Spillovers from Foreign Direct Investment in China: The Role of Ownership*

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Chapter 2

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Abstract

The objective of this study is two fold. First, using a firm-level panel data set of 90,000 Chinese manufacturing firms over the period of 1998-2001, I examine whether there exist productivity spillovers from foreign direct investment (FDI) to domestic firms in the same sector (horizontal spillovers), and in sectors supplying intermediate inputs to foreign affiliates (vertical spillovers through backward linkages). Consistent with the recent literature on FDI spillovers in developing countries, I find evidence of negative horizontal spillovers. These negative externalities become more pronounced when FDI in the same sector increases within the same province. While I find no evidence of vertical spillovers at the national level, domestic input suppliers' productivity growth decreases with the foreign presence in their downstream sectors in the same province. Second, this paper examines whether the ownership structure of foreign affiliates affects the magnitude of spillovers. I find that wholly owned and ethnic-Chinese foreign firms are associated with more negative horizontal spillovers, compared to jointly-owned and non-Chinese foreign firms, respectively. I also find that negative spillovers are mostly borne by domestic firms that are state-owned, technologically-backward and located in inland provinces.

Key Words Productivity spillovers, foreign direct investment, ownership.
JEL Classification Numbers

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1 Introduction

Attracting foreign direct investment (FDI) has been high on the development agenda of many developing countries' governments. It is believed that FDI can improve the host country's balance of payments, promote exports, and complement other economic policies to induce growth through employment creation and technology transfer. Hence, governments often employ a variety of policies, including tax exemptions, tax holidays, tariff reduction and subsidies for infrastructure and exports to attract FDI.

Among the benefits brought by FDI, productivity spillovers have received the most attention by policy makers, who believe that technology and know-how of foreign firms will be diffused to domestic firms and enhance their productivity. As such, there exists a vast literature searching for positive productivity spillovers of FDI. However, in contrast to the previously widely-held belief, recent studies based on micro-level panel data mostly find either insignificant or negative spillovers from FDI in the same sector. The disconnect between these recent findings and the conventional view of positive productivity spillovers from FDI is succinctly summarized by Dani Rodrik (1999), who remarks "Today's policy literature is filled with extravagant claims about positive spillovers from FDI, [but] the hard evidence is sobering."

Yet, maximizing productivity spillovers remains an important objective of FDI policies in many developing countries. Among these policies, domestic equity ownership in foreign invested projects was often enforced by policy makers, who believed that advanced knowledge would be first transferred to the local partners in joint-ventures, then spill over to the rest of the economy. From the foreign investors' point of view, however, restricting sole foreign ownership limits their ability to internalize the benefits of possessing superior technology and know-how. This concern is particularly relevant in countries with poor rule of law, where contracts cannot be effectively enforced to restrict know-how "leakage." As such, foreign investors often prefer to increase equity ownership, hoping that the associated control rights can enhance their ability to prevent knowledge dissipation. Thus, the tension between governments and foreign investors over equity ownership urges one to ask the question: "Does the ownership structure of foreign affiliates really matter for productivity spillovers?"

The objective of this paper is two fold. First, using firm-level panel data of more than 90,000 Chinese manufacturing firms over the period from 1998 to 2001, I examine whether there exist productivity spillovers from FDI in China. In particular, I follow the recent literature by Javorcik (2004) and Blalock and Gertler (2006) to disentangle spillover effects into horizontal (intra-industry) and vertical (inter-industry) spillovers. Although there are already studies on productivity spillovers in China, to my understanding, this study covers the most recent years for which data are available, and the most comprehensive sample of manufacturing firms. The second contribution of this paper is to examine whether the structure and nationality of foreign ownership affects the magnitude of spillovers. In particular, I examine spillovers from majority, minority and wholly owned foreign firms. Moreover, specific to the Chinese economy, I examine whether higher equity participation by ethnic-Chinese foreign investors is associated with higher productivity spillovers to domestic firms, and whether productivity of state-owned and exporting firms are affected by the presence of foreign firms differently.

To verify whether FDI affects domestic firm productivity, I use two methods to measure firm total factor productivity (TFP). First, I use a firm's Solow residual computed based on a sector-specific production function as my baseline measure of TFP. Second, I estimate a Cobb-Douglas production function for each sector; then for each firm, I take the difference between the actual log of output and the predicted log of output as my second TFP measure. To correct for the bias in the firm estimated TFP due to firm endogenous input selection, I adopt the semi-parametric two-stage estimation procedure of Olley and Pakes (1996) to obtain consistent estimates of input elasticities.

To capture the scope of horizontal spillovers, I follow the existing literature to use the share of output produced by foreign affiliates in a sector. For vertical spillovers from FDI to local input-supplying firms through backward linkages, I use coefficients from the input-output table for China to represent linkages across sectors. Specifically, the proxy for vertical spillovers for a local intermediate-input supplier is a weighted average of foreign presence across the firm's downstream sectors, with the weights equal to the corresponding downstream sectors' shares in aggregate expenditure on intermediate inputs produced by the sector the firm belongs to.

With the measures of firm TFP and the scope of spillovers constructed, I test for the existence of spillovers by regressing firm productivity growth on the first differences of the horizontal and vertical spillover measures, respectively. I find that higher foreign penetration is associated with lower domestic-firm productivity growth in the same sector. The negative impact is economically meaningful. A one standard-deviation increase in the share of output produced by foreign affiliates (a 4 percentage-point increase) in the same sector is associated with about 1 percentage-point decline in domestic-firm productivity growth.

These findings are consistent with the recent studies which also find negative horizontal spillovers. The authors of these studies attribute the observed negative spillovers to competition arising from foreign entry. The argument is based on the condition of increasing returns to scale due to the existence of fixed costs of production. When foreign firms "steal" market shares from domestic firms, the latter will have to spread fixed costs over a lower level of output, resulting in lower observed productivity.

In contrast to the recent literature, I find no evidence of vertical spillovers through backward linkages at the national level. In other words, when more foreign firms operate in a sector, the average productivity of their domestic suppliers is unaffected. Nevertheless, I find that higher foreign presence in the downstream sectors located in the same province is associated with lower domestic-firm productivity growth. While these findings are new, an explanation similar to the one for the well-documented negative horizontal spillovers can be applied here. On the one hand, downstream foreign firms transfer superior know-how to domestic input suppliers, hoping to improve their performance. On the other hand, theoretical models of FDI show that multinational firms can import intermediate inputs and crowd out demand for locally produced intermediate inputs (Rodriguez-Clare, 1996; Markusen and Venables, 1999). Under the condition of firms' increasing returns to scale, lower demand for locally-produced inputs implies higher average costs, which leads to lower observed productivity. Therefore, *a priori*, there is no presumption that higher foreign penetration in downstream sectors is always associated with positive backward spillovers, although it is the dominating view in the literature (Javorcik, 2004; Blalock and Gertler, 2006; Javorcik and Spatareanu, 2008). In the current study, I find that for China, the positive knowledge-diffusion effects and negative "crowding-out" effects happen to cancel out at the national level, with the negative effects dominating at the province level.

Next, I examine whether foreign firms of different ownership structures are associated with different degrees of spillovers. To this end, I use information on equity ownership by different types of investors to construct measures for the presence of minority, majority and wholly owned foreign firms in each sector, respectively. I find that compared to joint-ventures, wholly and majority owned foreign firms are associated with more negative horizontal spillovers. On the other hand, the ownership structure of foreign affiliates does not appear to affect spillovers through backward linkages at the national level. Nevertheless, consistent with the findings about negative vertical spillovers within the same province, I find negative vertical spillovers from wholly owned foreign firms, but not joint ventures. These results support the general theme of the paper that wholly owned foreign firms are more able to prevent knowledge dissipation or less willing to transfer technology to the locals, letting the "crowding-out" effects dominate at the province level.

Furthermore, I explore whether foreign ownership by different source countries affects the pattern of spillovers. Since the majority of foreign direct investment came from Hong Kong, Macau and Taiwan, I focus on the differences between spillovers from ethnic-Chinese and non-Chinese foreign investors, respectively. According to the recent work on the relationship between ethnicity and knowledge diffusion (Agrawal et al., 2007; Kerr, 2007), ethnic-Chinese foreign investors should have a higher propensity for knowledge dissipation. In contrast to the prediction of the theory on ethnic-network effects, I find that the presence of ethnic-Chinese foreign firms are associated with lower domestic-firm productivity in the same sector, although I find no relationship between ethnic-Chinese foreign ownership and vertical spillovers.

Finally, I examine whether the observed productivity spillovers associated with different ownership structures vary across different subsamples of recipient firms. I find that negative horizontal spillovers are particularly strong for domestic enterprises that are state-owned, technologically backward and located in inland provinces. Importantly, the effects are more pronounced for spillovers from wholly owned foreign firms than joint ventures across the board. These findings suggest that the entry of foreign firms into a sector forces less productive firms to reduce production, possibly enhancing the long-run average productivity of the host economy.

The rest of the paper is organized as follows. Section 2 reviews the literature on productivity spillovers from FDI, and how the ownership structure of foreign affiliates affects the spillover patterns. Section 3 describes the data set used in the empirical analysis. Section 4 presents a brief history of FDI in China. Section 5 formalizes the empirical strategy. Section 6 reports the findings and the final section concludes.

2 Theories of Productivity Spillovers from FDI and Related Literature

2.1 Horizontal Spillovers

Productivity (efficiency) spillovers from FDI to domestic firms are the most researched topic in the literature on the benefits of FDI.[1] Theories argue that domestic firms benefit from the entry of foreign firms through imitation, competition, arms-length transactions, and worker turnover (Kokko, 1996). Specifically, when more foreign affiliates operate in a sector of the host economy, domestic firms enhance their productivity by imitating foreign production technologies. They will also invest more in product development and quality assurance, or simply allocate resources more efficiently to stay competitive. Reinforcing these two channels is the turnover of workers, who bring with them the knowledge acquired from foreign managers when they move from foreign affiliates to domestic firms. Likewise, domestic business partners of jointly-invested projects can apply management skills acquired from their foreign partners in projects of their own.

Consistent with these theoretical predictions, early empirical studies based on industry-level data find evidence of positive spillovers. Among them, a pioneering study by Caves (1974) finds that a higher share of output produced by foreign firms is associated with higher average productivity for Australian manufacturing industries in the 60s. Subsequently, Globerman (1979) also finds a positive correlation between the two for Canadian industries in the 60s. More recently, Blomstrom and Wolff (1994) find that in Mexico, productivity growth and convergence to the productivity frontier of the U.S. affiliates were faster in manufacturing sectors with higher penetration of multinationals.

The conclusions of these pioneering empirical studies have been questioned for the problems of reverse causality and omitting time and industry effects. The common criticism is that foreign investors tend to "cherry-pick" high-productivity sectors to invest, and therefore it is hard to determine the direction of causality using sector-level data. Recent studies based on micro-level (firms or establishments) panel data cast doubt on the evidence of positive spillovers, and find either

[1] See Gorg and Greenway (2004) for an extensive review of the vast literature on FDI spillovers.

insignificant or negative intra-industry spillovers. Among them, Haddad and Harrison (1993) find no significant relationship between the level of FDI and domestic-plant productivity growth in the same sector for Morocco in the late 80s; Aitken and Harrison (1999) find a negative relationship between the two for Venezuelan manufacturing industries for the 70s and 80s, followed by similar findings for the 90s by Djankov and Hoekman (2000) on Czech Republic, Konings (2001) on Bulgaria and Romania,[2] and Javorcik (2004) on Lithuania. The authors of this literature put forth the possibility of negative efficiency spillovers arising from foreign firms stealing market shares from domestic firms. Specifically, when there are fixed costs of production, a lower level of output dispersed over the same fixed costs would imply lower observed productivity. They hypothesize that this "market-stealing" effect can dominate the positive benefits of knowledge dissipation from FDI, resulting in negative productivity spillovers.

The findings for developed countries are more encouraging. Keller and Yeaple (2005) and Haskel, Pereira and Slaughter (2007), find evidence for positive horizontal spillovers for manufacturing plants in the U.S. and U.K., respectively. Nevertheless, according to a comprehensive review by Gorg and Greenway (2004), among 24 firm-level panel studies, only 5 of them find positive spillovers, of which 4 of them are from developed countries, with Ghana being the only developing country having positive spillovers from FDI.

There have been several papers on FDI spillovers in China.[3] Liu (2008) also uses firm-level panel data and finds negative horizontal spillovers to manufacturing firms in China. He extends the study by examining the dynamic aspects of spillovers, and finds that despite the negative contemporaneous correlation between foreign penetration and domestic-firm productivity, there is a time lag for positive productivity spillovers to realize.[4] He attributes the lag of positive spillovers to managers' substituting production time for foreign know-how acquisition. There are several differences between his work and mine. First, his data set covers the first half of the 90s for medium- to large-sized firms, while mine covers the late 90s for all firms with at least five employees. Importantly, our focuses are different. He takes on a more novel path to explain the negative contemporaneous horizontal spillovers, focusing on the delay of spillovers due to manager's acquisition of foreign know-how, and I adopt a more conventional view of competition effects to explain negative spillovers. I also focus on how the structure of ownership of foreign firms affects the pattern of spillovers.

This paper is closed related to a recent study by Abraham, Konings and Slootmaekers (2007), which also examines productivity spillovers from FDI in China. The authors focus on horizontal spillovers, and how the magnitude of spillovers varies across recipient firms with different characteristics. Importantly, using a data set of publicly-listed, medium- and large-sized firms, they find

[2] Konings (2001) finds no spillovers to domestic firms in Poland.

[3] See Hale and Long (2007) for a review of this literature.

[4] Specifically, Liu (2008) interacts a time trend with the horizontal spillover term, and finds that the coefficient on the interaction is positive and significant.

positive horizontal spillovers, and that joint-ventures are responsible for most of the positive externalities.[5] Consistent with their findings, I find that joint-ventures are associated with less negative spillovers. In contrast to their findings, I find negative horizontal spillovers to domestic firms. To my understanding, there are at least two explanations for our drastic differences. First, the average firm size in their data set is bigger, and it is possible for them to find positive spillovers while I find negative spillovers. For instance, Gorodnichenko et al. (2007) find positive spillovers in a sample of firms with more than 30 employees in 17 emerging market economies, but not in a sample when smaller firms are included. Recent literature (Tybout, 2001; Helpman, Melitz and Yeaple, 2004) also shows that larger firms are on average more productive. Second, our regression specifications are different. They run a level regression with firm controls, but not firm fixed effects, while I use a first-difference specification, which removes firm fixed effects on productivity. The existence of unobserved firm characteristics that affect productivity can explain our different conclusions. Along these lines, Hale and Long (2007) review several studies that find positive spillovers in China, and argue that the findings could disappear once firm fixed effects are controlled for.

2.2 Vertical Spillovers

The lack of observed positive horizontal spillovers from FDI leads researchers to search for spillovers across industries through forward and backward linkages. The hypothesis is that through forward linkages, productive foreign firms in the input-supplying sectors provide better intermediate inputs, which would enhance downstream domestic-firm productivity. Through backward linkages, foreign firms have incentives to transfer knowledge to the upstream intermediate-input suppliers, hoping to improve the quality of the intermediate inputs. Supporting these theories are case studies which show that knowledge is transferred from downstream foreign affiliates to upstream domestic suppliers through intensive monitoring, training, and assistance and supervision in implementation of new technologies (Moran, 2001). Consistent with these observations, recent studies using micro-level data find evidence showing that increased foreign presence is associated with higher productivity (level or growth) of domestic input-supplying firms. This literature includes earlier work by Blalock (2001) on Indonesia, and Schoors and van der Tol (2002) on Hungary, followed by Javorcik (2004) on Lithuania and Javorcik and Spatareanu (2008) on Romania.

Similar to horizontal spillovers, in theory, vertical spillovers do not have to be unambiguously positive. Theoretical models by Rodriguez-Clare (1996) and Markusen and Venables (1999) posit that foreign firms sourcing intermediate inputs from abroad would "crowd-out" the demand for locally-produced inputs. They predict that the share of intermediate inputs sourced locally by multinationals is increasing in the distance between the multinational headquarters and the subsidiaries in the host country. Javorcik and Spatareanu (2008) use this theory to explain their findings of negative vertical spillovers from European foreign affiliates to Romanian manufactur-

[5] Specifically, Abrahams et al. (2007) use a data set compiled by Bureau van Dijk, which contains publicly listed firms, or firms with at least 150 employees, annual turnover (output) of at least 10 million USD, or total assets of 20 million USD.

ing firms. Similarly, Liu (2008) also reports negative vertical spillovers through backward linkages in China. In sum, although the majority of findings in recent literature finds positive vertical spillovers, particularly through backward linkages, the conclusions on the net effects of vertical spillovers remain mixed.

