Is There Evidence of FDI Spillover on Chinese Firms' Productivity and Innovation?

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Abstract

We review previous literature on productivity spillovers of foreign direct investment (FDI) in China and conduct our own analysis using a cross–section of firm data. We find that the evidence of FDI spillovers on the productivity of Chinese domestic firms is mixed, with many positive results largely due to aggregation bias or failure to control for endogeneity of FDI. Attempting over 2500 specifications which take into account forward and backward linkages, we find no evidence of systematic positive productivity spillovers from FDI. We do, however, find robust evidence that Chinese private firms tend to invest less in innovation in the presence of FDI. Combined with our previous findings that domestic private firms tend to be more involved in providing inputs and intermediary goods for foreign firms (Hale and Long, 2006), these results suggest a more passive role played by domestic firms in the global division of labor than envisioned by the Chinese government.

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1 Introduction

China has been extremely successful in attracting foreign direct investment (FDI) since it started the economic reforms at the end of the 1970s. Figure 1 illustrates the breathtaking speed of FDI growth in China. The FDI inflow was below $100 million in 1979, but the amount exceeded $60 billion by 2004, with an annual growth rate of close to 30%. Such rapid growth of FDI inflow has largely been accompanied by government policies that encourage FDI. Some of these policies aimed to equalize operating conditions for foreign capital inside and outside China, including those regarding foreign trade and foreign exchange control. Other policies provided monetary incentives for foreign investors, including preferential treatment in taxation and environmental regulation.

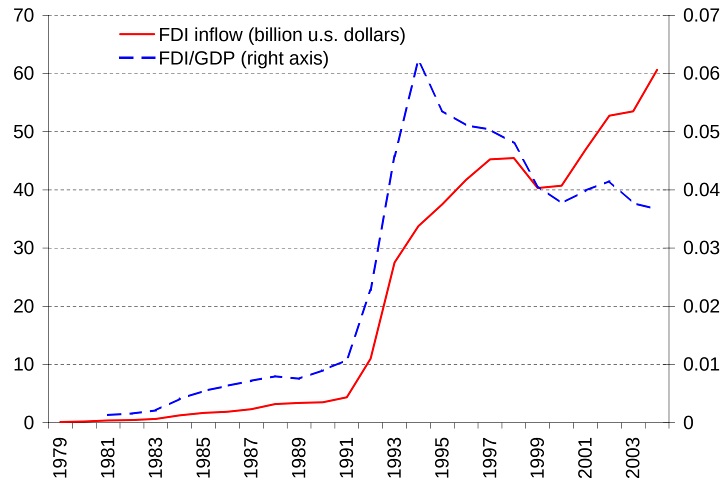
Although FDI growth and the effectiveness of government policies in prompting such growth have been unrefuted, the effects of FDI on domestic firms are far from clear. Previous studies on FDI spillover effects on productivity of Chinese firms have produced mixed evidence as to whether domestic firms have benefited from FDI presence. Due to limited availability of panel data at the firm level and difficulty in finding instruments for FDI presence, many positive results obtained by researches suffer from aggregation bias or failure to control for endogeneity of FDI, both of which tend to overstate the productivity spillovers of FDI.

We attempt to address these issues using a firm–level data set from a World Bank survey. In addition to limiting the sample to domestic firms, which removes the aggregation bias, we use instrumental variables analysis to address potential endogeneity of FDI presence, using three variables that do not affect domestic firms' productivity directly. After controlling for the endogeneity of FDI, we fail to find any significant FDI spillover effects on TFP or labor productivity for domestic firms in the same, upstream or downstream industries.

On the other hand, when we analyze various measures of innovation activity of domestic firms, we find robust evidence that Chinese private firms tend to invest less in innovation in the presence of FDI. Combined with our previous findings that domestic private firms tend to be more involved in providing inputs and intermediary goods for foreign firms (Hale and Long, 2006), these results suggest a more passive role played by domestic firms in the global division of labor than envisioned by the Chinese government.

The current paper relates closely to the literature on FDI spillovers as well as that on transition economies, which we review in the next section. It also contributes to the literature in several aspects. First, we carefully address the endogeneity of FDI presence by instrumenting it with exogenous variables such as location, transportation conditions, and tax rates. Second, we use firm innovation measures in addition to productivity measures to capture a larger scope of FDI spillover effects. Third, we include service sector

Figure 1: FDI inflows into China



Source: Statistical Yearbook, various issues (Chinese National Bureau of Statistics)

firms in addition to manufacturing firms. Fourth, we use the input–output table for China to study the vertical spillover effects of FDI, i.e., spillover effects of FDI in upstream and downstream industries. Finally, we explore the effects of ownership structure on FDI spillover effects on domestic firms.

The structure of the paper is as follows: Section 2 reviews previous literature on productivity spillovers of FDI in China and identifies potential biases in the estimates. Section 3 describes the data and empirical approach used in the study. Results on FDI spillover effects on productivity are presented in Section 4, while those on FDI spillover effects on innovations, in Section 5. Section 6 concludes.

2 Literature review

Although theoretical work has generally predicted positive effects of FDI presence on domestic firms' productivity, results from empirical studies are mixed.[1] Most studies focus on the spillover effects of FDI on domestic firms in the same industry—horizontal spillover effects. Among the 42 studies on horizontal productivity spillovers of FDI in developed, developing, and transition economies summarized in Görg and Greenaway (2004), only 20 studies report unambiguously positive and significant results. Furthermore, 14 out of the 20 studies finding positive effects either use cross–section data at the industry level, which leads to aggregation bias, or use cross–section of firm level data without controlling for the endogeneity of FDI

[1] Theoretical models studying the labor mobility channel include Kaufmann (1997), Haaker (1999), Fosfuri, Motta, and Rønde (2001) and Glass and Saggi (2002). Wang and Blomstrom (1992) emphasize the role of competition and also allude to the role of demonstration. Rodriguez-Clare (1996) outlines forward and backward linkages between foreign firms and domestic firms as a possible mechanism for positive spillovers.

presence. Among the 24 studies using firm level panel data, which Görg and Greenaway (2004) argue to be the most appropriate estimating framework, only 5 obtain positive and significant FDI spillover effects, with 4 from developed countries. For transition economies, only one out of the 8 studies discussed obtains positive and significant FDI spillover effects, using cross–section data.[2]

Similar to findings for other countries, studies on FDI spillover effects in China have obtained a wide range of estimates for the effects of FDI presence on the productivity of Chinese domestic firms. We summarize published studies of FDI spillover effects on productivity of Chinese firms in Table 1. As shown in the table, most studies of FDI spillover effects in China focus on how the presence of FDI affects the total factor productivity (TFP) and labor productivity of domestic firms, with the exception of Cheung and Lin (2004), which studies patent applications, and Buckley, Clegg, and Wang (2002), which include high-tech and new product development as well as export performance.

Although many of the studies included in Table 1 find positive and significant FDI spillovers, most of these studies tend to overestimate FDI spillover effects on Chinese domestic firms, with Hu and Jefferson (2002) being the only exception. Depending on the level of data aggregation, studies on FDI spillovers in China can be divided into provincial level studies, industry level studies, and firm level studies. First, studies using provincial or industry level data often do not exclude firms with foreign investment from the sample (Huang, 2004; Cheung and Lin, 2004; Liu, Parker, Vaidya, and Wei, 2001). Given that foreign invested firms are more productive than domestic firms, including these firms exaggerate the positive effects of FDI on domestic firms' productivity,[3] creating positive aggregation bias. Second, most studies do not control for the endogeneity of FDI when estimating its spillover effects. If FDI is more likely to go to places with higher productivity to begin with, then the positive correlation between FDI and productivity of domestic firms may simply reflect the location decision by foreign investors rather than the positive spillover effects of their investment. In fact, studies that analyze the location of FDI in China, including Sun, Tong, and Yu (2002) and Cheng and Kwanb (2000), tend to find a positive correlation between per capita GDP (a measure of productivity) and FDI.

As shown in Table 1, among provincial level studies only Liu (2001) is able to distinguish domestic firms from foreign invested firms. However, the paper does not address the endogeneity of FDI when analyzing the domestic sample. Thus, the significant and positive FDI spillover effects obtained for domestic firms of

[2]Among the five studies discussed in Görg and Greenaway (2004) that focus on vertical FDI spillover effects, i.e., effects of FDI presence on domestic firms located in upstream or downstream firms, three find positive backward FDI spillovers, one finds positive forward FDI spillovers.

