence from Chinese manufacturing. Mimeo, The University of Hong Kong.

UNCTAD (2001). *World investment report 2001 — Promoting linkage.*

UNCTAD (2003). *World investment report 2003 — FDI policies for development: National and international perspectives.*

World Bank (1993). *Foreign direct investment — Benefits beyond insurance.* Washington, D.C.: Development Brief.

Zhang, K. (2005). Why does so much FDI from Hong Kong and Taiwan go to mainland China? *China Economic Review*, *16*, 293−307.

Please cite this article as: Lin, P., et al., Do Chinese domestic firms benefit from FDI inflow? *China Economic Review* (2009), doi:10.1016/j.chieco.2009.05.010