2.3 The Impact of Different Ownership Structures of Foreign Firms on Spillovers

Domestic equity ownership requirement has been an important part of FDI policies in China and other developing countries. Policy makers believed that foreign knowledge would be more effectively transferred to the domestic parties within jointly owned firms, and eventually spill over to the rest of the economy. The argument has been put forth by Blomström and Sjöholm (1999), who claim that a local shareholder in a foreign-invested project often acquires proprietary technology which she can use in projects of her own.

From the foreign investors' point of view, however, restricting wholly foreign ownership reduces their ability to internalize the benefits of possessing superior technology and know-how. When contracts cannot be written or enforced to restrict know-how "leakage", foreign investors will choose to increase equity ownership, hoping that the associated control rights can enhance their ability to prevent knowledge dissipation. The predominance of wholly and majority owned foreign enterprises in developing countries is consistent with this claim. Survey findings also show that more advanced technology is deployed in wholly and majority owned foreign firms in India (Ramachandaram, 1993) and China (Long, 2005).[6] Consistently, Desai, Foley and Hines (2004) find that compared to minority owned foreign firms, wholly and majority owned foreign subsidiaries in host countries receive more investments in intangible assets from their parent firms.

At first sight, it seems that more technology transfer from the parents to the majority owned foreign subsidiaries implies more spillovers. However, as foreign parent firms tend to deploy more sophisticated know-how to their affiliates in the host economy, the resulting wide technology gap between majority owned foreign firms and domestic enterprises may dampen the potential for spillovers. In addition, the very reason why foreign investors choose to increase their equity ownership in foreign affiliates is to prevent knowledge dissipation. Stronger protection of knowledge externalities, along with a wider technology gap between local and foreign firms, implies that higher foreign equity participation impedes spillovers, both within and across industries.

For vertical spillovers through backward linkages, it has been argued that joint ventures are also associated with more knowledge transfer to intermediate-input suppliers than wholly owned foreign firms. The rationale is that joint ventures are more likely to source locally with the help of domestic partners (Javorcik and Spatareanu, 2008). Therefore, through more direct contacts

[6] In particular, Long (2005) finds that 39.7% of the majority owned and 31.7% of the solely owned foreign firms use the same advanced technology as the parent companies; while the numbers for domestic majority owned and equally-shared joint ventures are 5.8% and 22.6%, respectively.

with local suppliers, joint ventures are associated with more knowledge spillovers to domestic firms through backward linkages. Reinforcing this is a reduction in imports of intermediate inputs by joint-ventures relative to wholly owned foreign enterprises, which results in less crowding-out to the demand for locally-produced inputs.

Finally, there has been a growing literature which emphasizes the role of ethnicity in promoting knowledge transfer. Kerr (2007) shows that ethnicity of scientists is an important determinant of global patent citation. In addition, Agrawal et al. (2007) develop a model to understand the optimal spatial concentration of socially-proximate inventors. They predict that although both co-location and co-ethnicity facilitates knowledge diffusion among inventors, it's the latter that gives rise to a higher marginal benefit for innovation. While these theories imply that ethnic-Chinese foreign affiliates would transfer more knowledge to the locals than the non-Chinese foreign firms, on the other hand, Huang et al. (2008) find that ethnic-Chinese foreign affiliates in China did not command higher returns to equity or assets than non-Chinese multinationals in the late 90s.

3 FDI in China

Since 1979, the year the Chinese government opened its economy to foreign capital and trade flows, China has implemented a variety of policies to attract FDI. These policies gave foreign-invested enterprises favorable treatments, such as tax credits and subsidies for exports and infrastructure. Along with China's incredible growth in the past 25 years, these policies have been very successful in promoting FDI inflows. As illustrated in Figure 1, inward FDI flows to China increased by more than a thousand times in the past 25 years, from 57 million US dollars in 1981 to 70 billion US dollars in 2006. Evidently, FDI inflows picked up substantially after the famous "southern journey" endorsing economic reforms made by the late Deng Xiaoping in 1992. Since 1993, China has been the biggest recipient country of FDI among developing countries. In 2006, China's FDI inflows (69.5 billion USD) accounted for 18% of the total FDI flows to developing countries. The value is 80% of the total FDI flows to Latin America and the Caribbean, about the same as the amount to Eastern European transition economies, and twice as large as those to Africa (United Nations, 2007). In short, FDI has played an important role in fueling China's economic growth by promoting exports, creating jobs, and providing capital to productive business activities which were inadequately financed by the inefficient financial market.

Turning to the distribution of FDI, by the end of 2001[7], more than 80% of historical FDI flows were in the form of greenfield investment (Long, 2005). As reported in Table 1 (the last column), 60% of the total cumulated FDI went to the manufacturing sector, followed by real estate as the second largest recipient sector, which received 15% of the total. Given that China has been relying mainly on manufacturing output for growth, it is not surprising to see such a large share of FDI going to the manufacturing sector. Another explanation is that investments in many non-manufacturing

[7]2002 is the most recent year for which the statistics are available from China Ministry of Commerce.

sectors were prohibited by the Chinese government.[8] Turning to the source countries of FDI, East Asian economies have been the major source, because of their proximity and ethnic connection to mainland China. As of 2002, the top three FDI source countries were Hong Kong, United States and Japan, with Hong Kong itself contributed more than half of the total realized FDI stock (See Table 2 for details).[9]

In addition to using FDI as a main source of foreign capital to support growth, the Chinese government was also concerned about knowledge transfer from foreign firms. To facilitate knowledge transfer, in addition to financial incentives, the Chinese government laid out a series of guidelines and rules for foreign investors to follow, aiming at maximizing transfers of technology and management skills to domestic firms.[10] These rules diverted FDI to the "strategic" sectors where know-how transfers were believed to be the most beneficial for economic development. There were clauses which required foreign firms to satisfy minimum export and performance requirements regularly. Perhaps the most stylized FDI regulation in China is domestic equity requirement. Wholly foreign-owned enterprises were basically prohibited unless they promised to bring advanced technology and equipment to benefit domestic firms. With China's accession to WTO in 2001, this restriction was removed and a lot of previously jointly owned foreign affiliates turned into wholly owned foreign firms (Long, 2005).[11]

4 Empirical Strategy

4.1 Baseline Specification

To examine whether foreign presence affects domestic-firm productivity through both the horizontal and vertical channels, I regress the growth rate of firm TFP (defined as the first difference of the natural log of productivity) on the first differences of the measures for horizontal and vertical spillovers, respectively. I use first differences of all variables to remove all unobserved firm characteristics that affect the level of productivity.[12] First-differencing also removes sector and region fixed effects on firm productivity to alleviate the endogeneity problem arising from foreign investors'

[8] See the Law of People's Republic of China upon Foreign Wholly Owned Enterprises for details.

[9] Notice that Taiwan stood at number 4 on the list. However, Long (2005) points out that many Taiwanese businessmen invested in mainland China through Hong Kong, Virgin Islands and the Cayman Islands to avoid restrictions imposed by the Taiwanese government. He speculates that the actual value of FDI stock from Taiwan can be 2 to 3 times higher than what was recorded, making Taiwan the second largest FDI source for mainland China.

[10] These guidelines and rules include the Law of People's Republic of China upon Foreign Wholly Owned Enterprises, Law of the People's Republic of China upon Sino-Foreign Joint Ventures, and Guiding Directory on Industries Open to Foreign Investment.

[11] Unfortunately, the data set which I have access to ends in 2001. A fruitful topic of future research is to examine whether and how the spillover patterns changed after the restriction on sole foreign ownership was lifted as a result of China's accession to WTO in 2001.

[12] One can of course argue that productivity growth rate is also firm-specific, and therefore firm fixed effects have to be controlled for in a first-difference specification. It will be ideal to do so if I have a longer time series. Adding firm fixed effects in a 3-year unbalanced panel will greatly reduce the degree of freedom, and restrict identification based on limited within-firm variation in a short time series.

selection into productive sectors or regions. Moreover, since foreign investors "cherry-pick" productive firms to invest, including foreign firms in the sample would lead to overestimation of the true spillover effects. As such, I include only domestic manufacturing firms for all the regressions in this paper.[13] Formally, the regression specification takes the following form:[14]

$$\Delta \ln TFP_{ijrt} = \alpha + \beta_H \Delta H_{jt} + \beta_V \Delta V_{jt} + \eta_C \Delta Conc_{jt} + \eta_I \Delta \ln Imp_{jt} + f_j + f_r + f_t + e_{ijrt} \quad (1)$$

where i, j, r, t stand for firm, sector, region and year, respectively. Δ denotes the change of the corresponding variable from year $t-1$ to t; $\ln TFP_{ijrt}$ is firm i's log of total factor productivity. H_{jt} and V_{jt} are measures for horizontal and vertical spillovers for sector j, respectively (to be discussed below). Positive $\beta' s$ are interpreted as evidence of positive spillovers. While earlier studies based on industry-level data rely on cross-sector variation of FDI to identify the effects of spillovers, this specification instead relies on cross-sector variation of changes in FDI. Figures 2 and 3 illustrate that all 22 ISIC sectors have their measures of H_{jt} and V_{jt} varying over time, which do not appear to be highly correlated. As a confirmation, Pearson correlation between ΔH_{jt} and ΔV_{jt} is 0.05. See Appendix Table A3 for the correlation matrix between the key spillover measures.

$Conc_{jt}$ is a firm-concentration index of sector j at year t. It is measured by a 10-firm Herfindahl index, defined as the square root of the sum of the squares of value-added shares produced by the top 10 producers (by sales) in the sector in each year. A higher $Conc_{jt}$ corresponds to less competition in the goods market. This control is included because of the hypothesis that stiffer competition is associated with higher firm productivity. Imp_{jt} is the value of imports in sector j, capturing the effects of import competition on firm productivity.

f_j, f_r and f_t stand for sector, region and year fixed effects, respectively. In a first difference specification, these fixed effects represent the trends of productivity growth that are specific to a sector, region or year. Finally, e_{ijt} is an error term, assumed to be uncorrelated with the regressors.

Unless otherwise specified, standard errors for all regressions in this paper are clustered at the sector-year level to take into account the correlation between observations belonging to the same industry and year. Moulton (1990) points out that for micro-level regressions, when the regressors are aggregates at a higher level (in this case, at the sector-year level), estimated errors from OLS without clustering will be seriously downward biased.

[13] Joavorcik and Spatareanu (2008) also include only domestic firms in their empirical analysis for the same concern.

[14] Notice that this specification is very reduced-form. Because of data limitation, it is impossible to separate horizontal spillovers into the knowledge-diffusion and competition effects. If data permit, future research should examine these effects separately.

4.2 Measuring Firm TFP

To estimate the magnitude of spillovers of FDI, I use two methods to measure firm total factor productivity (TFP). First, I compute Solow residuals based on sector-specific constant returns to scale production functions. Second, by relaxing the assumption of constant returns to scale, I estimate a Cobb-Douglas production function for each sector. Then for each firm, I take the difference between the predicted and actual log value-added as my second measure of firm TFP. To deal with the problem of firm endogenous input selection, I adopt a two-stage version of the Olley-Pakes (1996) semi-parametric estimation procedure to correct for the bias in the estimated input elasticities.

4.2.1 Solow Residuals

I assume that all firms in a sector produce with the same constant returns to scale production technology, with capital and labor as inputs.[15] As such, I compute the Solow residual for a firm as:

$$\ln TFP_{ijt} = y_{ijt} - labor\_shr_j \times l_{ijt} - (1 - labor\_shr_j) \times k_{ijt}, \tag{2}$$

where subscripts i, j and t refer to firm, sector and year, respectively; y_{ijt} is the natural logarithm of output, measured in value-added terms; l_{ijt} and k_{ijt} stand for the natural logarithms of labor and capital stock, respectively. $labor\_shr_j = \frac{w_j L_j}{P_j Y_j}$ is the time-invariant share of wage bill in total value-added of sector j, of which data are obtained from OECD (2002) for the year 1997, disaggregated at the ISIC (Revision 3) 2-digit level, with 22 industries. This is also the data set from which I obtain the input-output coefficients (see Section 5 below).

4.2.2 Cobb-Douglas Production Function Estimation with Olley-Pakes Correction

Second, to estimate a firm TFP, I assume sector-specific Cobb-Douglas production functions, but relax the assumption of constant returns to scale in production. I regress log output (in terms of value added) on log capital and labor as:

$$y_{ijt} = \alpha + \gamma_j^k k_{ijt} + \gamma_j^l l_{ijt} + \epsilon_{ijt}, \tag{3}$$

where subscripts i, j and t refer to firm, sector and year, respectively. ϵ_{ijt} is an error term (e.g. measurement error). Since the underlying Cobb-Douglas production function is sector-specific, $\gamma's$ are also sector specific, and I estimate equation (3) for each sector separately. With input elasticities estimated, firm j's TFP is computed as the difference between the actual log value-added and the predicted log value-added, i.e. $\ln TFP_{ijt} = y_{ijt} - \widehat{\gamma_j^k} k_{ijt} - \widehat{\gamma_j^l} l_{ijt}$.[16]

[15] Ideally, I would compute Solow residuals based on a 3-factor production function, with materials as an additional input, and gross output instead of value-added as the firm output measure. Even though real output measure is available in the Chinese data set, reliable data and price deflators for material inputs are not. Therefore, I use a 2-factor model, similar to Liu (2008).

[16] Notice that as long as I control for sector fixed effects in all my regressions, it does not matter whether I subtract the sector-specific constant term from the actual log value-added or not.

It is well-known that firms' choices of inputs are endogenous to unobserved productivity of the firm. Suppose there exists a firm efficiency term ω_{ijt} which is observed to the firm, but not to the researchers. Then the term ϵ_{ijt} is composed of ω_{ijt} and some measurement error, which is now correlated with the regressors. Thus, the OLS estimates of $\gamma's$ will be biased upward. To correct for this bias, I follow the existing literature (e.g. Javorcik, 2004; Blalock and Gertler, 2006; Liu, 2008) to implement a two-step version of the Olley-Pakes (1996) estimation procedure to obtain consistent $\gamma's$ and unbiased estimates of firm TFP. The Olley-Pakes estimation uses investment as a proxy for ω_{ijt}. The identifying assumption is that investment is monotonically increasing in ω_{ijt}, conditional on capital. Capital is a quasi-fixed factor of production, and responds to ω_{ijt} only in a lagged fashion through contemporaneous investment. Then the return to labor can be estimated consistently by non-parametrically inverting investment and capital to proxy for the unobserved shock.[17] See Section 8.3 (Data Appendix) for details of the Olley-Pakes estimation, and Appendix Table A1 for the estimated input elasticities for each sector.

4.3 Constructing Proxies for Spillovers

To capture the scope of horizontal spillovers, I follow the existing literature to use the share of output produced by foreign affiliates in the same sector. A firm is considered foreign if it has at least 10% equity shares owned by foreigners. Based on this definition, I construct a sector's measure of horizontal spillovers as the share of output produced by foreign affiliates in the sector, formally as

$$H_{jt} = \sum_{i \in \mathcal{F}_j} Y_{it} / \sum_{i \in A_j} Y_{it},$$

where Y_{it} is the value of output (measured in value-added terms in 1997 constant yuans). A_j is the set of all firms (both foreign and domestic) in sector j. $\mathcal{F}_j \subset A_j$ is the set of foreign firms. Likewise, I define the horizontal spillover term for minority, majority, jointly and wholly owned foreign firms respectively as:

$$H_{jt}^{g} = \sum_{i \in \mathcal{F}_j^{g}} Y_{it} / \sum_{i \in A_j} Y_{it},$$

where $g \in \{\text{min, maj, 100, } jv\}$; $\mathcal{F}_j^{\text{min}}$ represents the set of foreign affiliates with less than (inclusive) 50% of equity shares owned by foreign investors, $\mathcal{F}_j^{\text{maj}}$ represents the set of foreign affiliates with more than (exclusive) 50% of equity shares owned by foreign investors, and $\mathcal{F}_j^{100}$ and $\mathcal{F}_j^{jv}$ represent the sets of foreign affiliates with 100% foreign equity and less than 100% foreign equity, respectively. By construction, $H_{jt} = H_{jt}^{min} + H_{jt}^{maj}$ and $H_{jt} = H_{jt}^{100} + H_{jt}^{jv}$.

To examine the scope of vertical spillovers through backward linkages, for a firm in sector j,

[17] The Olley-Pakes estimation requires each observation included in the estimation to have positive investment. In my panel data set, about 10% of the observations have non-positive investments, and are excluded from the estimation procedure. Alternatively, one can use a similar two-stage estimation procedure by Levinsohn and Petrin (2003), which uses material inputs, instead of investments, to proxy for firm unobserved productivity. However, limited availability of data on material inputs prevents me from adopting the Levinsohn-Petrin approach.

I construct a proxy for foreign presence in the downstream sectors to which sector j supplies its intermediate inputs as:

$$V_{jt} = \sum_{k \neq j} \alpha_{jk} H_{kt},$$

where α_{jk} is the proportion of sector j's output used by sector k. In other words, V_{jt} is a weighted average of H_{kt}'s across the sectors (k's) buying inputs from sector j. Notice that since I do not have detailed information on firms' intermediate-input sourcing, I implicitly assume that all firms in the same sector have the same input-output linkages to other sectors, and assign the same input-output coefficients ($\alpha_{jk}\prime s$) to all firms in the same sector.