[3]Focusing on the domestic firms exclusively could potentially underestimate the effect of FDI presence in the same industry. FDI through mergers and acquisitions tend to go to more productive firms, thus leading to the upper truncation of the productivity distribution of remaining firms, lowering their average productivity. We will refer to this effects as selection bias and will show that, at least in our sample, it has a negligible effect on productivity and innovation.

certain ownership types (state-owned enterprises, joint-owned enterprises, and shareholding enterprises) are subject to an upward bias. In addition, because the average level of FDI for Shenzhen's manufacturing sector is used for all 29 industries in the sample, the standard error on the coefficient of interest is underestimated (Moulton, 1990).

The majority of studies using industry level data do separate domestic firms from foreign invested firms, and two out of three such studies, Li, Liu, and Parker (2001) and Buckley, Clegg, and Wang (2002) find positive FDI spillover effects. Both studies explore the manufacturing sector using the 1995 Third Industrial Census of China. While Li, Liu, and Parker (2001) only explore the FDI effects on labor productivity, Buckley, Clegg, and Wang (2002) also study the potential FDI spillovers on other measures of firm performance (including high-tech and new product development as well as export performance) and finds positive spillover effects. However, neither study addresses the endogeneity of FDI. Buckley, Clegg, and Wang (2002) use ordinary least squares, while Li, Liu, and Parker (2001) uses three–stage least squares to address the endogeneity of value added of firms with different ownership types.

Only three studies use firm level data and among the three only two make use of the variation at the firm level. Chuang and Hsu (2004) begin with 455689 firms from the 1995 Third Industrial Census of China but aggregate the firm level data to 673 industry–province cells. Using OLS estimation, the paper finds positive and significant FDI spillover effects on domestic firms that have low technology gap from foreign firms. In addition to the failure to address the endogeneity of FDI, the definition of technology gap (defined as the difference of average sales revenue per worker between foreign-invested firms and domestic firms) is also subject to potential endogeneity bias. Thus the positive FDI effects obtained should be viewed with caution.

Similarly, in an unpublished paper, Tong and Hu (2003) aggregate close to 500,000 domestic firms to 10601 4-digit industry–province cells and find that FDI from the Greater China Area (GCA, including HongKong, Macao, and Taiwan) have negative effects on domestic productivity while that from other areas have positive effects. The paper also studies inter–industry spillovers by estimating the effects on the 4-digit industry–province cell's productivity of the average FDI share in the corresponding 2-digit industry–province cell. For FDI from both the GCA and other areas, the authors obtain positive and significant inter–industry spillover effects. Once again, because the paper does not control for the endogeneity of FDI either by using firm fixed effects or by instrumenting, these results are subject to an upward bias.

Wei and Liu (2006) uses a panel data from the Annual Report of Industrial Enterprise Statistics, including close to 8000 Chinese domestic firms for 1998-2001. This provides an ideal setting for addressing the issue of endogenous FDI. However, Wei and Liu (2006) only controls for year, industry, and area fixed effects, but not firm fixed effects. As a result, there is an upward bias in the FDI spillover effects estimated if the industry, the province, or the industry-province cell that have more productive domestic firms also tend to attract more foreign investment. Another potential upward bias may come from the sample exclusion criterion used in the paper, where any firm with less than 25% of foreign equity participation is defined as a domestic firm.

Hu and Jefferson (2002) is the only study we are aware of that includes estimates not subject to the endogeneity problem. The study uses 8917 domestic textile firms and 2289 domestic electronic firms and find negative and significant effects of FDI presence on the TFP of domestic electronic firms. But the more convincing findings are from the authors' panel data analysis of 701 textile firms and 212 electronic firms for 1995-1999, which includes firm fixed effects. If the unobserved factors that determine both the amount of FDI and the productivity of domestic firms are time invariant, then Hu and Jefferson (2002) produce unbiased estimates for FDI spillover effects. This results from the FE estimation show negative but insignificant FDI effects.

In summary, empirical evidence of FDI spillovers on Chinese domestic firms is mixed, largely because data limitation has hampered the effort to control for the endogenous location of FDI. The other main shortcoming of previous research is their limited coverage of industry and scope of spillovers. With the exception of Huang (2004) and Cheung and Lin (2004), which look at the total FDI amount at the provincial level, all other studies focus on the manufacturing sector in China. In terms of the scope of spillovers, all studies use TFP and labor productivity, except Cheung and Lin (2004) and Buckley, Clegg, and Wang (2002). In addition, all previous studies (except Tong and Hu (2003)) focus on the spillover effects of FDI in the same location or industry, while ignoring potential FDI spillovers through backward and forward linkages, shown to be important for other transition economies (Javorcik, 2004).

3 Data and empirical approach

In the following sections, we present results from our own analysis using a firm–level data set from a World Bank survey. We attempt to address the limitations of previous studies as follows: First, we limit our sample to firms without any foreign partners; Second, while we do not have a time dimension that would allow us to use firm fixed effects, we address the endogeneity of FDI by instrumenting for the level of FDI; Third, our data set includes both manufacturing firms and service firms. Furthermore, we use several measures of domestic firms' innovative activities in addition to TFP and labor productivity to explore the spillover effects of FDI. Finally, we also explore the potential spillover effects of FDI presence in upstream and downstream industries. We now describe the data and outline our empirical approach.

3.1 Data

We use data from the Study of Competitiveness, Technology & Firm Linkages conducted by the World Bank in 2001. The survey consists of two questionnaires, one filled up by the Senior Manager of the main production facility of the firm while the other filled up by the accountant or personnel manager of the firm. The methodology of the survey is stratified random sampling with the stratification based on sub-sectors including accounting and related services, advertising and marketing, apparel and leather goods, business logistics services, communication services, consumer products, electronic equipment and components, IT, and auto parts. A stratified random sample of 300 establishments is drawn in each of the following five Chinese cities: Beijing, Chengdu, Guangzhou, Shanghai, and Tianjin, giving a total sample size of 1500. Table 2 gives the city and industry distribution of firms included in the survey. See Figure 2 for the cities covered in the survey and their locations in China. Throughout the paper, we refer to firms with a foreign partner as 'foreign' or 'foreign–owned' firms and firms without a foreign partner as domestic firms. As shown in Table 2, among the 1500 firms interviewed during the survey, 382 are foreign firms in 2000.

The survey collects detailed information on firms and their operation environment. The firms were requested to provide information as of year 2000, but for many accounting measures, information from up to three previous years was also collected.[4] In addition to the comprehensive scope of information collected and the high response rate, our survey data has another advantage. A main concern to researchers studying FDI in China, round–tripping FDI is domestic capital disguised as FDI by registering firms at offshore financial centers that have lax controls on capital movements, which then invest in China. In our sample, however, only three out of the 381 firms with foreign partners list the British Virgin Islands as the FDI source country and only one lists the Cayman Islands, two of the most used offshore financial centers in round tripping FDI. Excluding these four firms from our sample does not substantially change the results. In other words, our data seems to suffer less from the bias associated with round–tripping FDI.[5]

In this study, we use a small portion of the survey that gives information on firms' input, output, as well as foreign ownership. In particular, we use the following variables directly or constructed from the survey, with all values referring to year 2000 unless indicated otherwise:

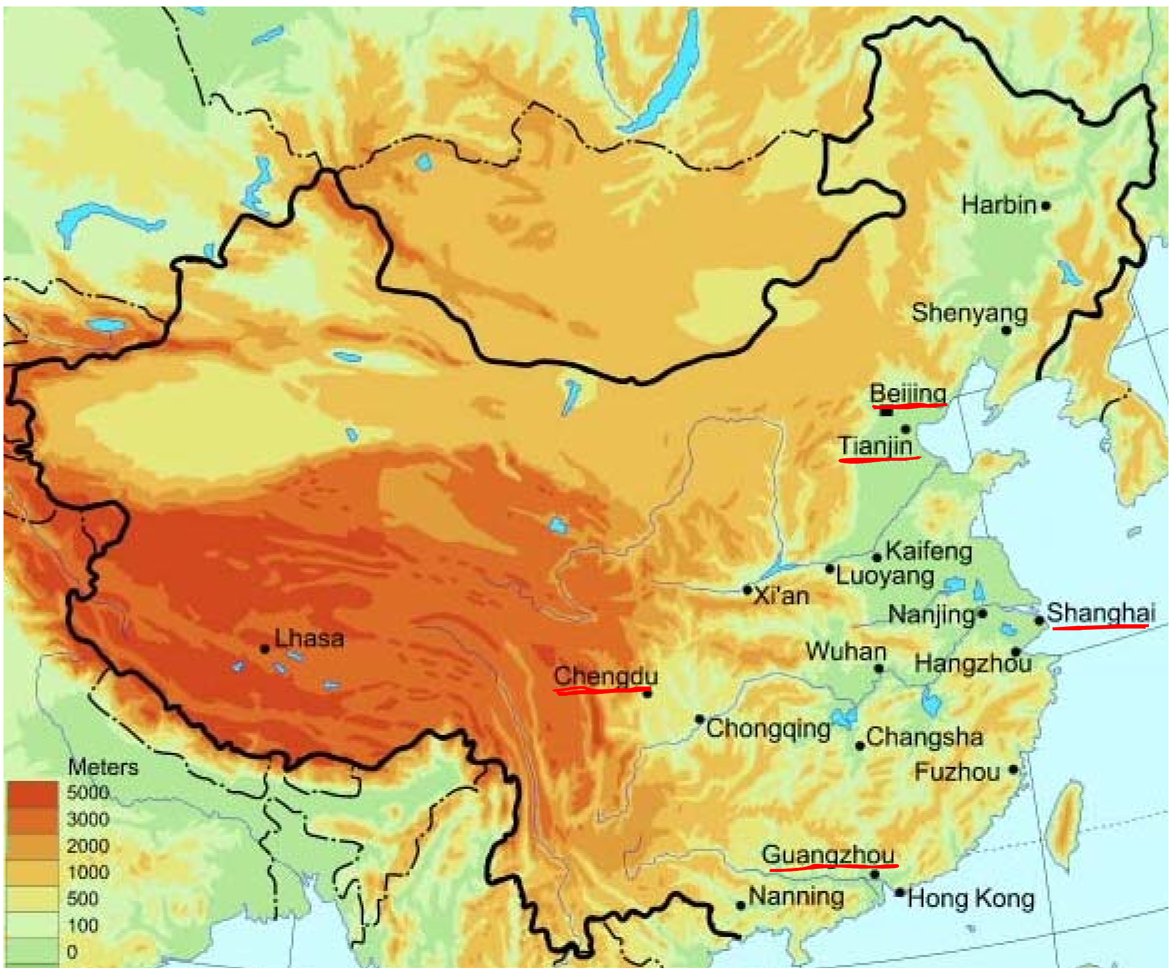
Value added: Firm sales (adjusted by change in final product inventory) minus total material costs, in year 2000 RMB, used in logs.

I(Patent): An indicator of whether the firm owned a patent.

[4] For a detailed description of the survey, see Hallward-Driemeier, Wallsten, and Xu (2003).

[5] Another main location used for round tripping FDI is Hong Kong. We address this concern by using a measure of non-GCA FDI presence, where GCA (or the Greater China Area) includes Hong Kong, Macao, and Taiwan.

Figure 2: Cities included in the sample



Underlined are the five cities included in the sample

Patent applications: Number of patents applications filed.

I(New products): An indicator of whether the firm developed new products.

R&D/sales: Ratio of R&D expenditures to sales.

R&D employment: Percentage of employees involved in R&D.

Capital input: Value of fixed assets in year 2000 RMB, used in logs.

Labor input: Number of employees in the firm, used in logs.

TFP: Total factor productivity obtained as a residual from linear regression of value added on capital and labor input for each industry on the sample of domestic firms.

Y/L: Labor productivity equal to the ratio of value added to labor input, used in logs.

Capital/Labor: Capital intensity of the firm, measured as the ratio between capital input and labor input.

Firm age: Firm's age.

Firm scale: Firm sales relative to the average firm sales in the same industry, used in logs.

Degree of competition: Number of competitors the firm has relative to the average number of competitors in the same industry, used in logs.

CEO-college: An indicator of whether the CEO of the firm has a college degree.

CEO-grad. degree: An indicator of whether the CEO of the firm has a post-graduate degree.

Favorable regulations: An indicator of whether favorable regulatory environment is among the top five reasons given for choosing the current location of the firm.

Average education: Average education level of engineering and managerial personnel in the firm, in years of schooling.

Average age: Average age of engineering and managerial personnel in the firm, in years.

Tax rate: The amount of taxes paid divided by sales.

Exporter: An indicator for whether the firm is exporting some of its products.

Transportation cost: Transportation expenses divided by sales.

Industry: Industry sector of the firm, a categorical variable 1,2,...,10.

City: City where the firm is located, a categorical variable 1,2,...,5.

Table 3 shows summary statistics for the variables used in the analysis. The sample of our analysis will include only domestic firms, but we provide the averages for these variables for foreign firms as well, for comparison. Domestic firms with private ownership of less than 20% are listed as SOEs, while others are listed as private.[6] This split is only done for the purpose of comparing our variables for domestic firms with different ownership, while in most of the regression analysis that follows, we use a continuous measure of the private ownership share. Table 3 suggests that foreign firms are substantially different from domestic firms in age, scale, and capital intensity, especially compared to domestic SOEs.

[6] This split corresponds most closely to the ownership characterizations provided by the firms.

The crucial variable in the study is the measure for FDI presence. Following the literature (Aitken and Harrison, 1999), we define and construct the measure of FDI presence in the same industry as the average of each firm's largest foreign partner's share in the same city–industry as the domestic firm, weighted by firm employment. Table 4 presents this measure by city and industry sector. We use this measure of FDI presence when focusing on the horizontal FDI spillover effects, within the same geographic location and industry.

To allow for inter–industry FDI spillover effects, we construct an input–output table for industries included in our sample based on the 2000 Input–Output Table for China, as shown in Table 5.[7] Using this table, we compute the upstream FDI presence for Firm i as the sum of FDI presence in all other industries in the same city weighted by the input coefficients of these industries corresponding to Firm i's industry. The downstream FDI presence, on the other hand, is computed as the sum of FDI presence in all other industries weighted by the output coefficients of Firm i's industry to these other industries. Table 6 presents summary statistics for upstream and downstream FDI presence by city and industry sector.

We test additional hypotheses by constructing a variety of measures for FDI presence. Since the degree of connection with local firms may be influenced by whether a firm has majority foreign ownership, it is possible that the presence and magnitude of FDI spillover effects may vary depending on the presence of firms with majority foreign ownership.[8] To test this hypothesis, we construct the presence of FDI by focusing on majority ownership foreign firms and construct FDI-majority presence measure by including only the foreign shares of firms with majority foreign ownership in our computation of FDI presence.

The source region of foreign ownership may also be relevant in determining FDI spillover effects. Several studies find that foreign investment from the Greater China Area (GCA) tends to be less technology intensive compared to FDI from other countries and regions.[9] We therefore construct the presence of non-GCA FDI, by computing the average of each firm's largest non-GCA partner's share in the same city–industry as the domestic firm, weighted by firm employment.

Many of the foreign–invested firms in China's port cities use their factories primarily as export platforms. While they might be using more advanced technologies, their interaction with domestic firms is likely to be limited. In this case, it would make sense to focus on the firms that are more present in the domestic markets and actually compete with domestic firms. To do this, we compute the FDI presence as the average foreign share of firms weighted by the product of their domestic sales to total sales ratio and their employment.

[7] The 2000 Input-output Table for China is accessed at http://www.stats.gov.cn/tjsj/ndsj/yb2004-c/html/C0322ac.htm on December 30, 2006.

[8] Xu and Lu (2006) finds that the impact of foreign firms' presence on the sophistication of Chinese exports differs depending whether the foreign invested firms have majority foreign ownership.

[9] See, for instance, Buckley, Clegg, and Wang (2002), Huang (2004), Hu and Jefferson (2002), Tong and Hu (2003), Wei and Liu (2006), and Xu and Lu (2006),.

Having constructed these additional FDI measures, we then use the Input-Output Table to compute the corresponding upstream and downstream FDI presence. In our regression analysis we use the measures of FDI presence in levels as well as in logs. To summarize, we use the following measures of FDI presence:

FDI presence: The average of each firm's largest foreign partner's share in the same city–industry as the domestic firm, weighted by firm employment.

Upstream FDI presence: The sum of FDI presence (as defined above) in all other industries in the same city as the domestic firm, weighted by the input coefficients of these industries to the industry of the firm.

Downstream FDI presence: The sum of FDI presence (as defined above) in all other industries in the same city as the domestic firm, weighted by the output coefficients to these industries of the industry of the firm.