To study the relationship between the ownership structure of foreign affiliates and the degree of spillovers, I construct proxies for vertical spillovers from wholly, jointly, majority, and minority owned foreign affiliates, respectively, using the corresponding horizontal spillover measures. Formally,

$$V_{jt}^{g} = \sum_{k \neq j} \alpha_{jk} H_{kt}^{g}$$

where V_{jt}^{g} represents the degree of vertical spillovers from foreign firms belonging to group g, where $g \in \{\text{min, maj, 100, } jv\}$, as defined above for horizontal spillovers. Table 4 lists the summary statistics of all the spillover measures used in the empirical analyses.

5 Data

I use firm-level panel data adopted from National Bureau of Statistics of China (NBSC) to conduct my empirical analysis. The data set contains the population of manufacturing firms in China with sales in excess of 5 million yuans (about 600,000 USD) for each year between 1998 and 2001. It is estimated that the data set covers about 85-90% of total output in most manufacturing industries.

In addition to detailed financial statement data, it includes information on equity ownership in each firm, which allows researchers to measure the extent of foreign presence in each sector. While the data set provides no information about the nationality of all foreign investors in each firm, it does record the share of equity owned by overseas ethnic Chinese from Hong Kong, Macau or Taiwan. Therefore, I can construct separate measures for foreign presence of ethnic Chinese and non-Chinese investors, respectively. Furthermore, the data set contains information on different types of domestic owners, which are categorized into 4 different types – 1) governments (either local or central government), 2) collective owners (e.g. township and villages cooperatives) 3) institutional investors and 4) domestic private investors. With these information, I can examine whether the magnitude of spillovers differs across domestic enterprises with different types of ownership.

I focus on a sub-sample of the data set of firms with at least 5 workers in each year in the panel. I drop observations with negative values for important variables (See Section 8.1 for details about the cleaning procedure). After removing unusable observations, the final unbalanced panel contains 330,508 observations, with 71,644, 96,183, 91,933 and 73,748 observations for 1998, 1999, 2000 and 2001, respectively.[18] Of these observations, 80% are for domestic firms, defined as enterprises with less than 10% foreign equity.

The data set contains data on firms' gross output in current and constant (1997) prices, value-added and capital in current prices, and the number of employees. First, I obtain firm-specific implicit output deflators by dividing gross output in current prices by gross output in constant prices. I use these deflators to deflate the nominal value of value-added to obtain real value-added, which I will use as my measure of output in the construction of firm TFP measures.[19] Labor is measured by the total number of employees, instead of hours worked, due to the lack of data. Capital stock is measured as the net value of fixed assets, deflated by province-specific weighted average of separate cost indices for investments in construction and installation, purchases of equipment and instruments, available in various issues of the China's Statistical Yearbook (1999-2002).

To construct the proxies for the extent of foreign presence in each sector, I adopt the Chinese input-output table for the year 1997 from the OECD Input-Output Database (2002). For each sector, it contains information on the total value of output used as intermediate inputs by all sectors. Based on these values, for a given sector, I calculate the input share in its total intermediate-input sales of each of its downstream sectors. Since in the OECD data set, a sector is defined as an ISIC (revision 3) 2-digit category, while in the Chinese firm census data set, it is classified under the Chinese NBS system (at a more disaggregated level), I use the concordance file available in the China's Industrial Statistical Yearbook to map all Chinese NBS industrial code to 22 ISIC 2-digit categories. Then I use the input-output coefficients as weights to construct proxies for vertical spillovers for each firm (as discussed in Section 4.3). From the same data set, I also take data on labor income and value-added to obtain sectoral labor shares for the construction of Solow residuals, and import and export data as the control variables in the regressions.

6 Results

6.1 Baseline Results

The empirical analysis begins by examining whether there are spillovers within sectors (horizontal) and across sectors through backward linkages (vertical). As discussed in section 2, *a priori*, we do not know whether spillovers exist in either channel, and if so, whether they are positive or negative. Horizontal spillovers would be expected to be positive if the positive effects of knowledge diffusion dominate other negative effects, such as the competition effects. Similarly, we would

[18]The balanced panel (containing firms which present in all 4 years) contains 31,289 firms.

[19]Data on the costs of "intermediate inputs" are available for a subset of firms in the data set. However, simple calculation shows that this measure contains much more than material inputs, which were included as an input in productivity estimation in previous literature (e.g., Aitken and Harrison (1997) and Javorcik (2004)).

observe positive vertical spillovers if multinational firms transfer enough knowledge to the upstream domestic firms, offsetting the possibility of negative crowding-out effects arising from imports of intermediate inputs.

The baseline regression analysis, based on specification (1), is performed on the sample of domestic firms, i.e. firms with less than 10% foreign equity. Results are reported in Table 5. All regressions include sector, province and year fixed effects to capture sector- and province-specific trends, and any economy-wide demand and supply shocks. Firm-specific productivity is measured as Solow residuals according to equation (2). I first exclude the controls of firm concentration and import penetration in the sector. In column (1), I find a negative and significant relationship between an increase in the share of output produced by foreign affiliates (ΔH_{jt}) and the productivity growth of domestic firms in the same sector. The coefficient on the horizontal spillover measure is statistically significant (at the 5% significance level) and economically meaningful. A point estimate of -0.238 implies that one standard-deviation increase in the change in foreign share of output in the same sector, ΔH_{jt} (i.e. a 4% increase from the mean equal to 2%) is associated with a 0.95 percentage-point decline in domestic-firm TFP growth.

In column (2), I regress firm productivity growth on the first difference of the vertical spillover term, ΔV_{jt}. The coefficient on ΔV_{jt} is insignificant at any conventional statistical significance level. In other words, productivity growth of a local input supplier is unrelated to the foreign presence in its downstream sectors (the sectors to which it supplies intermediate inputs). When I include both ΔH_{jt} and ΔV_{jt} as regressors in column (3), ΔH_{jt} remains a significant source of spillovers. In column (4), I control for a sector's firm concentration and import penetration. The coefficients on both the Herfindahl index and the volume of imports are statistically insignificant. These results are consistent with Nickell (1996), who points out that theoretical predictions on the impact of competition on productivity growth are ambiguous. Likewise, it is difficult to establish a causal relationship between a sector's volume of imports and firm productivity. Nevertheless, the findings of negative horizontal spillovers and 0 vertical spillovers remain robust across all four columns.

Researchers have argued that there can be a time lag for positive productivity spillovers to realize (Liu, 2008). In a level regression specification, adding lagged values are more important. In a first-difference specification, however, it is unclear whether lagged changes in foreign presence are related to the firm productivity growth at present. Irrespectively, in column (5), I include the lagged values of the first difference of the spillover terms. The coefficients on both the lagged spillover terms are insignificant, consistent with the claim that the lag of foreign knowledge absorption by domestic firms may offset some of the contemporaneous negative competition effects.[20] In column (6), I deviate from the baseline specification of this paper by running a level regression. I continue to find evidence of negative horizontal spillovers, but not vertical spillovers. However, one should be

[20] It is possible that a one-year lag is insufficient to account for the time lag of FDI spillovers. However, the short time horizon of the data set does not allow me to control for more lagged values. With a longer time series, studying the dynamic effects of spillovers is an interesting area of research.

careful in interpreting the results from a level specification without fixed effects, which are removed in a first-difference specification. Finally, I use a second-difference specification to verify the findings in column (7). The coefficient on the horizontal spillover term continues to be negative, as in the first-difference specification, but is no longer statistically significant.[21] This result is consistent with the findings from the regression when lagged values of spillovers are used. If locals need time to acquire foreign knowledge, an increase in foreign presence for two years (second differences) is likely to be associated with more knowledge transfer, which may offset more of the short-run competition effects.

If the net negative effects are due to the dominance of the negative competition effects, we should expect lower output growth of domestic firms associated with an increased foreign presence in a sector. In Table 6, I repeat the analogous analyses I did in Table 5, by replacing a firm's Solow residual growth by its value-added growth. In column (1), I find that the coefficient on the horizontal spillover measure is also negative and significant (at 5% significance level), consistent with the conjecture that foreign presence is associated with decreased domestic production in the short run. The point estimate of -0.257 means that a 4 percentage-point (one standard deviation) increase in the first difference of within-industry foreign presence is associated with about 1 percentage-point decline in output growth.

The magnitude of the coefficient seems too small to explain the net negative horizontal spillovers on TFP growth. To illustrate the point, consider the following simple exercise. Suppose that the production function of a representative domestic firm in a sector is $Y = A(Y_f)X^{\eta}$, where Y represents firm output, X represents cost-minimizing choices of inputs, and Y_f denotes an exogenous level of foreign output in the sector. The function $A(Y_f) > 0$ represents firm TFP, and is increasing in Y_f to capture positive knowledge transfer from foreign firms. For convenience, I assume that $A(Y_f) = Y_f^a$. Furthermore, increasing returns to scale due to firms' decreasing average costs implies $\eta > 1$. On the demand side, to capture the negative competition effects, suppose that demand for domestic products is negatively related to the exogenous level of foreign output in the sector. Therefore, abstracting from other determinants of demand, I denote demand for goods in a sector as $Y_d = B(Y_f)$, with $B'(Y_f) < 0$. For expositional purposes, I assume $B(Y_f) = Y_f^{-b}$, with $b > 0$. Taking log for both supply and demand functions, I obtain the following system of two equations

$$\begin{aligned} y &= ay_f + \eta x \\ y_d &= -by_f \end{aligned}$$

where lower cases stand for log values. In equilibrium, a firm's output and Solow residual $(y - x)$

[21] With the sample size decreases by half from the baseline sample, readers should interpret the results from a second-difference regression with caution.

can be expressed in terms of y_f as:

$$\begin{aligned} y &= -by_f, \\ y - x &= (a - (\eta - 1)\, b)\, \frac{y_f}{\eta}. \end{aligned}$$

Assume for the moment that gross knowledge transfer from FDI has a negligible impact on productivity, i.e. $a = 0$. The coefficient on y_f on the output regression is $-b$, while that for the productivity regression is $-\left(\frac{\eta-1}{\eta}\right) b$. The estimated coefficients from the corresponding regressions ($-b$ =-0.257; $-\left(\frac{\eta-1}{\eta}\right) b$ =-0.238) imply returns to scale η of 13.5! Such an implausible implied returns to scale can be a result of measurement errors in micro-level production data for developing countries. For example, if capital is over-measured, or is heavily under-utilized in reality but not captured in the data, measured productivity will be downward biased. In addition, materials are an important input of production. Although I use value-added as my measure of output, which already takes the omission of materials as an input into account, if changes in material inputs are not controlled for (because of data limitation), estimated impact of FDI on productivity growth can be biased away from 0. That said, further research is needed to fully understand the inconsistency between the results from the output and productivity regressions. Readers should interpret the magnitude of the spillover effects of FDI with this caveat in mind.

As reported from columns (2) to (4) of Table 6, I find a negative relationship between changes in foreign presence in a sector and domestic-firm value-added growth, consistent with the findings in Table 5. Similarly, I find no relationship between foreign equity participation in a local firm's downstream sectors and its value-added growth. These results remain robust after I control for changes in firm concentration and imports in the same sector. In column (5), I find a positive coefficient on the lagged horizontal spillover term (significant at the 10% significance level), implying that an increase in foreign presence in a sector with a year lag is associated with an increase in value-added growth of domestic firms. With the caveat of the significance level in mind, this result is consistent with the argument about the time lag of FDI spillovers. Finally, in column (7), I find evidence of negative horizontal spillovers based on a specification using second differences.

To check the robustness of the results, in Table 7, I conduct the identical analyses of Table 5, using Olley-Pakes estimated TFP growth as the dependent variable. Consistent with the results in Table 5, besides the regression with lagged spillover terms, I find negative and significant coefficients on the horizontal spillover term (ΔH_{jt}) across all specifications. The magnitudes of the coefficients are also comparable with those reported in Table 5. Likewise, I also find no evidence of vertical spillovers (ΔV_{jt}).

In sum, I find strong evidence supporting contemporaneous negative relationship between higher foreign presence and domestic-firm productivity growth in the same sector (i.e. horizontal negative spillovers) and no evidence of vertical spillovers. The first set of results supports the recent literature which finds negative horizontal spillovers from FDI (Aitken and Harrison, 1999; Djankov and Hoekman, 2000; Konings, 2001; Javorcik, 2004). The second set of results contrasts the findings of positive vertical spillovers through backward linkages in recent literature (Javorcik, 2004; Blalock and Gertler, 2006; Javorcik and Spatareanu, 2008). Although the negative competition effects are the dominant explanation for the observed net negative horizontal spillovers, I find no consistent evidence from the output regressions to support the argument.

6.2 Within-Province Spillovers

Next, I examine whether productivity spillovers from FDI take place within and across provinces, respectively. To this end, I decompose the measure for nation-wide horizontal spillovers into two separate measures, one for own-province horizontal spillovers, another one for spillovers from other provinces (cross-province spillovers). Specifically, the degree of own-province horizontal spillovers is measured by the share of output produced by foreign affiliates in both the same sector and province where the firm operates. The degree of horizontal spillovers from other provinces is measured by the share of output produced by foreign affiliates in the same sector, but located outside the province where the firm operates. The procedure to construct the vertical spillover measures is similar. Specifically, to construct the within-province vertical spillover proxy for a domestic firm, I use the same input-output coefficients taken to construct the nation-wide spillover measures, along with within-province horizontal spillover measures, to compute a weighted (weighted by input-output coefficients) average of the foreign presence in a firm's downstream sectors in the same province. Similarly, I construct the cross-province vertical spillover proxies, using the same input-output matrix, and the measures of cross-province horizontal spillovers.

To test whether spillovers exist both within and across provinces, in Table 8, firm productivity growth is regressed on own- and cross-province spillover terms, respectively. In column (1), using a firm's Solow residual as the measure of TFP, I find support for negative own-province horizontal spillovers (at 10% significance level), but also negative vertical spillovers from downstream foreign firms within the same province. The coefficient on the own-province vertical spillover is negative and significant (at 1% significance level), with a large magnitude. A one standard-deviation increase in the own-province vertical spillover measure (ΔV_own_{jt}) (a 1% increase from the mean of 2%) is associated with an average of 0.57 percentage-point decline in the productivity growth of domestic firms located in the same province.

In column (2), I replace all own-province spillover measures by their corresponding cross-province measures to examine whether productivity can "spill over" to firms in other provinces. I find evidence of negative horizontal spillovers from foreign firms in the same sector to a domestic firm located in a different province. Importantly, the coefficient on the cross-province horizontal spillover term is statistically significant, and bigger in magnitude than that for within-province spillovers. While for vertical spillovers, no cross-province spillovers are found. These results, together with those in column (1), are confirmed in column (3) when variables for both own- and cross-province spillovers are included as regressors. Nevertheless, I do not find support for negative spillovers when I use lagged values of spillover terms in column (4). From columns (5) to (8), I repeat the same regressions in columns (1) to (4), using the Olley-Pakes estimated TFP as the dependent variable. The results remain almost quantitatively identical.

These findings suggest that proximity to foreign firms is an important determinant of the net effects of spillovers, and can be explained by the particular situation of economic fragmentation in China. First, the theory emphasizing knowledge dissipation due to workers' turnovers can explain the observed different magnitudes of negative horizontal spillovers for within and between provinces. It is well-known that due to governments' restriction, cross-province worker mobility is low in China. As suggested by earlier literature (e.g. Kokko, 1996), if workers bring foreign know-how to domestic firms when they move from foreign to domestic firms, increased foreign presence in a province is more likely to transfer knowledge to domestic firms located nearby, rather than to those located in a different province. Hence, more pronounced knowledge diffusion effects within the same province can offset more of the competition effects, resulting in less negative horizontal spillovers from foreign to domestic firms in the same province than from other provinces.

Moreover, in contrast to the existing findings, I find negative vertical spillovers within the same province. These results are consistent with the hypothesis that imports of intermediate inputs by multinationals can crowd out demand for locally produced inputs. An explanation is that until recently, a majority of foreign direct investment in China were for labor-intensive final-stage assembly (Henley et al., 1999), which involved a lot of imported intermediate inputs. According to the theoretical models of Rodriguez-Clare (1996) and Markusen and Venables (1999), imported intermediate inputs substitute for locally-produced inputs, and can force less productive domestic input suppliers to reduce production or shut down.[22] Similar to the explanation for negative horizontal spillovers, under the condition that firms produce with fixed costs, the resulting short-run increasing returns to scale in production implies that crowding-out by downstream foreign firms will lead to negative vertical spillovers.

An important question is why the crowding-out effects through backward linkages are observed only within provinces, but not across provinces. As for the case of negative horizontal spillovers, economic fragmentation in China can shed light on this phenomenon. In addition to underdeveloped transportation infrastructure, fierce political and economic competition between provinces increase cross-province trade barriers in China (Kumur, 1994; Young, 2000), especially for differentiated products (Huang and Wei, 2002). As a result of high trade costs between provinces, a recent study by Amiti and Javorcik (2006) find that both market and supplier accesses are important

[22] In unreported results, when I regress value-added growth on the own-province vertical spillover term, I find a significant and negative coefficient on the latter. This result shows that foreign entrants in the downstream sectors of a firm did crowd out demand for its intermediate inputs. Similar to the earlier discussion about the required returns to scale, however, I do not find a sufficiently large coefficient in the corresponding output regression to explain the magnitude of the negative vertical spillovers. Further research is needed.

determinants for the location of foreign firms in China, with the latter being relatively more important. Thus, in an economically fragmented market, domestic and foreign firms are more likely to source inputs from firms operating in the same province. When foreign firms enter a sector, the crowding-out effects are particularly strong for the local intermediate-input suppliers, but weak for suppliers located farther away. A stronger crowding-out effect in the neighborhood of a domestic input supplier, therefore, can explain the existence of negative vertical spillovers at the province level, but not at the national level.

6.3 Ownership Structure and Spillovers

The second part of the paper examines whether the structure of ownership and the nationality of owners of foreign firms affect the extent of spillovers. First, I focus on the differences between spillovers associated with wholly and jointly owned foreign firms (joint-ventures), respectively. Recent literature posits that joint ventures are associated with more knowledge spillovers in the same sector. For vertical spillovers, joint-ventures are more likely to source locally with the help of the domestic partners, enhancing the potential for knowledge transfer to the intermediate-input producers through backward linkages (Javorcik and Spatareanu, 2008). Therefore, for both horizontal and vertical spillovers, we should expect higher spillovers associated with joint-ventures. Specific to the findings of negative horizontal spillovers in this paper so far, we should expect wholly owned foreign firms to be responsible for more negative spillovers.

To formally study different spillover effects associated with different ownership structures, I decompose nation-wide horizontal spillovers into two separate measures: a measure associated with wholly owned foreign firms and another one for joint-ventures. As discussed in Section 4.3, the proxy for horizontal spillovers from wholly owned foreign firms is measured by the share of output produced by these firms in the same sector. By construction, the share of the remaining output produced by foreign affiliates is the spillover measure for joint-ventures. Likewise, I decompose the vertical spillover proxy into measures for spillovers from wholly and jointly owned foreign affiliates, respectively.

Table 9 shows the results of the regressions for spillovers associated with foreign firms with different ownership structures. In column (1), I regress firm TFP growth on the first differences of the four spillover terms associated with wholly and jointly owned foreign firms. The coefficients on the two horizontal spillover measures are negative and significant, suggesting that both jointly and wholly owned foreign firms are responsible for lower domestic-firm productivity growth in the same sector. Importantly, the coefficient for wholly owned foreign firms is bigger than that for joint-ventures (-0.525 compared to -0.294, although their difference is not statistically significant). This result is consistent with the conjecture that joint-ventures tend to transfer more knowledge to the locals, offsetting more of the negative competition effects. In contrast, foreign presence in either form of ownership structure does not lead to vertical spillovers.

These findings remain robust to the inclusion of controls of the Herfindahl index and import growth of the sector (column (2)). In column (3), when lagged values of spillover terms are used instead of contemporaneous values, results become insignificant. When I use second-differences for all variables in column (4), I find that the coefficient for wholly-owned foreign firms is about 5 times the size of that for joint-ventures. The difference is statistically different (p-value of the test for same coefficients is equal to 0 at two decimal places).[23] Repeating the same exercises using the Olley-Pakes estimated TFP yields quantitatively similar results (columns (5) - (8)) .

Parallel to the study of own-province spillovers in Table 8, regressions in Table 10 examine whether the relationship between the ownership structure of foreign firms and spillovers is observed both within and across provinces. To this end, I decompose the measures of spillovers (horizontal or vertical) for each ownership structure (sole or joint ownership) into measures for within- and cross-province spillovers. As such, I obtain eight different spillover measures, four for own-province spillovers, four for cross-province spillovers. Formally, the regression specification including all eight spillover measures takes the following form:

$$\begin{aligned}\Delta \ln TFP_{ijrt} \quad = \quad & \alpha + \beta_1 \Delta H\_own^{100}_{jrt} + \beta_2 \Delta H\_own^{jv}_{jrt} + \beta_3 \Delta V\_own^{100}_{jrt} + \beta_4 \Delta V\_own^{jv}_{jrt} \\ & + \beta_5 \Delta H\_other^{100}_{jrt} + \beta_6 \Delta H\_other^{jv}_{jrt} + \beta_7 \Delta V\_other^{100}_{jrt} + \beta_8 \Delta V\_other^{jv}_{jrt} \\ & + \eta_C \Delta Conc_{jrt} + \eta_I \Delta \ln Imp_{jrt} + f_j + f_r + f_t + e_{ijrt},\end{aligned}$$

where i, j, r and t continue to stand for firm, sector, region and time, respectively. The suffix "$\_own$" stands for own-province spillovers, and "$\_other$" stands for cross-province spillovers, superscripts "100" and "jv" represent wholly and jointly owned foreign firms, respectively.

In columns (1), the growth of a firm's Solow residual is regressed on the four measures for own-province spillovers. I find negative horizontal spillovers from wholly owned foreign firms, but not from joint-ventures. The difference between the coefficient on the measure for wholly-owned horizontal spillovers and that for joint-ventures is statistically different at the 5% significance level. These results are consistent with the main prediction of the paper that joint-ventures are associated with more knowledge spillovers. Turning to vertical spillovers, I find negative vertical spillovers from wholly owned foreign firms to local input suppliers in the same province, while no such relationship is observed for joint-ventures. Importantly, the coefficients on the two vertical spillover measures are significantly different at the 1% significance level.

In column (2), consistent with the findings in Table 8, I find no cross-province vertical spillovers from either jointly or wholly owned foreign firms. As discussed earlier, the mechanism of economic fragmentation can be an explanation. For cross-province horizontal spillovers, I find evidence of negative spillovers from joint ventures, but not wholly owned foreign firms. These results are in contrast to the prediction that wholly-owned foreign firms are associated with more negative horizontal spillovers. Including all eight spillover terms for own- or cross-province spillovers associated

[23] Because of the reduced sample size, readers should interpret these results with caution.

with different ownership structures do not overturn the results obtained in column (1) and (2). Repeating the same analyses using Olley-Pakes estimated TFP also yields quantitatively similar results (columns (4) through (6)).

To check the robustness of the findings of spillovers from jointly and wholly owned foreign firms, I examine whether majority owned foreign enterprises (foreign firms with more than 50% foreign equity) are associated with more negative spillovers than minority owned foreign enterprises (those with less than 50% foreign equity). In Table 11, I find that increased presence of majority owned foreign firms is associated with more negative horizontal spillovers, whenever the coefficients on both the majority- and minority-owned spillover terms are statistically significant. The findings remain robust in second-difference specifications (columns (4) and (8)) , and when Olley-Pakes estimated TFP growth is used (columns (5) through (8)). In sum, except columns (3) and (7), when lagged spillover terms are used, the coefficient on horizontal spillovers associated with majority owned foreign firms is always negative and significant at the 1% significance level, with a magnitude higher than that for minority-owned foreign firms (although the coefficients are not statistically different). These results are consistent with the findings in Table 9.

6.4 Nationality of Foreign Investors

Besides studying the spillover effects of different equity-sharing structure between domestic and foreign owners in foreign firms, I consider another dimension of equity ownership that can be related to spillovers – the nationality of foreign investors. If data permit, it would be ideal to examine how different source countries of FDI are related to the degree of spillovers. However, the data set contains only information on whether a firm's foreign investors are from Hong Kong, Macau and Taiwan (ethnic-Chinese henceforth) or other countries. Given that a majority of foreign direct investment came from these three regions (See Table 2), it is still important to study whether there exist different spillover patterns from ethnic-Chinese vis-à-vis non-Chinese foreign firms.

Recent literature emphasizes the role of ethnicity in enhancing knowledge diffusion (Kerr, 2007; Agrawal, 2007). Kerr (2007) finds that scientists are more likely to cite patents by others belonging to the same ethnic group. The direct implication to this paper is that ethnic-Chinese foreign investors should be associated with more know-how transfer, and therefore higher spillovers. To test this hypothesis, I construct measures for spillovers associated with ethnic-Chinese and non-Chinese foreign firms, respectively. Specifically, the ethnic-Chinese spillover measure is the share of output produced by foreign firms with at least 50% ethnic-Chinese equity, i.e. equity owned by Hong Kong, Macau and Taiwan investors. Correspondingly, the remaining share of output produced by foreign firms will be considered a source of spillovers from non-Chinese foreign affiliates.

In contrast to the predictions of the theory on ethnic-network effects, as reported in Table 12, I find that increased presence of ethnic-Chinese foreign firms in the same sector is associated with lower domestic-firm productivity growth, while the entry of non-Chinese foreign firms does not appear to matter at all. The coefficient on the ethnic-Chinese spillover measure is always negative and significant (at 1% significance level), independent of whether I use a second-difference specification (columns (4) and (8)) or Olley-Pakes estimates as measures of firm productivity (columns (5) through (8)). Importantly, when I use lagged changes in foreign presence (columns (3) and (7)) as the explanatory variable of interest, I find evidence of negative vertical spillovers from ethnic Chinese foreign firms, and positive vertical spillovers from the non-Chinese ones. The first set of results is consistent with the findings of negative horizontal spillovers from ethnic-Chinese foreign affiliates, while the second set of results supports the existing literature which finds positive vertical spillovers through backward linkages (Javorcik, 2004; Blalock and Gertler, 2006) .

The findings of negative horizontal spillovers from ethnic-Chinese firms are puzzling. One is tempted to think that ethnic Chinese firms are on average less technologically advanced than non-Chinese foreign firms, and therefore are associated with less knowledge transfer.[24] However, lower productivity also implies lower sales by ethnic-Chinese foreign affiliates, and smaller competition effects. Thus, the net spillover effects from ethnic-Chinese firms should be ambiguous, according to the productivity-competition framework of the paper. One has to deviate from this framework to explain the puzzle.

An explanation is that compared to other foreign investors, ethnic-Chinese foreign investors mainly invest in small scale, labor-intensive projects, often focusing on processing of imported inputs for re-export (Henley et al., 1999). Moreover, because of their proximity and therefore relatively lower communication costs with their subsidiaries in mainland China, ethnic-Chinese foreign owners leave a larger fraction of skill-intensive business services at home, letting more low-skilled final-stage assembly work to be done in mainland China. Increased presence of this sort of foreign presence, compared to those from other countries, have less potential for technology spillovers. A study by Huang et al. (2008) provides evidence for this conjecture. Using the same data set I use, they find that ethnic-Chinese foreign firms do not appear to command higher returns on asset or equity than non-Chinese foreign firms. They explain this by showing that ethnic-Chinese parent firms tend to invest less in intangible assets in their subsidiaries in mainland China, than non-Chinese foreign parents. That said, further research is needed to fully understand the puzzle.[25]

6.5 Different Types of Recipient Firms

Finally, I examine the spillover patterns across various ownership structures over different subsamples of domestic firms. First, I divide the sample of domestic firms into groups of state-owned

[24] For instance, geographical proximity and ethnic connection of Hong Kong, Macau and Taiwan to mainland China may imply lower fixed costs of entry for the ethnic-Chinese investors. If only more productive firms find it profitable to pay the fixed costs of FDI, lower fixed costs for ethnic Chinese foreign investors implies lower average productivity for their foreign affiliates, compared to non-Chinese foreign firms. For a formal analysis, see Melitz (2003) and Antras and Helpman (2004), among others.

[25] A direction of research is to examine whether ethnic-Chinese foreign firms receive different tax treatments, compared to domestic and non-Chinese foreign firms, respectively.

and non state-owned enterprises, respectively. Different from private enterprises, state-owned enterprises have softer budget constraints and have little incentive to stay competitive. They are therefore less responsive to changes in the market environment and are more reluctant to adopt new technologies. As such, state-owned enterprises are expected to experience more negative spillovers.

I define a firm as state-owned if it has more than 50% state-government equity. Using this rule, 28% of the domestic firms in the sample are classified as state-owned enterprises. Columns (1) through (4) in Table 13 show that productivity growth of state-owned enterprises is negatively associated with increased presence of both wholly and jointly owned foreign firms in the same sector, but is unaffected with their presence in the downstream sectors. Importantly, the coefficient on the measure of horizontal spillovers from wholly owned foreign firms is twice as big as that for joint-ventures. Turning to the subsample of non-state-owned firms, I find no productivity spillovers through either horizontal or vertical channel, independent of the ownership structure of foreign firms. In sum, state-owned enterprises bear very negative horizontal spillovers from FDI, particularly from wholly owned foreign firms, possibly due to their lower adoptability to new technology and softer budget constraints.

Second, I consider the subsamples of exporters and non-exporters, respectively. By directly interacting with importing firms, exporters can acquire know-how directly from foreign importers, in addition to FDI. Hence, their productivity growth should be less sensitive to the entry of foreign firms into the domestic economy. I define a firm as an exporter if it exported in all four sample years. As such, 16% of the domestic firms are classified as exporters. Columns (5) through (8) in Table 13 show that exporters' productivity growth is unaffected by the presence of either wholly or jointly owned foreign firms through both vertical and horizontal channels. For the subsample of non-exporters, I find strong evidence of horizontal spillovers, mainly from joint-ventures. In sum, I find evidence supporting the hypothesis that productivity of exporters is less sensitive to FDI, compared to non-exporters.

Third, I consider the subsamples of domestic firms located in coastal and inland provinces, respectively. Since coastal provinces in China are more developed than inland provinces, FDI are unevenly distributed, with the highest concentration of FDI in coastal regions. If geographical proximity to FDI plays an important role for spillovers, as I already showed in the exercise comparing within- and cross-province spillovers, we should expect different spillover patterns between coastal and inland provinces. In columns (1) through (4) in Table 14, I find no relationship between foreign penetration in a sector and productivity growth of domestic firms in coastal provinces. However, for the sample of domestic firms in inland provinces, I identify strongly negative horizontal spillovers.

It should be noted that these results do not contradict the conclusions of within-province negative horizontal spillovers reported earlier. Within-province negative spillovers can be explained by a possibility of competition effects dominating the knowledge-diffusion effects. As shown in Tables 8 and 10, cross-province spillovers arise from foreign firms in both the same and other provinces.

For domestic firms in inland provinces, staying far away from the center of FDI in the coastal regions may imply less knowledge diffusion arising from interaction with foreign firms and worker turnovers. Therefore, with very low knowledge diffusion and relatively high competition effects from foreign firms in other provinces (as shown in Table 8), domestic firms in inland provinces are likely to be hurt more by foreign entry in other provinces.

Finally, I consider the subsamples of technology leaders and laggards, respectively. Technology leaders are domestic firms with TFP (Solow Residuals or Olley-Pakes TFP estimates) in the top 50 percentile in a sector. Recent literature finds that the technology gap between domestic recipient firm and foreign firms determines the extent of knowledge transfer (Aghion et al., 2005; Gorodnichenko et al., 2007), with technology transferability decreases with the gap. More negative spillovers are therefore expected for technology laggards. As shown in columns (5) through (8), the average productivity growth of technology laggards is negatively related to the presence of wholly and jointly owned foreign firms, with the former having a three-time bigger impact than the latter (the coefficients are statistically different at the 5% significance level when Solow residuals are used as the TFP measures). Nevertheless, I find no evidence of positive spillovers from FDI to technology leaders.

The findings of negative spillovers mainly from the sample of state-owned, technologically backward and non-exporters imply that FDI have disciplinary effects on the host economy by forcing inefficient firms to reduce production. If that is the case, we should observe a positive relationship between increased foreign presence in a sector and overall sectoral productivity growth. To explore this relationship, in Table 15, I regress the growth rate of a sector's weighted average of TFP (either Solow residuals or Olley-Pakes estimates) on changes in the sector's foreign presence.[26] As expected, I find positive coefficients on both the horizontal and vertical spillover terms. However, only when I exclude sector fixed effects and use Olley-Pakes estimated productivity growth as the dependent variable, do I find statistically significant coefficients on the horizontal spillover term. Readers should interpret these results with two caveats. First, sector-level regressions examining spillovers are often subjected to the problem of reverse causality. Second, with a short time series, it is difficult to fully capture the long-term positive productivity effects of FDI on overall sectoral productivity. In short, this is a first step to explore the cleansing effects of FDI, which were under-emphasized in the previous literature. Preliminary evidence seems to suggest that FDI is associated with higher overall sectoral productivity growth.

[26]To calculate sectoral productivity, first, for both Solow residuals and Olley-Pakes estimated TFP, I standardize $\ln TFP$ for all firms using sector-specific mean and standard deviation of the variable. Then I take the exponent of a firm's standardized $\ln TFP$ to obtain the level of firm TFP. Then for each year, I compute the weighted average of the levels of productivity of firms belonging to the same sector, using firms' output share in the sector as weights. Sectoral productivity is the log of this weighted average.