FDI-majority presence: The average of the largest foreign partner's share of the firms with majority foreign stake in the same city–industry as the domestic firm, weighted by firm employment.

Upstream FDI-majority presence: The sum of FDI-majority presence (as defined above) in all other industries in the same city as the domestic firm, weighted by the input coefficients of these industries to the industry of the firm.

Downstream FDI-majority presence: The sum of FDI-majority presence (as defined above) in all other industries in the same city as the domestic firm, weighted by the output coefficients to these industries of the industry of the firm.

FDI-non GCA presence: The average of each firm's largest foreign partner's share (excluding partners from GCA — Hong Kong, Taiwan, and Macao) in the same city–industry as the domestic firm, weighted by firm employment.

Upstream FDI-non GCA presence: The sum of FDI-non GCA presence (as defined above) in all other industries in the same city as the domestic firm, weighted by the input coefficients of these industries to the industry of the firm.

Downstream FDI-non GCA presence: The sum of FDI-non GCA presence (as defined above) in all other industries in the same city as the domestic firm, weighted by the output coefficients to these industries of the industry of the firm.

FDI-domestic sales presence: The average of each firm's largest foreign partner's share in the same city–industry as the domestic firm, weighted by the product of the firm's domestic sales to total sales ration and firm's employment.

Upstream FDI-domestic sales presence: The sum of FDI-domestic sales presence (as defined above) in all other industries in the same city as the domestic firm, weighted by the input coefficients of these industries to the industry of the firm.

Downstream FDI-domestic sales presence: The sum of FDI-domestic sales presence (as defined above) in all other industries in the same city as the domestic firm, weighted by the output coefficients to these industries of the industry of the firm.

We use the following variables from outside of our survey data to construct the instruments for FDI presence, as discussed below:

Port berth: The total number of berths (including both productive and non-productive ones) in the port located by the city (valued at 0 if the city has no port), obtained from Chinese Statistical Yearbook 2001, National Bureau of Statistics.

Distance between cities: The distance between the capital city of each province or autonomous region and the cities in our sample, obtained from the official web site of Chinese government.[10]

Provincial population: The population of each province or autonomous region, obtained from Chinese Statistical Yearbooks 2001, National Bureau of Statistics.

3.2 Empirical approach

Our focus is on the effects of foreign presence on performance of domestically owned firms. Thus, the sample of our main analysis is limited to domestic firms and is not subject to the aggregation bias that occurs when lumping together foreign and domestic firms — where the higher productivity of foreign firms may be mistaken as FDI spillovers. Our main regression specification is therefore:

$$Y_{jic} = \alpha_i + \alpha_c + \beta_1 \; FDI_{ic} + Z'_{jic}\,\Gamma + \varepsilon_{jic}, \tag{1}$$

where Y_{jic} is a performance measure for firm j operating in industry i and located in city c, α_i and α_c are industry and city fixed effects, respectively, FDI_{ic} is a measure of foreign firm presence in the same city–industry cell as firm j, Z_{jic} is a set of firm–level control variables corresponding to the outcome variable, ε_{jic} is a random error term. Thus, the coefficient β_1 measures the relationship between foreign presence in a city–industry cell and the characteristic of an average domestic firm measured by the outcome variable. When studying the backward and forward linkages of FDI effects, we use the upstream and downstream FDI presence as the FDI measure.

To fully explore the FDI spillover effects, we use not only the TFP and labor productivity as the firm performance measures, but also the following measures of firm innovations: whether the firm had a patent, the number of patent applications filed by the firm, whether the firm developed a new product, the R&D

[10]http://www.cmst.com.cn/mileage/mileage.asp last accessed on January 29, 2007.

expenditure to sales ratio, and the share of employees engaged in R&D. For the continuous outcome measures (TFP and labor productivity) we use linear regression, for binary outcomes (indicators of patents and new products) we use probit model, for truncated outcome measures (the two R&D measures) we use tobit regression, while for the number of patent applications we use a negative binomial model appropriate for the analysis of such count data.[11]

As discussed above, the biggest challenge in accurately estimating FDI spillover effects is potential endogeneity of FDI. To address this issue in our cross–section data, we adopt the instrumental variable (IV) approach. Blonigen (2005) argues that multinational corporations make overseas investment for several reasons, including obtaining lower tax rate, securing access to domestic market, and using cheap local resources, such as labor, to produce for other markets.[12] We therefore use the following three instruments for FDI, which are not correlated with productivity of domestic firms: the average tax rate of all firms in the city–industry, obtained as simple average of the tax rate of the firms in each city–industry cell, the percentage of firms in the industry that exported in year 2000 multiplied by the berth capacity of the city's seaport ($Port * export$), and the average transportation cost as a percentage of sales in the industry multiplied by the sum of population of all other provinces weighted by the inverse of the distance between the provincial capital and the city squared ($Dist * trcost$).

The average tax rate in the city–industry proxies for preferential tax treatments some locations and sectors receive and thus affects the attractiveness of the city–industry to foreign investors. The capacity of the seaport affects the cost of exporting, while the percentage of firms that export serves as a proxy for the importance of exporting in a particular industry. Thus, $Port * export$ measures the access to overseas market and the attractiveness to FDI of the particular city–industry cell. The sum of population of all other provinces weighted by the square of the inverse of their distance to a city gives a measure of how centrally located the city is, while the average transportation cost as a percentage of sales measures the bulkiness of the industry. $Dist * trcost$ therefore measures the access to the domestic market and thus the attractiveness to FDI of the city–industry. Table 7 gives the means of the three instruments by city and industry.[13]

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[11] See Cameron and Trivedi (1998).

[12] Empirical studies demonstrating the importance of these factors include de Mooij and Ederveen (2003) (tax rate), Coughlin, Terza, and Arromdee (1991) (tax rate and infrastructure), Ma (2006) (access to international market), Bagchi-Sen and Wheeler (1989) (population size, population growth, and per capita sales), and Kravis and Lipsey (1982) and Blomstrom and Lipsey (1991) (size of domestic market). Other studies on location of FDI in China include Cheng and Kwanb (2000) and Sun, Tong, and Yu (2002).

[13] Since for service industry the berth capacity and transportation costs are not relevant, we use only average tax rate as an instrument when estimating regressions limited to service sector part of our sample.

Specifically, we estimate, using two–stage least squares, the following system:

$$\begin{cases} FDI_{ic} & = & \delta_i + \delta_c + \delta_1 \; TAX_{ic} + \delta_2 \; Port * export_{ic} + \delta_3 \; Dist * trcost_{ic} + \overline{Z'}_{ic} \, \Phi + \omega_{ic} \\ Y_{jic} & = & \alpha_i + \alpha_c + \beta_1' \; FDI_{ic} + Z_{jic}' \, \Gamma + \varepsilon_{jic}, \end{cases}$$

where TAX_{ic} is the average tax rate in city i and industry c and $\overline{Z'}_{ic}$ is a matrix of firm characteristics, average for each city–industry cell.

While aggregation bias and endogeneity tend to overstate the effects of FDI on domestic firms' productivity, there is potentially a negative selection bias when limiting the sample to domestic firms. Since the majority of FDI into China takes the form of mergers and acquisition, the sample of domestic firms is not randomly formed.[14] Rather, the domestic firms may be those that foreign investors found less attractive, because most likely foreign investors will choose to invest in more productive firms. As a result, if for some reason unrelated to productivity a given city–industry cell is more attractive to foreign investors, a larger upper tail of the productivity distribution will be foreign–invested, lowering the mean productivity of remaining domestic firms. Since in the regression analysis we limit ourselves to the sample of domestic firms, we thus might be underestimating the effects of FDI presence.[15] We test whether the selection bias is present in our sample by estimating the effects of FDI on productivity using maximum likelihood Heckman selection model (Heckman, 1979), where in the selection equation we use as instruments the same variables as we used in our IV analysis.

Specifically, we estimated the following system by maximum likelihood:

$$\begin{cases} DOM_{jic} & = & \lambda_i + \lambda_c + \lambda_1 \; TAX_{ic} + \lambda_2 \; Port * export_{ic} + \lambda_3 \; Dist * trcost_{ic} + Z_{jic}' \, \Psi + \nu_{ic} \\ Y_{jic} & = & \alpha_i + \alpha_c + \beta_1'' \; FDI_{ic} + Z_{jic}' \, \Gamma + \varepsilon_{jic}, \quad \text{if} \;\; DOM_{jic} = 1, \end{cases}$$

where DOM_{jic} is an indicator for whether firm j is classified as domestic.