7 Conclusions

This paper achieves two goals. The first goal is to examine whether there exist horizontal and vertical spillovers through backward linkages in China. Using a rich panel data set of Chinese manufacturing firms, I find evidence showing that FDI is associated with lower domestic-firm productivity in the same sector. These results are consistent with the recent literature which attributes negative horizontal spillovers to the dominance of negative competition effects over positive knowledge-diffusion effects of FDI.

I find no evidence of vertical spillovers from FDI at the national level. However, I find that increased foreign presence in the downstream sectors in the same province is associated with lower productivity growth of local intermediate-input suppliers. This phenomenon can be a result of negative crowding-out effects arising from multinationals' imports of intermediate inputs, which are particularly strong in the economically fragmented Chinese market.

The second goal of the paper is to examine whether the structure of ownership of foreign affiliates affects the magnitude of spillovers. It was believed that jointly owned foreign affiliates are associated with more knowledge spillovers than wholly owned foreign firms. Consistent with this prediction, I find that wholly owned foreign firms account for a larger share of negative horizontal spillovers, compared to joint ventures. For vertical spillovers, I find no evidence showing that the ownership structure of foreign firms matters. I also examine whether ethnic-Chinese FDI is associated with more knowledge transfer and therefore higher spillovers, than non-Chinese FDI. In contrast to the prediction of the theory on ethnic-network effects, I find that ethnic-Chinese FDI is associated with much more negative horizontal spillovers than non-Chinese FDI.

Finally, I investigate whether the findings of negative spillovers are observed across different sub-samples of domestic firms. I find that mainly the domestic firms that are state-owned, technologically backward and located in inland provinces experience negative horizontal spillovers. These results imply that FDI could exert disciplinary effects on the host economy by forcing inefficient firms to reduce production.

In sum, this paper presents a static view of a negative relationship between FDI and domestic-firm productivity growth. It should be noted that I find no relationship between lagged changes in foreign presence and domestic-firm productivity growth. In other words, this paper does not propose governments to restrict FDI inflows, nor reject the claim that FDI can bring know-how and management skills to the host economy. Owing to the short time series of the data set, it is difficult to study the dynamic effects of foreign entry in a sector on firm productivity. In research in progress, I use an extended panel data set of Chinese manufacturing firms with a longer time series to study the dynamic productivity effects of FDI, and also the impact of the removal of domestic equity requirement in foreign firms after China's accession to WTO in 2001.

8 Appendix

8.1 Data Construction and Cleaning

1. Drop observations with non-positive values for gross output, value-added and fixed assets.
2. Reconstruct the unique firm identifier, based on the 6-digit regional code and the firm identifier.
3. Drop observations with multiple sector affiliation in the four sample years.

8.2 Procedures to Construct V_j

1. Assign OECD ISIC (Revision 3) 2-digit code to each observation in the firm panel data set.
2. For each OECD category, compute the share of output produced by foreign firms (defined as firms with at least 10% of foreign equity). These are the measures of horizontal spillovers, H_{jt}.
3. For each year t, multiple H_{jt} to the input coefficient, α_{ij}, for sector $j's$ input sourcing from sector i.
4. Sum up $\alpha_{ij} H_{jt}$ across all $j's$ to obtain the vertical spillover measure,V_i, for sector i.
5. Other vertical measures are obtained similarly by using different $H'_{jt}s$.

8.3 Olley-Pakes Estimation

First Stage The first-stage equation of the Olley-Pakes estimation takes the following form:

$$y_{it} = \alpha + \beta_k k_{it} + \beta_l l_{it} + \omega_{it} + \epsilon_{it}, \tag{4}$$

where l_{it} (ln(labor)) is treated as a variable input and k_{it} (ln(capital stock)) is assumed to be predetermined at $t-1$. Investment at t, i_{it} is assumed to depend on k_{it} and firm productivity ω_{it}, which is observed by the firm, but unknown to the researchers. In other words, I can express i_{it} as

$$i_{it} = i\left(k_{it}, \omega_{it}\right).$$

The identifying assumption is that i_{it} is monotonically increasing in ω_{ijt}, conditional on k_{it}. By inverting $i\left(k_{it}, \omega_{it}\right)$, I obtain an expression for ω_{it} in terms of investment and capital stock at year time t as

$$\omega_{it} = \omega\left(i_{it}, k_{it}\right).$$

Substituting this into the regression specification, I obtain

$$y_{it} = \underbrace{\alpha + \beta_k k_{it} + \omega\left(i_{it}, k_{it}\right)}_{h(i_{it}, k_{it})} + \beta_l l_{it} + \epsilon_{it}. \tag{5}$$

Denote the unknown function $h(i_{it}, k_{it})$ as

$$h(i_{it}, k_{it}) = \alpha + \beta_k k_{it} + \omega(i_{it}, k_{it})$$

Since the functional form of $h(i_{it}, k_{it})$ is unknown, I approximate $\omega(i_{it}, k_{it})$ by a third-order polynomial in i_{it} and k_{it} to obtain consistent estimates for β_l from estimating (5).

Second Stage To estimate β_k, now I consider the expectation of $y_{it+1} - \beta_l l_{it+1}$

$$E[y_{it+1} - \beta_l l_{it+1} | k_{it+1}] = \alpha + \beta_k k_{it+1} + E[\omega(i_{it+1}, k_{it+1}) | \omega(i_{it}, k_{it})] \quad (6)$$

By assuming that $\omega(i_{it}, k_{it})$ follows a first-order Markov process with white noise ξ_t ($\omega_t = \omega_{t-1} + \xi_t$), I rewrite (6) as

$$E[y_{it+1} - \beta_l l_{it+1} | k_{it+1}] = \beta_k k_{it+1} + g(\alpha + \omega(i_{it}, k_{it}))$$

From (5), $\omega(i_{it}, k_{it}) = h(i_{it}, k_{it}) - \beta_k k_{it} - \alpha$. Hence, using $\widehat{h}(i_{it}, k_{it})$ estimated in the first stage, and approximating $g(\omega(i_{it}, k_{it}))$ by a third-order polynomial in i_{it} and k_{it}, I estimate the second-stage equation as

$$y_{it+1} - \widehat{\beta}_l l_{it+1} = \beta_k k_{it+1} + g\left(\widehat{h}(i_{it}, k_{it}) - \beta_k k_{it}\right) + \xi_{t+1} + \epsilon_{it+1}$$

Since β_k is embedded in non-linear terms of function g, I use non-linear least square method to estimate this equation. According to Olley and Pakes (1996), by restricting the coefficients on k_{it} to be the same both inside and outside the function $g(.)$, the estimate of β_k will be consistent. Readers are referred to Javorcik (2004) for a more detailed description of the implementation of the Olley-Pakes method.

9 References

Abraham, Filip, Jozef Konings and Veerle Slootmaekers (2007) "FDI Spillovers in the Chinese Manufacturing Sector: Evidence of Firm " CEPR Discussion Paper No. 6573.

Aghion Philippe, Nick Bloom, Richard Blundell, Rachel Griffith, and Peter Howitt (2005) "Competition and Innovation: An Inverted U Relationship" *Quarterly Journal of Economics*, Vol. 120, No. 2, pp.701-728.

Agrawal, Ajay, Devesh Kapur and John McHale (2007) "Birds of a Feather - Better Together? Exploring the Optimal Spatial Distribution of Ethnic Inventors," NBER Working Paper No. W12823.

Aitken, Brian J. and Ann E. Harrison (1999) "Do Domestic Firms Benefit from Direct Foreign Investment? Evidence from Venezuela" *American Economic Review*, Vol. 89, No. 3, pp. 605-618.

Amiti, Mary and Beata Javorcik Smarzynska (2006) "Trade Costs and Location of Foreign Firms in China," mimeo, Federal Reserve Bank of New York. forthcoming *Journal of Development Economics.*

Antras, Pol and Elhanan Helpman (2004) "Global Sourcing," *Journal of Political Economy*, Vol. 112, No. 3, pp. 552-580.

Blalock (2001) "Technology from Foreign Direct Investment: Strategic Transfer through Supply Chains," University of California, Berkeley, manuscript.

Blalock, Garrick and Paul J. Gertler (2008) "Welfare gains from Foreign Direct Investment through technology transfer to local suppliers," *Journal of International Economics,* Vol. 74, Issue 2, pp. 402-421.

Blomström, Fredrik and Sjoholm, Fredrik, (1999) "Productivity Growth in Indonesia: The Role of Regional Characteristics and Direct Foreign Investment," *Economic Development and Cultural Change*, University of Chicago Press, vol. 47(3), pp. 559-84.

Blomström, Magnus and Edward N. Wolff (1994) "Multinational Corporations and Productivity Convergence in Mexico" NBER Working Paper No. 3141.

Caves, Richard (1974) "Multinational Firms, Competition, and Productivity in Host-Country Markets," *Economica*, New Series, Vol. 41, No. 162, pp. 176-193.

Desai, Mihir A., C. Fritz Foley and James R. Hines, Jr. (2004) "The costs of shared ownership: Evidence from international joint ventures " *Journal of Financial Economics*, Vol. 73, No. 2, pp. 323-374.

Djankov, Simeon and Bernard Hoekman (2000) "Foreign Investment and Productivity Growth in Czech Enterprises," *World Bank Economic Review*, Vol. 14, No. 1, pp. 49-64.

Globerman, Steven (1979). "Foreign Direct Investment and 'Spillover' Efficiency Benefits in Canadian Manufacturing Industries," *Canadian Journal of Economics*, vol. 12(1), pp. 42-56.

Gorg and Greenway (2004) "Much ado about nothing? Do domestic firms really benefit from foreign direct investment?" *World Bank Research Observer*, 19, pp.171-197

Gorodnichenko, Yuriy, Jan Svejnar, and Katherine Terrell (2007) "When Does FDI Have Positive Spillovers? Evidence from 17 Emerging Market Economies" IZA Discussion Papers no, 3079.

Haddad, Mona and Ann Harrison (1993) "Are there positive spillovers from direct foreign investment? Evidence from panel data for Morocco" *Journal of Development Economics,* Vol. 42, No. 1, pp. 51-74.

Hale, Galina and Cheryl Long (2007) "Are there productivity spillovers from foreign direct investment in China?," Working Paper Series 2006-13, Federal Reserve Bank of San Francisco.

Haskel, Jonathan E. , Sonia C. Pereira , Matthew J. Slaughter (2007) "Does Inward Foreign Direct Investment Boost the Productivity of Domestic Firms?, " *Review of Economics and Statistics*, Vol. 89, No. 3, pp. 482-496.

Helpman, Elhanan, Marc Melitz, and S. Yeaple (2004) "Export versus FDI with Heterogeneous Firms," *American Economic Review,* Vol. 94, No. 1, pp. 300-316.

Henley, John, Colin Kirkpatrick and Georgina Wilde (1999), "Foreign direct investment in China: Recent trends and current policy issues," *World Economy*, Vol. 22 Issue 2, p223-

Huang, Yasheng, Li Jin and Yi Qian (2008) "Does Ethnicity Pay? Evidence from Overseas Chinese FDI in China," MIT Sloan Research Paper No. 4690-08

Huang, Lin and Shang-Jin Wei (2002), "One China, Many Kingdoms? Using Individual Product Prices to Understand Local Protectionism in China," mimeo, International Monetary Fund, Washington, DC.

Javorcik, Beata Smarzynska (2004) "Does Foreign Direct Investment Increase the Productivity of Domestic Firms? The Search for Spillovers through Backward Linkages." *American Economic Review* Vol. 94, No. 3 pp. 605-627.

Javorcik, Beata Smarzynska and Mariana Spatareanu (2008) "To share or not to share: Does local participation matter fo spillovers from foreign direct investment?" *Journal of Development Economics*, Vol. 85 (1-2), pp. 194-217.

Keller and Yeaple (2005) "Multinational Enterprises, International Trade, and Productivity Growth: Firm-Level Evidence from the United States", Kiel Institute for the World Economy.

Kerr, William R. (2007) “Ethnic Scientific Communities and International Technology Diffusion,” Harvard Business School Working Paper 06-022. forthcoming *Review of Economics and Statistics.*

Kokko (1996) “Productivity spillovers from competition between local firms and foreign affiliates,” *Journal of International Development,* Vol. 8, No. 4 , pp. 517 - 530.

Konings, Jozef (2001) “The effects of foreign direct investment on domestic firms : Evidence from Firm Level Panel Data in Emerging Economies,” *Economics of Transition* Vol. 9 No 3 pp. 619 - 633.

Kumar, Anjali (1994) “China: Internal Market Development and Regulation” NetLibrary, Incorporated, NetLibrary, Inc.

Levinsohn, James and Amil Petrin (2003) “Estimating Production Functions Using Inputs to Control for Unobservables,” *Review of Economic Studies*, Vol. 70, No. 2, pp. 317–341.

Liu, Zhiqiang (2008) “Foreign Direct Investment and Technology Spillovers: Theory and Evidence ” SUNY Buffalo Working Paper. Forthcoming *Journal of Development Economics.*

Long, Guoqiang (2005) “China’s Policies on FDI: Review and Evaluation,” in *Does Foreign Direct Investment Promote Development? (Ed.* Theodore H. Moran, Edward M. Graham, Magnus Blomstrom, Edward M. Graham) Peterson Institute for International Economics.

Markusen, James and Anthony Venables (1999) “Foreign direct investment as a catalyst for industrial development,” *European Economic Review,* Vol. 43, No. 2, pp. 335-356.

Melitz, Marc (2003) “The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity,” *Econometrica*, Vol. 71, No. ? pp. 1695-1725.

Moran, Theodore (2001) “How Does FDI Affect Host Country Development? Using Industry Case Studies to Make Reliable Generalization” *Does Foreign Direct Investment Promote Development?* Edited by Theodore H. Moran, Edward M. Graham,

National Bureau of Statistics of China (2002) “China’s Industrial Statistical Yearbook” China Statistics Press, Beijing, China.

National Bureau of Statistics of China (2002) “China’s Statistical Yearbook,” , China Statistics Press, Beijing, China.

Nickell, Stephen J, (1996) “Competition and Corporate Performance,” *Journal of Political Economy*, Vol. 104(4), pp. 724-46.

OECD (2002) Input-Output Tables (2002 edition). http://www.oecd.org/document/ OECD, Paris.

Olley, G. Steven and Ariel Pakes (1996) "The Dynamics of Productivity in the Telecommunications Equipment Industry," *Econometrica*, Vol. 64, No. 6, pp. 1263-1297.

Ramachandran, Vijaya (1993) "Technology transfer, Firm Ownership, and Investment in Human Capital," *Review of Economics and Statistics* Vol. 75, No. 4, pp. 664-670.

Rodrik, Dani (1999) "The New Global Economy and Developing Countries: Making Openness Work," Overseas Development Council Policy Essay Number 24, Washington, DC.

Rodriguez-Clare, Andres (1996) "Multinationals, Linkages, and Economic Development" *American Economic Review*, Vol. 86, No. 4, pp. 852-873.

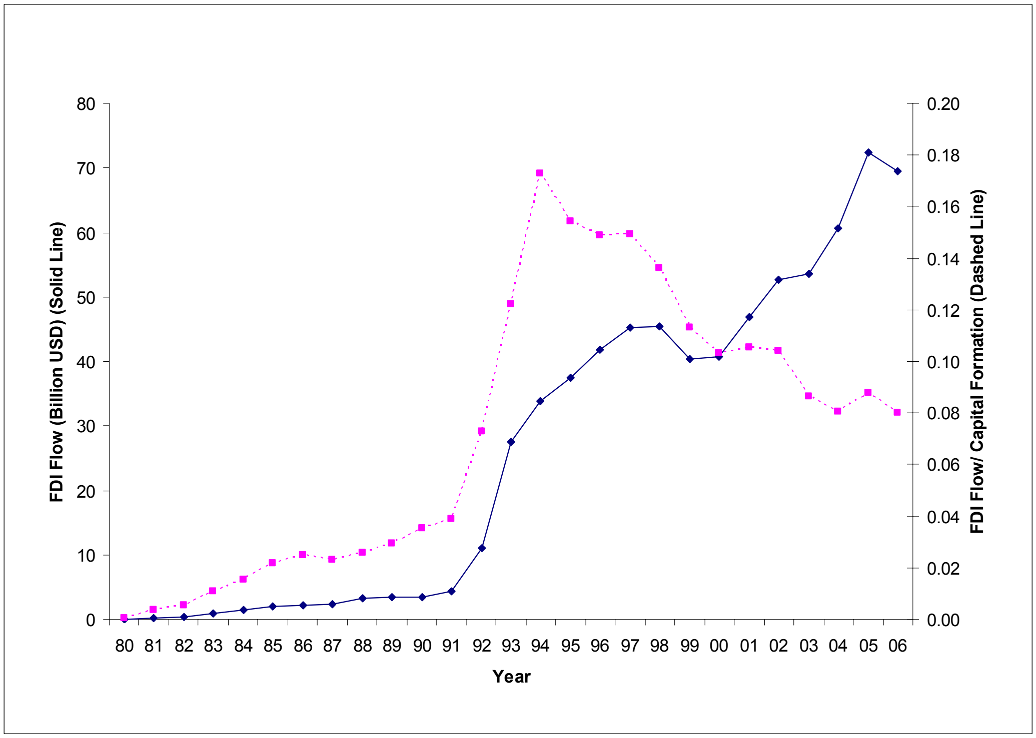
Schoors, Koen and Bartoldus van der Tol (2002) "Foreign Direct Investment Spillovers Within and Between Sectors: Evidence from Hungarian Data " Ghent University Working Paper.

Tybout, James (2001) "Plant- and Firm-Level Evidence on "New" Trade Theories" *Handbook of International Trade*, Kwan Choi and James Harrigan (ed.), Vol.1, pp. 388-417.

UNCTAD (2007) "World Investment Report 2007," United Nations, Geneva.

Young, Alwyn (2000) "The Razor's Edge: Distortions and Incremental Reform in the People's Republic of China" *Quarterly Journal of Economics*, Vol. 115, No. 4, pp. 1091-1135.

Figure 1: Inward FDI Flows and FDI/Capital Formation in China (1980 – 2006)



Source: United Nations World Investment Report (2007).

Note: FDI flows are measured in billions of current US dollars. The solid line corresponds to inward FDI flows, associated with the vertical axis on the left. The dashed line corresponds to the share of FDI flows in total capital formation, associated with the vertical axis on the right.

Figure 2: Evolution of Horizontal and Vertical Spillovers (1998-2001)

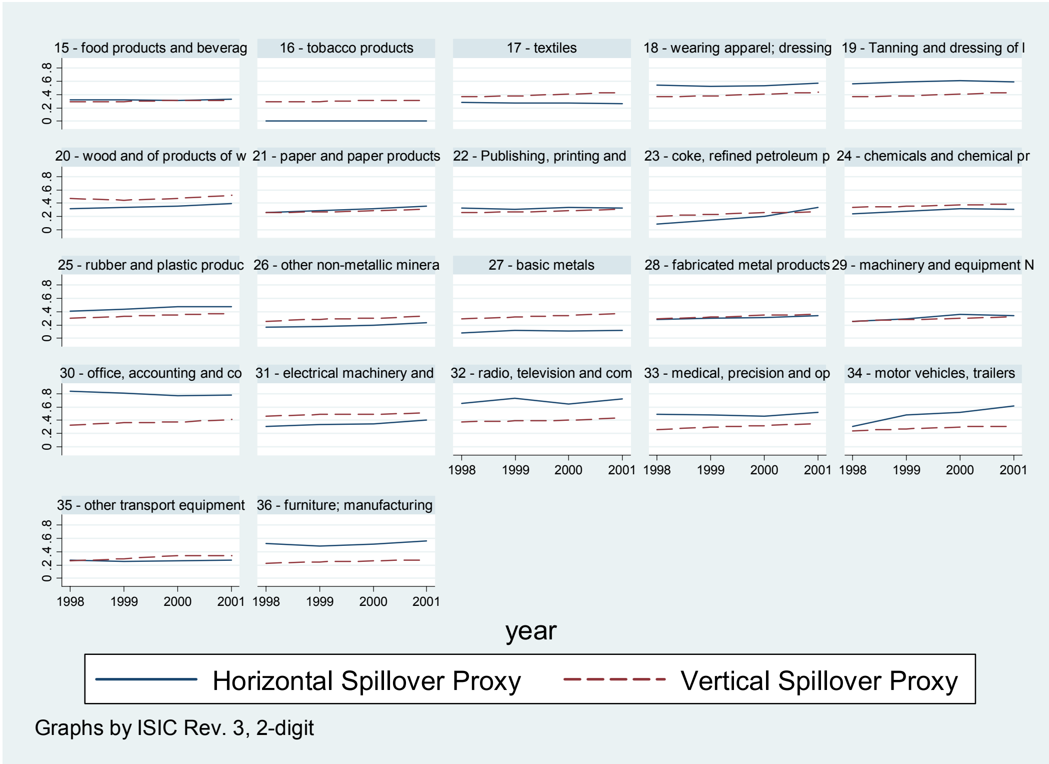


Figure 3: Evolution of First-differences of Horizontal and Vertical Spillovers (1998-2001)

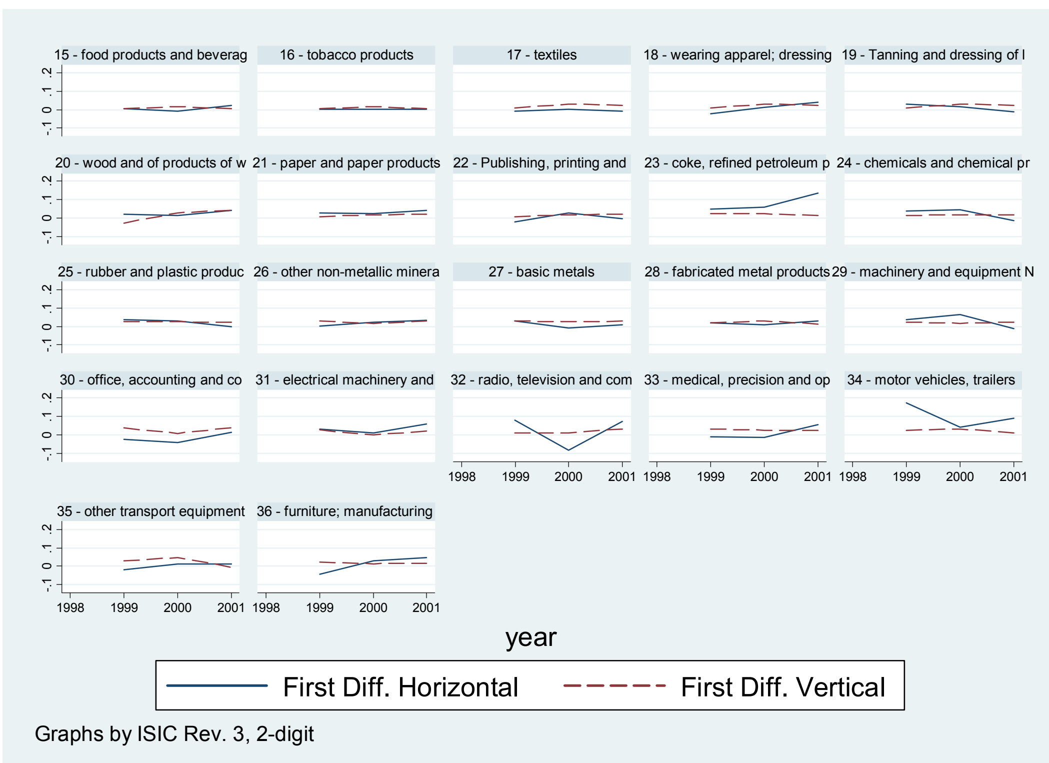


Figure 4: Evolution of Horizontal Spillovers by Ownership Structure (1998-2001)

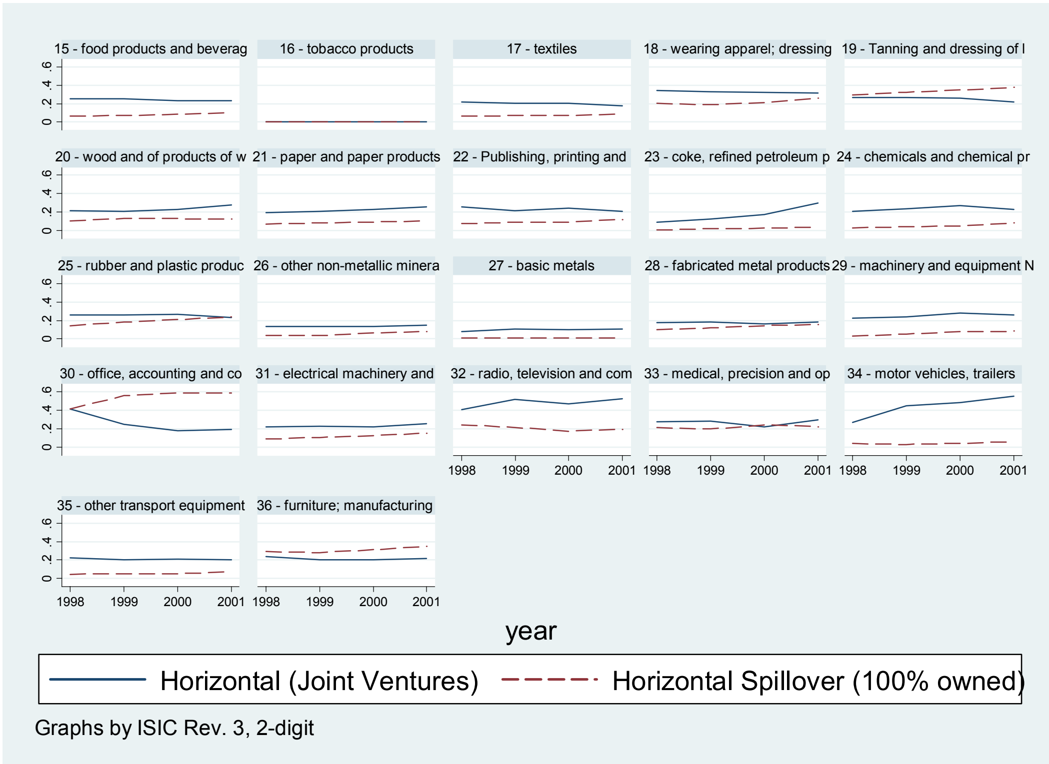


Figure 5: Evolution of Vertical Spillovers by Ownership Structure (1998-2001)

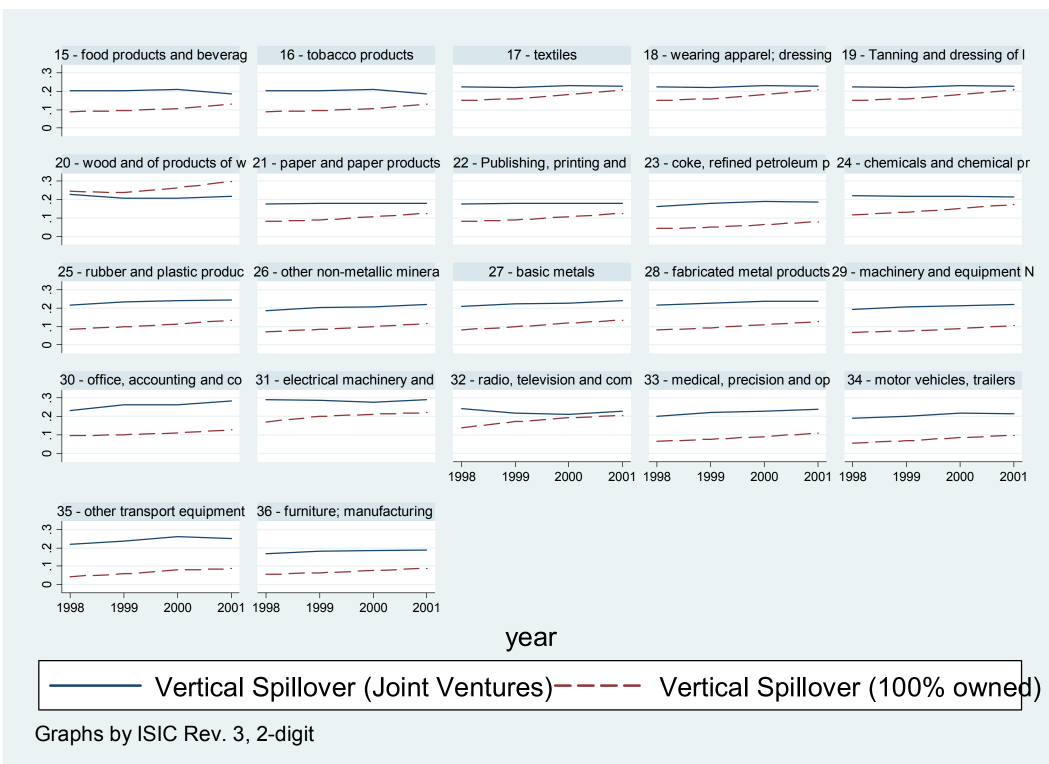


Table 1: Distribution of FDI Stock in Different Industries in China (to the end of 2001)

Sector	Cumulated Investment in Foreign Affiliates	Share	Cumulated Foreign Direct Investment in Foreign Affiliates	Share
Manufacturing	491,322	56.15%	214,931	59.76%
Real estate	149,094	17.04%	55,536	15.44%
Social services	56,274	6.43%	23,188	6.45%
Logistics and communication	41,442	4.74%	15,163	4.22%
Electricity, gas and water	49,505	5.66%	11,606	3.23%
Distribution	24,592	2.81%	11,311	3.14%
Construction	21,547	2.46%	7,743	2.15%
Others	13,994	1.60%	7,179	2.00%
Agricultural	9,135	1.04%	4,763	1.32%
R&D and technology service	4,334	0.50%	2,171	0.60%
Mining	3,282	0.38%	1,462	0.41%
Geology investigation	4,237	0.48%	1,412	0.39%
Finance and insurance	2,089	0.24%	1,415	0.39%
Health and sports	2,774	0.32%	1,128	0.31%
Education, culture and films	1,390	0.16%	675	0.19%
Total	875,011	100.00%	359,683	100.00%

Source: China Statistical Yearbook 2002 and Long (2005)

Table 2: Top 10 Source Countries of FDI in China (cumulated to the end of 2002 dollars)

	Number of projects	FDI Realized (billions of USD)	Share Among Top 10
Hong Kong	210,876	204.90	51.29%
United States	37,280	39.90	9.98%
Japan	25,147	36.30	9.10%
Taiwan	55,691	33.10	8.29%
Virgin Islands	6,659	24.40	6.10%
Singapore	10,727	21.50	5.37%
South Korea	22,208	15.20	3.80%
United Kingdom	3,418	10.70	2.68%
Germany	3,053	8.00	2.00%
France	2,033	5.50	1.39%

Source: China Ministry of Commerce (2003) and Long (2005)

Table 3: Summary Statistics (Firm Level)

	Num. Obs	Mean	Standard Dev.
Value-added (constant 1997 mn yuan)	257,952	95.3460	564.9406
Output (constant 1997 mn yuan)	257,952	400.0462	216.3251
Labor	257,952	363.0409	1295.811
Capital (constant 1997 mn yuan)	257,952	339.8232	3603.0230
TFP Growth (Solow Residuals)	156,447	0.0146	0.7932
TFP Growth (Olley-Pakes Estimated)	156,447	0.0030	0.7843

Note: Summary statistics are for the sample of domestic firms (defined as firms with less than 10% foreign equity). Total number of observations is 323,741, with 79.7% of them associated with domestic firms.

Table 4: Summary Statistics (Sector Level)

Sector Level Variables	Num. Obs	Mean	Standard Dev.
Horizontal Spillovers	88	0.3708	0.1876
Wholly-Owned	88	0.1370	0.1288
Joint-Owned	88	0.2337	0.1049
Majority-Owned	88	0.2295	0.1688
Minority-Owned	88	0.1413	0.0756
Ethnic-Chinese	88	0.1826	0.0901
Non-Chinese	88	0.1882	0.1198
Vertical Spillovers	88	0.3386	0.0697
Wholly-Owned	88	0.1218	0.0536
Jointly-Owned	88	0.2169	0.0276
Majority-Owned	88	0.2065	0.0637
Minority-Owned	88	0.1321	0.0148
Ethnic-Chinese	88	0.2214	0.0975
Non-Chinese	88	0.2068	0.0625
Imports (current mn USD)	88	10080.06	13441.92
Exports (current mn USD)	88	10725.5	11329.97
Herfindahl (10-firm)	88	0.0725	0.0619

Sector First-Differences	Num. Obs	Mean	Standard Dev.
ΔHorizontal Spillovers	66	0.0208	0.0390
Wholly-Owned	66	0.0144	0.0230
Joint-Owned	66	0.0065	0.0459
Majority-Owned	66	0.0167	0.0260
Minority-Owned	66	0.0042	0.0390
Ethnic-Chinese	66	0.0083	0.0316
Non-Chinese	66	0.0125	0.0406
ΔVertical Spillovers	66	0.0201	0.0119
Wholly-Owned	66	0.0157	0.0074
Jointly-Owned	66	0.0043	0.0109
Majority-Owned	66	0.0177	0.0094
Minority-Owned	66	0.0023	0.0069
Ethnic-Chinese	66	0.0077	0.0116
Non-Chinese	66	0.0141	0.0122
ln(Imports)	66	0.1363	0.1845
ln(Exports)	66	0.1065	0.1996
Herfindahl Index (10-firm)	66	-0.0017	0.0189

Table 5: Horizontal and Vertical Spillovers (Dependent Variable = Solow Residuals)

This table examines the effects of foreign presence on domestic-firm TFP growth through both the horizontal and vertical (backward linkages) channels. The results of first-difference, second-difference and level regressions are reported.