Finally, we study the influence of ownership structure on how FDI presence affects domestic firms by adding two terms to Equation 1 as follows:

$$Y_{jic} = \alpha_i + \alpha_c + \beta_1 FDI_{ic} + \beta_2 PR_{jic} + \beta_3 FDI_{ic} \cdot PR_{jic} + Z_{jic}' \, \Gamma + \epsilon_{jic}, \tag{2}$$

where PR_{jic} is the share of private ownership of firm j. The coefficient of the interaction between PR_{jic} and

[14]In fact, sole foreign ownership was not allowed till the passage in 1986 of *the Law of the Peoples Republic of China on Enterprises Operated Exclusively with Foreign Capital.*

[15]Note that this problem only arises when measuring horizontal spillovers and is not applicable to our analysis of FDI spillovers through backward and forward linkages.

FDI_{ic}, β_3, measures how private ownership affects the relationship between FDI presence in a city–industry cell and the outcome for an average domestic firm.

Because of the potential endogeneity of FDI_{ic}, the interaction term $FDI_{ic} \cdot PR_{jic}$ may also be endogenous. To control for endogeneity in this context, we follow Wooldridge (2002) and use the three instruments discussed above (average tax rate, $Port * export$, and $Dist * trcost$) as well as their interaction terms with PR_{jic} as instruments in the IV estimation of Equation 2.

3.3 Productivity of domestic and foreign firms

As can be seen from Table 3 foreign firms have higher labor productivity, submit more patent applications, and are more likely to introduce new products than domestic firms, SOEs or private. All these differences are statistically significant at the 10% confidence level.

To test whether foreign–invested firms also have higher TFP, we estimate the following regression using a sample of all firms (including both domestic and foreign firms):

$$VAD_{jic} = \beta_0 + \beta_1 L_{jic} + \beta_2 K_{jic} + \epsilon_{jic}, \tag{3}$$

where VAD_{jic} is the value added of firm j in industry i and city c, L_{jic} is the labor input and K_{jic} the capital input of the firm (both in logs), while ϵ_{jic} is a random error term. We then construct the measure of TFP for each firm as the residual from this regression.

The regression is conducted separately for each industry, using year 2000 information. We refer to the residual of the regression in Equation (3) as TFP1. By including additional firm characteristics into the above equation, we compute two alternative measures of TFP. We will refer to the TFP measure net of firm age and firm economy of scale as TFP2 (obtained by adding firm age and firm scale to the explanatory variables), and that net of firm age and firm scale as well as the human capital component, as TFP3 (obtained by adding firm age, firm scale, average education, average age and average age squared to the explanatory variables.)

We then conduct t-tests comparing the TFP of domestic firms with that of firms with positive share of foreign ownership in year 2000. Table 8 gives the t-test results from using the three measures of TFP. All three measures of TFP confirm that foreign firms have significantly higher productivity than domestic firms.

The reduction in the TFP gap between foreign and domestic firms from TFP1 to TFP2 and then to TFP3 is explained by the advantages of foreign firms over domestic firms that boost productivity and are controlled for in TFP2 and TFP3: Foreign firms are younger and enjoy greater economy of scale, and they hire younger employees with more education (see Table 3). In fact, differences in firm age and firm scale between foreign and domestic firms are statistically significant, as well as differences in age and education for the high–skilled employees (managers and engineers).

Even after controlling for firm vintage, scale, and average employee education and age, foreign firms still exhibit a significant productivity edge over domestic firms. This difference in productivity is consistent with the argument that FDI embodies more advanced technology and management practices. In turn, the affinity to such advantages brings about positive effects on the productivity of domestics firms located close to the foreign firms (geographically or technologically).[16] Since the assumption of superior productivity of foreign firms seems justified for our sample,[17] we now turn to testing the hypothesis that this productivity advantages spill over to domestic firms.

4 FDI spillovers on TFP and labor productivity

As mentioned previously, we estimate variations of Equation (1) using the sample that includes only domestic firms. Our measure of FDI presence is the average foreign share in each city–industry cell, weighted by firm employment. When we analyze the spillover effects of upstream and downstream FDI presence, the FDI measure is computed using the input–output table, as described above.

Table 9 reports estimates of FDI effects on domestic firms' TFP (coefficient β_1 in regression (1)) from various specifications, where Row (1) includes labor and capital inputs (both in logs) as well as firm age, firm scale, and the degree of competition as explanatory variables, Row (2) adds information on CEO education and regulatory environment, Row (3) adds information on age and education of technical and managerial personnel, while Row (4) adds information on private ownership share. Rows (5)-(8) use different sub-samples to estimate the basic specification used in Row (1). Row (9) uses the full sample and includes the variables in Row (1) and their interaction terms with industry dummy variables.

Column (1) presents results from OLS estimation, Column (2) computes robust standard errors clustered on city–industry to avoid downward bias in the standard error associated with β_1, Column (3) includes industry and city fixed effects as crude controls for endogeneity of FDI, while Column (4) further computes robust

[16]Although a conventional belief, the premise of FDI embodying technological or managerial advantages is challenged by Huang (2003), who provides examples where the "foreign" investor is in fact a domestic firm that first registered in Hong Kong and then returned to the mainland using the foreign entity with the purpose to enjoy the preferential treatment offered to foreigners. We address this problem by using a measure of non-GCA FDI presence.

[17]Note that these results do not necessarily imply that foreign capital increases firm productivity. Due to the "cherry–picking" nature of FDI, establishing such causal relationship, which is not a goal of this paper, would require panel data and more sophisticated analysis.

standard errors clustered on city–industry for the FE estimates in Column (3).

Our preferred approach to address the issue of endogeneity is instrumental variable estimation. Columns (5) and (6) present results from using two–stage least squares method (2SLS) and the generalized method of moments (GMM). Compared with 2SLS, GMM produces more efficient estimates (Hayashi, 2000). As described previously, the instruments for FDI include average tax rate, $Port * export$, and $Dist * trcost$. The first–stage results are largely consistent with our expectations, with average tax rate having a negative and significant effect on FDI and $Port * export$ having a positive and significant effect. Finally, column (7) uses Heckman maximum likelihood (ML) estimation to control for the potential selection bias that arises if foreign investors invest in more productive firms, leading to upper truncation of the distribution of domestic firms' productivity. We use the same set of instruments in the selection equation as we do in the IV regressions.

The top panel of Table 9 measures the spillover effects of FDI presence in the same city–industry, the middle panel measures the spillover effects of FDI presence in upstream industries, while the bottom panel measures the spillover effects of FDI presence in downstream industries. Overall, Table 9 presents the results of estimation of 164 regressions.

Some of the results are consistent with the literature. For instance, when we control for human capital and estimate β_1 using simple OLS, we find positive and significant effect of same city–industry FDI presence (all three panels, Row (3), Column (1)). However, this effect is no longer significant if we cluster standard errors on city–industry (Column (2)). Adding city and industry fixed effects lowers the coefficient and makes it insignificant with or without clustered standard errors (Columns (3) and (4)), suggesting the upward bias in OLS estimate. While IV regressions lead to higher estimated coefficients in the top panel, these coefficients are not statistically significant (Columns (5) and (6)). In fact, none of the IV estimates in Table 9 are significantly different from zero and many of them are, in fact, negative.

Using Heckman ML estimation technique to control for the selection bias, we find that the contribution of this bias is basically zero. We only conduct this analysis for the effects of FDI presence in the same industry as the bias does not arise when measuring the effects of FDI presence in upstream or downstream industries. Comparing Columns (7) and (4), since our Heckman estimation includes industry and city fixed effects, we do not find any effect of the selection bias — in fact, the coefficients are very close to the FE estimation and are not higher than the FE coefficients, as correcting selection bias would imply.[18]

We also use labor productivity instead of TFP as a measure of firm performance and obtain very similar results, as shown in Table 10. The only significant estimate from the IV regressions is in the top panel, Row

[18]The only exception is the coefficient in Row 8 which is higher in Column 7 than it is in Column 4, but the difference is statistically insignificant and small.

9, Column 6.

We estimate the same set of regressions with each of our three alternative measures of FDI presence described above: FDI-majority, FDI-non GCA, and FDI-domestic sales. The results of these regressions are not reported in the interest of space, but are available from the authors upon requests. Our findings are essentially the same as in Tables 9 and 10, with two exceptions. First, when FDI-majority measures are used, we find positive horizontal spillovers on the service sector TFP and labor productivity, although the coefficients are not statistically significant in any of the IV regressions. When FDI-non GCA measures are used, however, these coefficients become negative. Second, when FDI-domestic sales measures are used, we find positive and significant horizontal spillover effects on TFP and labor productivity in OLS and FE regressions. However, only 4 out of 18 coefficients are significant when we include fixed effects and cluster standard errors on city–industry. Moreover, vertical spillover effects are negative and significant in this specification. As before, none of the coefficients are significant when IV approach is adopted.

Next, we estimated all of the above regressions using logs of dependent variables (FDI presence) instead of levels. Our results remain basically the same, except more coefficients are now positive and significant in OLS specification. However, the significance goes away and the coefficients become smaller when fixed effects are included and standard errors are clustered. Again, none of the coefficients are significant when we control for endogeneity of FDI presence using IV approach.

An additional dimension of FDI spillover effects on Chinese domestic firms studied in the literature is the impact of domestic firms' ownership structure.[19] Taking into account of the ownership type, however, does not change the main results obtained for our sample. As shown in Rows (4)-(6) in Table 9 and Table 10, we find no significant differences in how FDI presence affects the TFP or labor productivity of domestic firms of different ownership types. In contrast, the ownership structure of domestic firms does affect how FDI presence impacts their innovative behaviors, which is the focus of our discussion in the next section.

In summary, we do not find evidence of positive or negative FDI spillover effects on domestic firms' TFP or labor productivity. We also find that some of the positive results obtained in previous studies also hold in our sample when the empirical model is mis-specified. Once we control for endogeneity, however, we fail to find the evidence of FDI spillovers on domestic firms' productivity.

[19]See, for instance, Buckley, Clegg, and Wang (2002), Hu and Jefferson (2002), and Li, Liu, and Parker (2001).

5 Ownership and FDI effects on innovation

To measure firm innovation, we use three sets of variables: variables related to patents, new product development, and R&D. Specifically, we study how FDI presence affects the following innovative behaviors of a domestic firm: whether the firm owned a patent, how many patent applications the firm filed, whether the firm developed a new product, what percentage of sales revenue was allocated to R&D expenditure in the firm, and what percentage of employees worked in R&D. To investigate the effect of firm ownership on FDI spillover, we estimate Equation (2) using the full sample of domestic firms, adding the firm's private share and its interaction with FDI presence to the list of explanatory variables.

Columns (2)-(6) in Table 11 give the estimation results, where the Probit model is used in Columns (2) and (4) whereas the Tobit model is used in Columns (3), (5), and (6). Column (1) presents results estimating the production function, producing results similar to those in Rows (4)-(6) in Table 9 and Table 10, where FDI presence has no effect on domestic firms' productivity, regardless of the private share in their ownership. Among the rest of the regressions, FDI has a significant positive effect on the probability of introducing a new product and on the share of workers employed in R&D (Columns (4) and (6)), provided the domestic firm has zero private ownership share (the main effect of FDI presence). However, since the interaction of FDI presence and the private share in this columns has a negative coefficient, we find that private firms do not experience such positive spillovers, as confirmed by the Wald test results reported at the bottom of the Table.[20] In fact, the Wald test shows that the total effect of FDI presence on the probability of owning a patent is negative and significant for a wholly privately owned firm.

Alternatively, we look at different effects of private ownership on firm innovations depending on the level of FDI presence. The row headed by "FDI range" at the bottom of the Table gives the range of FDI share for each estimation such that the following Wald-test has a p-value of less than 0.10: $\hat{\beta}_{\text{private share}} + \hat{\beta}_{FDI*\text{private share}} * FDI\% \leq 0$. We can see from Table 4 that for some of the city–industry cells in our sample, the estimates in Table 11 imply that private ownership share has negative and significant effects on the whether a 100% privately owned firm had a patent and had developed a new product.

As argued previously, results in Table 11 suffer from the endogeneity of FDI presence. We address this issue by instrumenting FDI presence using, as before, average tax rate, $Port * export$, and $Dist * trcost$ as instruments. For the interaction of FDI presence and private share, we use these instruments as well as their interactions with the private share as the instruments. The results from the 2SLS estimation are provided

[20] To look at the total effect of FDI on purely private firms, we conduct the Wald-test of the following hypothesis after each estimation: $\hat{\beta}_{FDI\%} + \hat{\beta}_{FDI\%*\text{private share}} * 100\% = 0$. The p-values of these tests are shown in the row headed by "$Pr((1) + (1) * (2) = 0)$".

in Table 12. Column (1) confirms the insignificant effect of FDI presence on domestic firms' productivity, while Columns (2)-(6) show the different effects of FDI presence on the innovative behaviors of domestic firms with different ownership types.

In every column with results on firm innovations, the interaction between FDI presence and private share has a negative and significant effect, implying that firms with higher private share are less likely to engage in innovations in the presence of FDI. To address the overall effect of FDI presence on purely private firms, we again look at the Wald test results reported at the bottom of the Table. In Columns (2) and (6), the P-value is less than 10%, implying an overall negative and significant effect of FDI on patent possession and R&D employment for purely private domestic firms.

We next look at the effect of private ownership on innovation conditional on the level of FDI. As the row "FDI range" shows, as long as $FDI\% \geq 14\%$, the total effect of an increase in private share is significantly negative for the number of patent applications, the probability of new product development, and the percentage of R&D employment. When $FDI\% \geq 17\%$, the total effect on the probability of owning a patent also becomes significantly negative. As shown in Table 4, these conditions are satisfied in many city–industry cells. In contrast to the positive and significant effects private share has on most firm innovations in the absence of FDI (the main effect of private share in Table 12), these results highlight the detrimental effects of FDI presence on domestic private firms' innovation investment.

The magnitudes of the significant effects are also substantial. With regards to the probability of having a patent, the average is 19% for domestic firms. An increase in FDI from 0 to 14% (the average) leads to 0.8 percentage point increase in the probability of having a patent for an SOE, in contrast to 80 percentage point decrease for a 100% privately owned firm. An increase in the private share from 0 to 100% with 17% FDI presence lowers the probability of having a patent by 29 percentage point. In contrast, the same increase leads to 69 percentage point increase in the absence of FDI presence. Similarly, for the number of patent applications, the average is 0.53 for domestic SOEs and 0.24 for domestic private firms. An increase in FDI from 0 to 14% increases the average number of patent applications for SOEs by 1.4 but lowers that for 100% privately owned firms by 0.60. An increase in private share from 0 to 100% for 14% FDI presence lowers the number of patent applications by 0.72, while the same increase leads to a 1.32 rise in the number in the absence of FDI.

For the probability of introducing a new product, the mean is 34% for domestic SOEs and 26% for domestic private firms. An increase in FDI from 0 to 14% increases the probability of product introduction for SOEs by 20 percentage point and lowers that for private domestic firms by 46 percentage point. With FDI presence of 14%, an increase in private share from 0 to 100% lowers the probability of introducing new product by

27 percentage point; but when FDI is absent, the same change increases the probability by 41 percentage point. Finally, the average R&D employment share is 0.06 for SOEs and 0.07 for private firms. An increase in FDI from 0 to 14% lowers this share for SOEs by 0.13 and for private by 0.23. At the 13% FDI level, an increase in private share from 0 to 100% lowers the R&D employment share by 0.046 (large, given the mean of the variable).

For SOEs, FDI presence has no effects on the patent possession and application or new product development, but has a significant positive effect on the R&D/Sales ratio and a significant negative effect on the percentage of employees working on R&D.[21] In summary, FDI presence has different effects on firm innovations for firms of different ownership types. When FDI presence is high, private firms invest less in innovation.

We believe that there are two explanations for our findings. The first lies in the disadvantages of private firms in China compared to the SOEs. In particular, private firms have less access to credit and basic research compared to the SOEs. Thus, they are more likely to give up innovation when competition from foreign–invested firms in their area is severe or when FDI presence allows them to produce according to foreign firms' specifications, as shown in Hale and Long (2006).