Dependent variable: Solow Residual (Level, First-difference or Second-difference)							
	(1)[f]	(2)[f]	(3)[f]	(4)[f]	(5)[g]	(6)[h]	(7)[i]
Specification	First Diff.	First Diff.	First Diff.	First Diff	First Diff (Lagged)	Level	Second Diff
Horizontal	-0.238**		-0.239**	-0.247**	0.121	-0.502***	-0.367
	(0.110)		(0.111)	(0.115)	(0.113)	(0.125)	(0.220)
Vertical		0.098	0.111	-0.038	-0.553	-0.939	-0.651
		(0.317)	(0.312)	(0.328)	(0.422)	(0.790)	(0.731)
Herfindahl10				0.102	0.343	0.204	0.537
				(0.274)	(0.340)	(0.550)	(0.409)
ln(Imports)				-0.05	0.030	0.014	-0.077*
				(0.041)	(0.031)	(0.042)	(0.043)
Fixed Effects	Y	Y	Y	Y	Y	Y	Y
R-squared	0.003	0.003	0.003	0.003	0.004	0.141	0.006
Number of Obs.	156,447	156,447	156,447	156,447	73,220	257,681	77,051

Notes:

a) A firm's Solow residual is measured according to equation (1) in the text.
b) All regressions include a constant, sector, province and year fixed effects.
c) Standard errors, corrected for clustering at the sector-year level, are reported in parentheses.
d) ***, ** and * denote 1%, 5% and 10% significance levels, respectively.
e) Only domestic firms (with less than 10% foreign equity) are included in the sample.
f) Columns (1) – (4) use first-differences for all variables.
g) Column (5) uses lagged measures of spillovers. Other variables are not lagged.
h) Column (6) uses levels of all variables, instead of first differences.
i) Column (7) uses second differences of all variables, instead of first differences.

Table 6: Horizontal and Vertical Spillovers (Dependent Var. = Value-added)

This table examines the effects of foreign presence on domestic-firm value-added growth through both the horizontal and vertical (backward linkages) channels. The results of first-difference, second-difference and level regressions are reported.

Dependent variable: Value-added (Level, First-difference or Second-difference)							
	(1)[e]	(2)[e]	(3)[e]	(4)[e]	(5)[f]	(6)[g]	(7)[h]
Specification	First Diff.	First Diff.	First Diff.	First Diff	First Diff (Lagged Spillovers)	Level	Second Diff
Horizontal	-0.257**		-0.256**	-0.251**	0.146*	-0.617***	-0.350*
	(0.115)		(0.115)	(0.123)	(0.085)	(0.155)	(0.183)
Vertical		-0.160	-0.146	-0.224	-0.474	-0.271	-0.881*
		(0.347)	(0.345)	(0.360)	(0.502)	(1.059)	(0.511)
Herfindahl10				-0.119	0.141	1.212**	0.134
				(0.301)	(0.441)	(0.568)	(0.346)
ln(Imports)				-0.025	0.034	-0.008	-0.061
				(0.034)	(0.028)	(0.045)	(0.039)
Fixed Effects	Y	Y	Y	Y	Y	Y	Y
R-squared	0.003	0.002	0.003	0.003	0.004	0.089	0.007
Number of Obs.	156,447	156,447	156,447	156,447	73,220	257,681	77,051

Notes:

a) All regressions include a constant, sector, province and year fixed effects.
b) Standard errors, corrected for clustering at the sector-year level, are reported in parentheses.
c) ***, ** and * denote 1%, 5% and 10% significance levels, respectively.
d) Only domestic firms (with less than 10% foreign equity) are included in the sample.
e) Columns (1) – (4) use first-differences for all variables.
f) Column (5) uses lagged measures of spillovers. Other variables are not lagged.
g) Column (6) uses levels of all variables, instead of first differences.
h) Column (7) uses second differences of all variables, instead of first differences.

Table 7: Horizontal and Vertical Spillovers (Dependent Var. = Olley-Pakes Estimated TFP)

This table examines the effects of foreign presence on domestic-firm TFP growth through the horizontal and vertical (backward linkages) channels. The results of first-difference, second-difference and level regressions are reported.

Dependent variable: Olley-Pakes Estimated TFP (Level, First-difference or Second-difference)							
	(1)[e]	(2)[e]	(3)[e]	(4)[e]	(5)[f]	(6)[g]	(7)[h]
Specification	First Diff.	First Diff.	First Diff.	First Diff	First Diff (Lagged Spillovers)	Level	Second Diff
Horizontal	-0.260**		-0.261**	-0.262**	0.120	-0.527***	-0.393*
	(0.110)		(0.111)	(0.117)	(0.110)	(0.125)	(0.218)
Vertical		0.038	0.053	-0.069	-0.666	-1.021	-0.681
		(0.326)	(0.323)	(0.331)	(0.430)	(0.908)	(0.703)
Herfindahl10				-0.011	0.241	0.535	0.438
				(0.287)	(0.370)	(0.532)	(0.426)
ln(Imports)				-0.04	0.031	-0.01	-0.071*
				(0.036)	(0.030)	(0.042)	(0.042)
Fixed Effects	Y	Y	Y	Y	Y	Y	Y
R-squared	0.002	0.002	0.002	0.002	0.003	0.367	0.006
Number of Obs.	156,447	156,447	156,447	156,447	73,220	257,681	77,051

Notes:

a) A firm's TFP is measured based on the Olley-Pakes estimation of a sector-specific Cobb-Douglas production function. See Section 8.3 (Data Appendix) for details.
b) All regressions include a constant, sector, province and year fixed effects.
c) Standard errors, corrected for clustering at the sector-year level, are reported in parentheses.
d) ***, ** and * denote 1%, 5% and 10% significance levels, respectively.
e) Only domestic firms (with foreign equity share less than 10%) are included in the sample.
f) Column (5) uses lagged measures of spillovers. Other variables are not lagged.
g) Column (6) uses levels of all variables, instead of first differences.
h) Column (7) uses second differences of all variables, instead of first differences.

Table 8: Horizontal and Vertical Spillovers within the Same Province

This table examines horizontal and vertical (backward) spillovers to domestic firms, from foreign firms within and outside the same province.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent Variables	ΔSolow	ΔSolow	ΔSolow	ΔSolow	ΔOlley-Pakes	ΔOlley-Pakes.	ΔOlley-Pakes	ΔOlley-Pakes
Specification	First Diff.	First Diff.	First Diff.	First Diff. Lagged Spillovers	First Diff.	First Diff.	First Diff.	First Diff. Lagged Spillovers
ΔHorizontal (Own Province)	-0.095*		-0.099*	0.050	-0.099*		-0.102*	0.036
	(0.051)		(0.051)	(0.054)	(0.051)		(0.051)	(0.051)
ΔVertical (Own Province)	-0.569***		-0.565***	-0.065	-0.542***		-0.540***	-0.062
	(0.116)		(0.118)	(0.085)	(0.115)		(0.117)	(0.080)
ΔHorizontal (Other Provinces)		-0.188**	-0.196**	0.126		-0.198**	-0.206**	0.114
		(0.087)	(0.082)	(0.130)		(0.086)	(0.082)	(0.123)
ΔVertical (Other Provinces)		0.262	0.104	0.755*		0.199	0.051	0.707*
		(0.247)	(0.225)	-0.394		(0.241)	(0.223)	-0.402
Fixed Effects	Y	Y	Y	Y	Y	Y		Y
Controls		-- Δln(Imports) + ΔHerf10 ---						
R-squared	0.003	0.003	0.003	0.004	0.003	0.002	0.003	0.003
Number of Obs.	156,447	156,447	156,447	73,220	156,447	156,447	156,447	73,220

Notes:

a) The dependent variable is the first difference of the natural logarithm of firm total factor productivity. In columns (1) - (4), TFP measures are Solow Residuals. In columns (5) – (8), TFP are estimated by Olley-Pakes estimation procedure of a sector-specific Cobb-Douglas production function. See Section 8 for details.

b) All regressions include a constant, sector, province and year fixed effects.

c) Standard errors, corrected for clustering at the sector-year level, are reported in parentheses.

d) ***, ** and * denote 1%, 5% and 10% significance levels, respectively.

e) Only domestic firms (with foreign equity share less than 10%) are included in the sample.

f) Columns (4) and (8) use lagged measures of spillovers.

Table 9: Horizontal and Vertical Spillovers from Joint Ventures and Wholly-owned Foreign Affiliates

This table examines horizontal and vertical (backward) productivity spillovers to domestic firms from jointly-owned (with less than 100% foreign equity) and wholly-owned foreign firms (with 100% foreign equity) respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent Var.	ΔSolow	ΔSolow	ΔSolow	Δ_2Solow	ΔOlley-Pakes	ΔOlley-Pakes	ΔOlley-Pakes	Δ_2Olley-Pakes
Specification	No control	With controls	Lagged spillovers	Second Diff.	No control	With controls	Lagged spillovers	Second Diff.
ΔHorizontal (100% owned)	-0.525**	-0.460*	-0.711	-1.588***	-0.488**	-0.442*	-0.775*	-1.586***
	(0.240)	(0.246)	(0.464)	(0.211)	(0.242)	(0.252)	(0.447)	(0.223)
Δ Horizontal (Joint-ventures)	-0.294***	-0.303***	0.031	-0.324**	-0.317***	-0.318***	-0.004	-0.364**
	(0.097)	(0.103)	(0.176)	(0.159)	(0.096)	(0.104)	(0.165)	(0.157)
Δ Vertical (100% owned)	-0.197	-0.225	0.187	-0.661	-0.297	-0.329	0.216	-0.776
	(0.459)	(0.447)	(0.798)	(0.644)	(0.472)	(0.463)	(0.791)	(0.642)
ΔVertical (Joint-ventures)	0.084	-0.046	-1.685*	-0.559	0.059	-0.039	-1.939**	-0.501
	(0.382)	(0.397)	(0.969)	(0.721)	(0.394)	(0.402)	(0.925)	(0.706)
Controls	No	--------------- Δln(Imports) + ΔHerf10 ----------------------			No	--------------- Δln(Imports) + ΔHerf10 ----------------------		
Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.003	0.003	0.004	0.006	0.003	0.003	0.003	0.006
Number of Obs.	156,447	156,447	73,220	77,051	156,447	156,447	73,220	77,051
Horizontal 100 = Horizontal JV (p-value)	0.35	0.55	0.06	0.00	0.49	0.63	0.05	0.00
Vertical 100 = Vertical JV (p-value)	0.62	0.75	0.23	0.86	0.54	0.61	0.15	0.63

Notes:

a) The dependent variable is the first difference of the natural logarithm of firm total factor productivity. In columns (1) - (4), TFP measures are Solow Residuals. In columns (5) – (8), TFP are estimated by Olley-Pakes estimation procedure of a sector-specific Cobb-Douglas production function. See Section 8 for details.

b) All regressions include a constant, sector, province and year fixed effects.

c) Standard errors, corrected for clustering at the sector-year level, are reported in parentheses.

d) ***, ** and * denote 1%, 5% and 10% significance levels, respectively.

e) Only domestic firms (with foreign equity share less than 10%) are included in the sample.

f) Columns (3) and (7) use lagged measures of spillovers.

g) The last two rows report the *p*-values of the tests for whether the coefficients on wholly and jointly-owned spillovers are the same.

Table 10: Horizontal and Vertical Spillovers from Joint Ventures and Wholly-owned Foreign Affiliates within the Same Province

This table examines horizontal and vertical (backward) productivity spillovers to domestic firms from jointly and wholly owned foreign firms, and from within and outside the same province, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Var.	ΔSolow	ΔSolow	ΔSolow	ΔOlley-Pakes	ΔOlley-Pakes	ΔOlley-Pakes
ΔHorizontal (100 Own)	-0.261***		-0.258***	-0.274***		-0.271***
	(0.092)		(0.094)	(0.092)		(0.094)
ΔHorizontal (JV Own)	-0.069		-0.075	-0.071		-0.076
	(0.051)		(0.050)	(0.050)		(0.050)
ΔVertical (100 Own)	-1.061***		-1.051***	-1.000***		-0.995***
	(0.231)		(0.236)	(0.227)		(0.231)
ΔVertical (JV Own)	0.075		0.075	0.083		0.087
	(0.107)		(0.105)	(0.106)		(0.104)
ΔHorizontal (100 Others)		0.122	-0.044		0.107	-0.057
		(0.274)	(0.250)		(0.271)	(0.246)
ΔHorizontal (JV Others)		-0.236**	-0.215***		-0.244***	-0.224***
		(0.091)	(0.081)		(0.090)	(0.081)
ΔVertical (100 Others)		0.545	0.175		0.422	0.061
		(0.493)	(0.418)		(0.483)	(0.416)
ΔVertical (JV Others)		-0.072	0.075		-0.053	0.091
		(0.300)	(0.325)		(0.300)	(0.325)
Fixed Effects & Controls	Y	Y	Y	Y	Y	Y
R-squared	0.003	0.003	0.003	0.003	0.002	0.003
Number of Obs.	156,447	156,447	156,447	156,447	156,447	156,447
Hori. (JV Own) = Hori. (100 Own) (p-value)	0.03	-	0.04	0.02	-	0.03
Vert. (JV Own) = Vert. (100 Own) (p-value)	0.00	-	0.00	0.00	-	0.00
Hori. (JV Others) = Hori. (100 Others) (p-value)	-	0.19	0.51		0.20	0.51
Vert. (JV Others) = Vert. (100 Others) (p-value)	-	0.25	0.85		0.36	0.95

Notes:

a) The dependent variable is the first difference of the natural logarithm of firm total factor productivity. In columns (1) - (3), TFP measures are Solow Residuals. In Column (4) – (6), TFP are estimated by Olley-Pakes estimation procedure of a sector-specific Cobb-Douglas production function. See Section 8 for details.

b) All regressions include a constant, sector, province and year fixed effects; and controls of Δln(Imports) and ΔHerf10.

c) Standard errors, corrected for clustering at the sector-year level, are reported in parentheses.

d) ***, ** and * denote 1%, 5% and 10% significance levels, respectively.

e) The last two rows report the *p*-values of the tests for whether the coefficients on wholly and jointly-owned spillovers are the same.

f) Only domestic firms (with foreign equity share less than 10%) are included in the sample.

Table 11: Horizontal and Vertical Spillovers from Minority-owned and Majority-owned Foreign Affiliates

This table examines horizontal and vertical (backward) productivity spillovers to domestic firms from minority- and majority-owned foreign firms respectively. Majority-owned foreign affiliates are foreign firms with more than 50% of foreign equity. The remaining foreign affiliates are defined as minority-owned.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent Var.	∆Solow	∆Solow	∆Solow	Δ_2Solow	∆Olley-Pakes	∆Olley-Pakes	∆Olley-Pakes	Δ_2Olley-Pakes
Specification	No control	With controls	Lagged spillovers	Second Diff.	No control	With controls	Lagged spillovers	Second Diff.
∆Horizontal (Majority)	-0.439***	-0.435***	0.009	-0.750***	-0.445***	-0.449***	-0.039	-0.801***
	(0.131)	(0.131)	(0.344)	(0.209)	(0.136)	(0.135)	(0.330)	(0.208)
∆Horizontal (Minority)	-0.277**	-0.273*	0.068	-0.553***	-0.292**	-0.272*	0.013	-0.572***
	(0.132)	(0.155)	(0.189)	(0.201)	(0.126)	(0.150)	(0.168)	(0.193)
∆Vertical (Majority)	0.218	0.085	-0.375	-0.031	0.11	-0.003	-0.345	-0.07
	(0.405)	(0.385)	(0.602)	(0.900)	(0.401)	(0.384)	(0.567)	(0.869)
∆Vertical (Minority)	-0.303	-0.447	-0.971	-1.753*	-0.27	-0.376	-1.378	-1.764*
	(0.627)	(0.648)	(1.152)	(1.041)	(0.620)	(0.630)	(1.005)	(1.024)
Controls	No		∆ln(Imports) + ∆Herf10		No		∆ln(Imports) + ∆Herf10	
Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.003	0.003	0.004	0.006	0.003	0.003	0.003	0.006
Number of Obs.	156,447	156,447	73,220	77,051	156,447	156,447	73,220	77,051
Horizontal Minority = Horizontal Majority (p-value)	0.35	0.42	0.82	0.51	0.37	0.37	0.83	0.43
Vertical Minority = Vertical Majority (p-value)	0.51	0.50	0.69	0.17	0.62	0.62	0.42	0.18

Notes:

a) The dependent variable is the first difference of the natural logarithm of firm total factor productivity. In columns (1) - (4), TFP measures are Solow Residuals. In columns (5) – (8), TFP are estimated by Olley-Pakes estimation procedure of a sector-specific Cobb-Douglas production function. See Section 8 for details.

b) All regressions include a constant, sector, province and year fixed effects.

c) Standard errors, corrected for clustering at the sector-year level, are reported in parentheses.

d) ***, ** and * denote 1%, 5% and 10% significance levels, respectively.

e) Only domestic firms (with less than 10% foreign equity) are included in the sample.

f) Columns (3) and (7) use lagged measures of spillovers.

g) The last two rows report the *p*-values of the tests for whether the coefficients on majority and minority-owned spillovers are the same.