The second potential explanation has to do with the selection bias discussed above. If foreign mergers and acquisitions tend to involve firms that are more innovative, the larger is the share of FDI in a particular city–industry cell, the lower will be the average innovation activity of the firms that remain domestic. Insofar as private firms are more likely to be targets for foreign investment than SOEs, we would see negative association between FDI presence and innovative activity of private firms in the same city–industry cell. To test for this possibility, we re–estimate the regressions in Table 11 using Heckman ML and Heckman–probit ML technique, where in the first stage we include both foreign and domestic firms and estimate the probability of a firm being fully domestic. As instruments for the first stage, we use the same set of variables as we do in the IV regressions. The results are reported in Table 13. Since in this analysis we do not instrument for the FDI presence, the results should be compared with those in Table 11. Unlike in the analysis of productivity spillovers, confirmed again in Column (1), we do find some evidence of the selection bias, which is reflected in now higher coefficients on the interaction term of FDI presence and private share. However, we know that the selection bias is not the whole story since these coefficients, with one exception, remain negative. Moreover, we find that with FDI presence of more than 6%, the number of private firms' patent applications is significantly lower than that of SOEs.

Tables 14 and 15 report the results of the IV regression analysis of the effects of forward and backward FDI

[21]One should be cautious in interpreting the results for the R&D regressions, since the use of assets and labor for technology duplication and reverse engineering are likely to increase due to FDI presence and might be reported by firms as R&D expenses.

presence of firms' innovation activity. Overall, the results reported in these tables are similar to those we found for horizontal spillovers. Namely, FDI presence upstream or downstream lowers innovation activity by private firms. We also find, like for horizontal spillovers, that for city–industry cells with above average FDI presence in upstream or downstream industries (see Table 6), private ownership lowers innovative activity. The fact that the results are similar for both upstream and downstream FDI presence, suggests that both competition and incentive factors that we discuss above are at work. Given that these results are not subject to selection bias, they further confirm that there are negative spillovers of FDI presence on private firms' innovation activity.

6 Conclusion

In this paper we surveyed the existing literature on the productivity spillovers of FDI presence in China and conducted our own analysis of these effects. Our discussion and a large set of empirical results suggest that there is no evidence of positive effects of FDI presence on the productivity of domestic firms in China.

Hale and Long (2006) find that domestic private firms in China are more likely to provide inputs, intermediate goods and services for foreign firms as well as manufacturing final products to the specifications of the foreign firms. Our findings suggest that such backward linkages may reduce incentives for domestic firms to engage in innovations. In other words, with the entry of foreign capital, domestic firms in China, especially private firms, have successfully integrated into the global production chain, but the role played by these Chinese firms is a relatively passive one. To evaluate the total effects of FDI presence on Chinese firms, benefits obtained from such integration in the short run need to be weighed against potential impediment to the long–run growth.

References

Aitken, B., and A. Harrison (1999): "Do Domestic Firms Benefit from Direct Foreign Investment? Evidence from Venezuela," *American Economic Review*, 90(3), 605–618.

Bagchi-Sen, S., and J. Wheeler (1989): "A spatial and temporal model of foreign direct investment in the United States," *Economic Geography*, 65(2), 113–129, population size, population growth, and per capita retail sales.

Blomstrom, M., and R. Lipsey (1991): "Firm size and foreign operations of multinationals," *Scandinavian Journal of Economics*, 93(1), 101–107, domestic market size.

Blonigen, B. A. (2005): "A Review of the Empirical Literature on FDI Determinants," *NBER Working Paper*, 11299.

Buckley, P. J., J. Clegg, and C. Wang (2002): "The impact of inward FDI on the performance of Chinese manufacturing firms," *Journal of International Business Studies*, 33(4), 637–655.

Cameron, C. A., and P. K. Trivedi (1998): *Regression Analysis of Count Data*. Cambridge University Press.

Cheng, L. K., and Y. K. Kwanb (2000): "What are the determinants of the location of foreign direct investment? The Chinese experience," *Journal of International Economics*, 51, 379–400.

Cheung, K.-y., and P. Lin (2004): "Spillover effects of FDI on innovation in China: Evidence from the provincial data," *China Economic Review*, 15(1), 25–44.

Chuang, Y.-C., and P.-F. Hsu (2004): "FDI, trade, and spillover efficiency: evidence from China's manufacturing sector," *Applied Economics*, 36, 1103–1115.

Coughlin, C., J. Terza, and V. Arromdee (1991): "State characteristics and the location of foreign direct investment within the United States," *Review of Economics and Statistics*, 73(4), 675683, tax rate and infrastructure.

de Mooij, R. A., and S. Ederveen (2003): "Taxation and Foreign Direct Investment: A Synthesis of Empirical Research," *International Tax and Public Finance*, 10(6), 673–693, tax rate.

Fosfuri, A., M. Motta, and T. Rønde (2001): "Foreign Direct Investment and Spillovers through Workers Mobility," *Journal of International Economics*, 53(1), 205–222.

Glass, A., and K. Saggi (2002): "Multinational Firms and Technology Transfer," *Scandinavian Journal of Economics*, 104(4), 495–514.

Görg, H., and D. Greenaway (2004): "Much Ado about Nothing? Do Domestic Firms Really Benefit from Foreign Direct Investment?," *World Bank Research Observer*, 19(2), 171–197.

Haaker, M. (1999): "Spillovers from Foreign Direct Investment through Labour Turnover: The Supply of Management Skills," Discussion Paper, London Scool of Economics.

Hale, G., and C. Long (2006): "FDI Spillovers and Firm Ownership in China: Labor Markets and Backward Linkages," *Pacific Basin Working Paper*.

Hallward-Driemeier, M., S. J. Wallsten, and L. C. Xu (2003): "The Investment Climate and the Firm: Firm-Level Evidence from China," World Bank Policy Research Working Paper No. 3003.

Hayashi, F. (2000): *Econometrics*. Princeton University Press, efficiency of GMM compared to 2SLS.

Heckman, J. (1979): "Sample Selection Bias as a Specification Error," *Econometrica*, 47, 153–161.

Hu, A. G., and G. H. Jefferson (2002): "FDI Impact and Spillover: Evidence from China's Electronic and Textile Industries," *The World Economy*, 25, 1063–1076.

Huang, J.-T. (2004): "Spillovers from Taiwan, Hong Kong, and Macau investment and from other foreign investment in Chinese industries," *Contemporary economic policy*, 22(1), 13–25.

Huang, Y. (2003): *Selling China: Foreign direct investment during the reform era*, Cambridge Modern China Series. Cambridge; New York and Melbourne: Cambridge University Press.

Javorcik, B. S. (2004): "Does Foreign Direct Investment Increase the Productivity of Domestic Firms? In Search of Spillovers through Backward Linkages," *American Economic Review*, 93(3), 605–627.

Kaufmann, L. (1997): "A Model of Spillovers trough Labor Recruitment," *International Economic Journal*, 11(3), 13–34.

Kravis, I., and R. Lipsey (1982): "The location of overseas production and production for export by U.S. multinational firms," *Journal of International Economics*, 12(3/4), 201–223, domestic market size.

Li, X., X. Liu, and D. Parker (2001): "Foreign direct investment and productivity spillovers in the Chinese manufacturing sector," *Economic Systems*, 25(4), 305–321.

Liu, X., D. Parker, K. Vaidya, and Y. Wei (2001): "The impact of foreign direct investment on labour productivity in the Chinese electronics industry," *International Business REview*, 10(4), 421–439.

Liu, Z. (2001): "Foreign direct investment and technology spillover: evidence from China," *Journal of Comparative Economics*, 30(3), 579–602.

Ma, A. C. (2006): "Geographical Location of Foreign Direct Investment and Wage Inequality in China," *The World Economy*, 29(8), 1031–1055, access to international market.

Moulton, B. R. (1990): "An Illustration of a Pitfall in Estimating the Effects of Aggregate Variables on Micro Units," *The Review of Economics and Statistics*, 72(2), 334–338.

Rodriguez-Clare, A. (1996): "Multinationals, Linkages, and Economic Development," *American Economic Review*, 86(4), 852–873.

Sun, Q., W. Tong, and Q. Yu (2002): "Determinants of foreign direct investment across China," *Journal of International Money and Finance*, 21, 79–113.

Tong, S. Y., and A. Y. Hu (2003): "Do Domestic Firms Benefit from Foreign Direct Investment? Initial Evidence from Chinese Manufacturing," mimeo, The University of Hong Kong.

Wang, J.-Y., and M. Blomstrom (1992): "Foreign Investment and Technology Transfer: A Simple Model," *European Economic Review*, 36(1), 137–155.

Wei, Y., and X. Liu (2006): "Productivity spillovers from R&D, exports and FDI in China's manufacturing sector," *Journal of International Business Studies*, 37(4), 544–557.