Table 12: Horizontal and Vertical Spillovers from ethnic-Chinese and Non-Chinese Foreign Affiliates

This table examines horizontal and vertical (backward) productivity spillovers to domestic firms from Chinese-ethnic and non-Chinese foreign firms respectively. Chinese foreign affiliates are defined as firms with more than 50% equity owned by Hong Kong, Macau and/or Taiwan investors. Non-Chinese foreign affiliates are the rest of the foreign affiliates.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent Var.	ΔSolow	ΔSolow	ΔSolow	Δ_2Solow	ΔOlley-Pakes	ΔOlley-Pakes	ΔOlley-Pakes	Δ_2Olley-Pakes
Specification	No control	With controls	Lagged spillovers	Second Diff.	No control	With controls	Lagged spillovers	Second Diff.
ΔHorizontal (Chinese)	-0.424***	-0.428***	-0.198	-0.728***	-0.427***	-0.423***	-0.275	-0.768***
	(0.113)	(0.111)	(0.220)	(0.161)	(0.116)	(0.118)	(0.220)	(0.160)
ΔHorizontal (Non-Chinese)	-0.231	-0.213	0.286*	-0.431*	-0.280**	-0.269*	0.296*	-0.456*
	(0.145)	(0.153)	(0.157)	(0.253)	(0.136)	(0.145)	(0.155)	(0.246)
ΔVertical (Chinese)	-0.288	-0.368	-1.524**	-0.442	-0.337	-0.405	-1.581**	-0.469
	(0.380)	(0.380)	(0.612)	(0.711)	(0.385)	(0.388)	(0.626)	(0.681)
ΔVertical (Non-Chinese)	0.018	-0.121	1.252**	0.046	0.01	-0.076	0.875*	0.073
	(0.359)	(0.377)	(0.533)	(0.876)	(0.360)	(0.379)	(0.515)	(0.837)
Controls	No	Δln(Imports) + ΔHerf10			No	Δln(Imports) + ΔHerf10		
Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.003	0.003	0.004	0.006	0.003	0.003	0.003	0.006
Number of Obs.	156,447	156,447	73,220	77,051	156,447	156,447	73,220	77,051
Horizontal (Chinese) = Horizontal (Non-Chinese) (p-value)	0.22	0.19	0.06	0.20	0.33	0.33	0.02	0.17
Vertical (Chinese) = Horizontal (Non-Chinese) (p-value)	0.25	0.36	0.00	0.21	0.19	0.24	0.01	0.17

Notes:

a) The dependent variable is the first difference of the natural logarithm of firm total factor productivity. In columns (1) - (4), TFP measures are Solow Residuals. In columns (5) – (8), TFP are estimated by Olley-Pakes estimation procedure of a sector-specific Cobb-Douglas production function. See Section 8 for details.

b) All regressions include a constant, sector, province and year fixed effects.

c) Standard errors, corrected for clustering at the sector-year level, are reported in parentheses.

d) ***, ** and * denote 1%, 5% and 10% significance levels, respectively.

e) Only domestic firms (with foreign equity share less than 10%) are included in the sample.

f) Columns (3) and (7) use lagged measures of spillovers.

g) The last two rows report the *p*-values of the tests for whether the coefficients on ethnic-Chinese and non-Chinese spillovers are the same.

Table 13: Horizontal and Vertical Spillovers (Different Subsamples)

This table examines horizontal and vertical (backward) productivity spillovers to domestic firms from jointly- and wholly-owned foreign firms, respectively. Subsamples of state-owned /non-state-owned enterprises and exporters/ non-exporters are considered.

Dependent variable: $\Delta\ln(TFP_t) = \ln(TFP_t) - \ln(TFP_{t-1})$								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	State-owned Enterprises		Non-state-owned		Export-oriented		Non-export-oriented	
TFP Measure	Solow Resid.	Olley-Pakes	Solow Resid.	Olley-Pakes	Solow Resid.	Olley-Pakes	Solow Resid.	Olley-Pakes
∆Horizontal (100% owned)	-1.454***	-1.409***	-0.200	-0.193	-0.193	-0.105	-0.428	-0.450
	(0.456)	(0.465)	(0.268)	(0.256)	(0.256)	(0.565)	(0.341)	(0.348)
∆Horizontal (Joint Ventures)	-0.718***	-0.687***	-0.146	-0.190*	-0.190*	0.029	-0.277**	-0.285**
	(0.165)	(0.172)	(0.098)	(0.097)	(0.097)	(0.223)	(0.128)	(0.126)
∆Vertical (100% owned)	-0.711	-0.419	-0.259	-0.511	-0.511	0.162	-0.562	-0.77
	(0.956)	(1.010)	(0.488)	(0.490)	(0.490)	(1.201)	(0.521)	(0.555)
∆Vertical (Joint Ventures)	0.209	-0.146	-0.184	-0.014	-0.014	0.472	-0.146	-0.198
	(0.767)	(0.837)	(0.373)	(0.338)	(0.338)	(0.694)	(0.479)	(0.496)
Fixed Effects and Controls	---------- Yes ----------							
R-squared	0.004	0.003	0.004	0.004	0.010	0.008	0.003	0.004
Number of Obs.	43,979	43,979	112,468	112,468	22,392	22,392	118,049	118,049
Horizontal JV = Horizontal 100 (p-value)	0.11	0.12	0.84	0.99	0.81	0.96	0.66	0.64
Vertical JV = Vertical 100 (p-value)	0.29	0.76	0.90	0.40	0.78	0.90	0.50	0.39

Notes:

(a) The dependent variables are the first differences of the natural logarithm of firm total factor productivity ($\ln(TFP_t)$- $\ln(TFP_{t-1})$). TFP measures are either Solow residuals or Olley-Pakes estimated TFP.
(b) All regressions include a constant, sector, province and year fixed effects.
(c) Standard errors, corrected for clustering at the sector-year level, are reported in parentheses.
(d) ***, ** and * denote 1%, 5% and 10% significance levels, respectively.
(e) The last two rows report the *p*-values of the tests for whether the coefficients on wholly and jointly-owned spillovers are the same.
(f) Only domestic firms (with less than 10% foreign equity) are included in the sample.
(g) State-owned enterprises are firms with at least 50% state-government equity.
(h) Export-oriented firms are firms that always export in all years in the sample.

Table 14: Horizontal and Vertical Spillovers (Different Subsamples Cont')

This table examines horizontal and vertical (backward) productivity spillovers to domestic firms from jointly- and wholly-owned foreign firms, respectively. Subsamples of coastal/ inland domestic enterprises and technology leaders/ technology laggards are considered.

Dependent variable: $\Delta\ln(TFP_t) = \ln(TFP_t) - \ln(TFP_{t-1})$								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Coastal		Inland		Technology Leaders		Technology Laggards	
TFP Measure	Solow Resid.	Olley-Pakes	Solow Resid.	Olley-Pakes	Solow Resid.	Olley-Pakes	Solow Resid.	Olley-Pakes
ΔHorizontal (100% owned)	-0.369	-0.343	-0.847*	-0.872*	-0.055	-0.164	-0.890**	-0.934***
	(0.304)	(0.299)	(0.465)	(0.471)	(0.294)	(0.252)	(0.364)	(0.334)
ΔHorizontal (Joint Ventures)	-0.176	-0.209	-0.515***	-0.511***	-0.129	-0.179	-0.463***	-0.465***
	(0.125)	(0.126)	(0.191)	(0.186)	(0.140)	(0.123)	(0.155)	(0.142)
ΔVertical (100% owned)	-0.290	-0.416	-0.500	-0.604	0.144	-0.669	-0.905	-0.334
	(0.605)	(0.594)	(0.680)	(0.671)	(0.641)	(0.574)	(0.675)	(0.662)
ΔVertical (Joint Ventures)	0.632	0.763*	-0.899*	-1.068*	-0.579	-0.262	0.147	-0.096
	(0.481)	(0.456)	(0.535)	(0.548)	(0.484)	(0.404)	(0.600)	(0.582)
Fixed Effects & Controls	---------- Yes ----------							
R-squared	0.003	0.002	0.004	0.004	0.010	0.010	0.007	0.007
Number of Obs.	89,355	89,355	67,092	67,092	77,258	74,606	79,189	81,841
Horizontal JV = Horizontal 100 (p-value)	0.55	0.69	0.48	0.44	0.80	0.95	0.25	0.16
Vertical JV = Vertical 100 (p-value)	0.21	0.08	0.56	0.51	0.28	0.50	0.15	0.73

Notes:

(a) The dependent variables are the first differences of the natural logarithm of firm total factor productivity ($\ln(TFP_t) - \ln(TFP_{t-1})$). TFP is either Solow residuals or Olley-Pakes estimated.
(b) All regressions include a constant, sector, province and year fixed effects.
(c) Standard errors, corrected for clustering at the sector-year level, are reported in parentheses.
(d) ***, ** and * denote 1%, 5% and 10% significance levels, respectively.
(e) The last two rows report the *p*-values of the tests for whether the coefficients on wholly and jointly-owned spillovers are the same.
(f) Only domestic firms (with less than 10% foreign equity) are included in the sample.
(g) Coastal provinces include Fijian, Guangdong, Hainan, Heilongjiang, Jiangsu, Jilin, Liaoning, Shandong, Shanghai, Tijian and Zhejiang.
(h) Technology leaders are firms with TFP in the top 50th percentile.

Table 15: Sectoral Productivity Growth and Spillovers

Dependent variable: $\Delta \ln(TFP_t) = \ln(TFP_t) - \ln(TFP_{t-1})$						
	(1)	(2)	(3)	(4)	(5)	(6)
TFP Measures	Solow	Solow	Solow	Olley-Pakes	Olley-Pakes	Olley-Pakes
∆Horizontal	1.488	1.464	1.648	1.655**	1.630**	1.926
	(0.902)	(0.901)	(1.391)	(0.715)	(0.708)	(1.256)
∆Vertical		1.488	1.906		1.519	2.128*
		(1.089)	(1.711)		(1.084)	(1.190)
∆ln(Imports)			0.029			-0.008
			(0.216)			(0.143)
∆Herf10			-1.865			0.639
			(1.641)			(2.183)
Sector Fixed Effects	N	N	Y	N	N	Y
Year Fixed Effects	Y	Y	Y	Y	Y	Y
R-squared	0.206	0.218	0.325	0.228	0.241	0.404
Number of Obs.	66	66	66	66	66	66

Notes:

(a) The dependent variables are the first differences of the natural logarithm of the sectoral weighted average of firm total factor productivity.

(b) All regressions include a constant and year fixed effects.

(c) Robust standard errors are reported in parentheses.

(d) ***, ** and * denote 1%, 5% and 10% significance levels, respectively.

Appendix Tables

Table A1: Olley-Pakes Estimated Input Elasticities by Sector

ISIC	Sector	Labor		Capital		
		Estimate	Std. Dev	Estimate	Std. Dev	Sum
15	Food products and beverages	0.522	(0.014)	0.365	(0.029)	0.887
16	Tobacco products	0.530	(0.104)	0.595	(0.017)	1.125
17	Textiles	0.370	(0.011)	0.333	(0.024)	0.703
18	Wearing apparel	0.525	(0.018)	0.428	(0.037)	0.953
19	Tanning, dressing leather	0.434	(0.017)	0.274	(0.046)	0.708
20	wood and wood products	0.537	(0.023)	0.195	(0.043)	0.732
21	Paper and paper products	0.360	(0.020)	0.323	(0.045)	0.683
22	Publishing, printing and reproduction recorded media	0.388	(0.028)	0.392	(0.066)	0.780
23	Coke, refined petroleum products and nuclear fuel	0.296	(0.039)	0.235	(0.072)	0.531
24	Chemicals and chemical products	0.299	(0.012)	0.409	(0.024)	0.708
25	Rubber and plastics products	0.431	(0.016)	0.412	(0.041)	0.843
26	Other non-metallic mineral products	0.415	(0.011)	0.288	(0.022)	0.703
27	Basic metals	0.312	(0.020)	0.269	(0.045)	0.581
28	Fabricated metal products, except machinery and equipment	0.391	(0.016)	0.361	(0.032)	0.752
29	Machinery and equipment n.e.c.	0.392	(0.014)	0.537	(0.023)	0.929
30	Office, accounting and computing machinery	0.368	(0.071)	0.366	(0.126)	0.734
31	Electrical machinery and apparatus n.e.c.	0.323	(0.017)	0.436	(0.040)	0.759
32	Radio, television and communication equipment	0.405	(0.027)	0.536	(0.041)	0.941
33	Medical, precision and optical instruments, watches and clocks	0.355	(0.036)	0.369	(0.054)	0.724
34	Motor vehicles, trailers and semi-trailers	0.327	(0.027)	0.432	(0.057)	0.759
35	Other transport equipment	0.353	(0.027)	0.494	(0.058)	0.847
36	Furniture; manufacturing n.e.c.	0.541	(0.017)	0.293	(0.038)	0.834

Note: All estimated input elasticities are significant at the 1% significance levels.

Table A2: Spillover Measures by Sector

ISIC	Sector	Horizontal		Horizontal (100% owned)		Vertical		Vertical (100% owned)	
		Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
15	Food products and beverages	0.323	0.009	0.081	0.017	0.304	0.013	0.105	0.019
16	Tobacco products	0.004	0.001	0.000	0.000	0.304	0.013	0.105	0.019
17	Textiles	0.274	0.007	0.074	0.010	0.399	0.029	0.174	0.026
18	Wearing apparel	0.543	0.022	0.215	0.029	0.399	0.029	0.174	0.026
19	Tanning, dressing leather	0.589	0.020	0.335	0.036	0.399	0.029	0.174	0.026
20	wood and wood products	0.351	0.034	0.122	0.012	0.477	0.030	0.261	0.027
21	Paper and paper products	0.308	0.041	0.087	0.015	0.281	0.021	0.101	0.020
22	Publishing, printing and reproduction recorded media	0.323	0.012	0.093	0.020	0.281	0.021	0.101	0.020
23	Coke, refined petroleum products and nuclear fuel	0.192	0.106	0.021	0.015	0.240	0.028	0.059	0.016
24	Chemicals and chemical products	0.284	0.037	0.049	0.023	0.363	0.023	0.144	0.025
25	Rubber and plastics products	0.448	0.032	0.193	0.041	0.341	0.032	0.107	0.021
26	Other non-metallic mineral products	0.193	0.028	0.054	0.022	0.296	0.031	0.092	0.018
27	Basic metals	0.106	0.014	0.008	0.002	0.333	0.036	0.108	0.023
28	Fabricated metal products, except machinery and equipment	0.307	0.024	0.130	0.024	0.331	0.028	0.102	0.020
29	Machinery and equipment n.e.c.	0.312	0.047	0.061	0.024	0.291	0.027	0.084	0.016
30	Office, accounting and computing machinery	0.800	0.029	0.539	0.082	0.370	0.035	0.109	0.015
31	Electrical machinery and apparatus n.e.c.	0.349	0.042	0.117	0.028	0.487	0.020	0.201	0.022
32	Radio, television and communication equipment	0.690	0.045	0.208	0.030	0.402	0.024	0.177	0.030
33	Medical, precision and optical instruments, watches and clocks	0.489	0.024	0.219	0.019	0.307	0.036	0.085	0.019
34	Motor vehicles, trailers and semi-trailers	0.482	0.129	0.042	0.013	0.283	0.031	0.077	0.019
35	Other transport equipment	0.266	0.010	0.056	0.012	0.310	0.037	0.067	0.019
36	Furniture; manufacturing n.e.c.	0.524	0.033	0.309	0.030	0.253	0.023	0.072	0.015

Table A3. Correlation Matrix of Explanatory Variables of Interest

	ΔHorizontal	ΔHorizontal (JV)	ΔHorizontal (100)	ΔVertical	ΔVertical (JV)	ΔVertical (100)	Δln(Imports)	Δherf10
ΔHorizontal (JV)	0.8655	1						
ΔHorizontal (100)	-0.0297	-0.5264	1					
ΔVertical	0.0457	0.0219	0.0338	1				
ΔVertical (JV)	0.0204	-0.0760	0.1862	0.7951	1			
ΔVertical (100)	0.0437	0.1479	-0.2210	0.4402	-0.1946	1		
Δln(Imports)	0.0569	-0.0127	0.1219	-0.0354	0.0178	-0.0835	1	
Δherf10	0.1389	0.2391	-0.2413	0.0041	-0.152	0.2316	0.2307	1