Wooldridge, J. M. (2002): *Econometric Analysis of Cross-Section and Panel Data*. MIT Press.

Xu, B., and J. Lu (2006): "The Impact of Foreign Firms on the Sophistication of Chinese Exports," *China Europe International Business School Working Paper*.

Table 1: FDI spillover effects on TFP, labor productivity, and innovation: literature survey

Reference	Outcome measure	FDI measure	Coefficient[a]	Method	Sample	Domestic firms only?	Potential bias
Provincial level studies							
Liu2002	TFP	overall avg.	-0.149 to 0.462**	weighted RE, FE	1993-98, 29 industries	Yes	Up
	Y/L		0.310 to 0.843**		in Shenzhen		
Huang2004	TFP	province avg.	-0.007 to 0.006**	OLS	1993, 1994, 1997	No	Up
	Y/L		-0.012* to 0.013*		26 provinces		
CL2004	Patents	province avg.	0.01 to 0.48***	OLS, FE, RE	1995-2000, 26 provinces	No	Up
Industry level studies							
Liu2002	TFP	industry avg.	0.02 to 0.04	weighted RE, FE	1993-98, 29 industries	Yes	Up
	Y/L		-0.13 to 0.02		in Shenzhen		
LLP2001	Y/L	industry avg.	0.00** to 0.0001**	3SLS	1995, 182 industries	Yes	Up
LPVW2001	Y/L	industry avg.	0.13** to 0.16**	3SLS	1996-97	No	Up
					41 sub-sectors in electronics		
BCW2002	Y/L	industry avg.	0.044** to 0.098**	OLS	1995, 130 industries	Yes	Up
	high-tech		0.43** to 0.51**				
	new product		0.31** to 0.38**				
	export		0.25** to 0.48***				
Firm level studies							
HJ2002	TFP	industry avg.	-1.36* to -0.27	OLS, FE	1995-1999, 8917 textile firms	Yes	None
					and 2289 electronic firms		
WL2006	TFP	industry-province avg.	0.25*** to 0.30***	FE (not firm)	1998-2001, 7697 firms	Yes	Up
		industry avg.	0.012 to 0.12				
		province avg.	0.48*** to 1.24***				
CH2004	Y/L	industry avg.	0.36 to 0.96**	OLS	1995, 673 ind.–prov. cells	Yes	Up
					aggregated from 455689 firms		

*=significant at 10%, **=significant at 5%, ***=significant at 1%

[a] FDI is measured in percentage, while all other variables are in logs, except in Buckley, Clegg, and Wang (2002) and Liu, Parker, Vaidya, and Wei (2001) where FDI share is also in log, and in Li, Liu, and Parker (2001) where all values are in levels.

Table 2: Distribution of Foreign and Domestic Firms

	All	Foreign	Domestic	Share of foreign
Number of firms	1500	382	1118	0.25
by city:				
1. Beijing	300	75	225	0.25
2. Chengdu	300	32	268	0.11
3. Guangzhou	300	84	216	0.28
4. Shanghai	300	122	178	0.41
5. Tianjin	300	69	231	0.23
by industry:				
1. Accounting etc.	104	11	93	0.11
2. Advertising and marketing	89	15	74	0.17
3. Apparel and leather	222	63	159	0.28
4. Business logistics services	110	22	88	0.2
5. Communication services	71	3	68	0.04
6. Consumer products	165	40	125	0.24
7. Electronic components	203	77	126	0.38
8. Electronic equipment	192	65	127	0.34
9. IT services	128	21	107	0.16
10. Vehicles and parts	216	65	151	0.30

Table 3: Summary statistics of the firm variables

	Foreign			Domestic-SOE			Domestic-Private		
Variable	N.obs.	Mean	S.D.	N.obs.	Mean	S.D.	N.obs.	Mean	S.D.
Log(value added)	311	10.0	1.92	511	8.86	2.05	223	8.72	1.93
Log(Y/L)	311	4.43	1.36	511	3.32	1.39	223	3.65	1.20
Has Patent	382	0.19	0.40	779	0.19	0.39	339	0.19	0.39
# Patent Applications	382	0.68	3.79	779	0.53	3.23	339	0.24	1.29
I(New Products)	382	0.47	0.50	779	0.34	0.48	339	0.26	0.44
R&D/Sales	366	0.15	0.67	697	0.19	1.06	314	0.26	1.01
R&D employment	372	0.05	0.12	742	0.06	0.15	323	0.07	0.17
Log(capital)	382	10.0	2.18	773	8.92	2.58	333	7.95	2.32
Log(labor)	382	5.41	1.46	779	5.17	1.60	339	4.63	1.44
Capital/Labor	382	4.60	1.41	773	3.74	1.56	333	3.30	1.44
Firm age	382	8.29	8.79	779	17.2	18.1	338	6.45	7.33
Firm scale	381	2.36	11.4	775	0.60	3.44	335	0.38	1.34
Degree of competition	352	0.71	4.42	718	0.96	5.38	314	1.42	5.68
CEO-college	382	0.91	0.29	779	0.83	0.37	339	0.79	0.41
CEO-grad. degree	382	0.23	0.42	779	0.15	0.36	339	0.15	0.36
Favorable regulations	382	0.20	0.40	779	0.10	0.30	339	0.14	0.35
Average education	320	13.3	1.36	588	12.9	1.40	235	13.1	1.45
Average age	320	33.8	6.11	589	37.0	6.07	233	32.9	6.77
Private share	382	0.59	0.30	779	0.07	0.17	339	0.99	0.03

Table 4: Foreign share by city and industry sector

Industry, city	Beijing	Chengdu	Guangzhou	Shanghai	Tianjin	Overall
Accounting and related services	0.182	0.000	0.007	0.030	0.019	0.052
Advertising and marketing	0.037	0.010	0.014	0.098	0.193	0.075
Apparel and leather goods	0.169	0.010	0.207	0.178	0.278	0.167
Business logistics services	0.006	0.000	0.062	0.041	0.041	0.031
Communication services	0.000	0.010	0.000	0.003	0.002	0.004
Consumer products	0.099	0.065	0.113	0.156	0.310	0.153
Electronic components	0.165	0.029	0.219	0.306	0.473	0.239
Electronic equipment	0.244	0.018	0.108	0.360	0.262	0.202
Information technology services	0.076	0.047	0.029	0.332	0.006	0.084
Vehicles and vehicle parts	0.113	0.093	0.135	0.255	0.121	0.141
Overall	0.083	0.038	0.15	0.20	0.21	0.138

Table 5: Input-output table for industries in our sample

Input industry, output industry	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) Apparel & leather	0.783	0.062	0.062	0.062	0.062	0.036	0.019	0.056	0.056	0.056
(2) Consumer products	0.139	0.786	0.786	0.786	0.786	0.372	0.114	0.230	0.230	0.230
(3) Electronic components	0.139	0.786	0.786	0.786	0.786	0.372	0.114	0.230	0.230	0.230
(4) Electronic equipment	0.139	0.786	0.786	0.786	0.786	0.372	0.114	0.230	0.230	0.230
(5) Vehicle & vehicle parts	0.139	0.786	0.786	0.786	0.786	0.372	0.114	0.230	0.230	0.230
(6) Business logistics	0.064	0.090	0.090	0.090	0.090	0.080	0.051	0.131	0.131	0.131
(7) Accounting	0.037	0.051	0.051	0.051	0.051	0.038	0.062	0.041	0.041	0.041
(8) Advertising & marketing	0.011	0.012	0.012	0.012	0.012	0.014	0.008	0.036	0.036	0.036
(9) Information technology services	0.011	0.012	0.012	0.012	0.012	0.014	0.008	0.036	0.036	0.036
(10) Communications services	0.011	0.012	0.012	0.012	0.012	0.014	0.008	0.036	0.036	0.036

Source: Adapted from 2000 Input-Output Table for China

Table 6: Upstream and downstream FDI presence by city and industry

FDI presence upstream

Industry, city	Beijing	Chengdu	Guangzhou	Shanghai	Tianjin	Overall
accounting and related services	0.071	0.026	0.111	0.163	0.090	0.091
advertising and marketing	0.157	0.052	0.233	0.338	0.193	0.192
apparel and leather goods	0.088	0.031	0.131	0.196	0.108	0.108
business logistics services	0.200	0.082	0.332	0.509	0.263	0.280
communication services	0.163	0.052	0.236	0.342	0.195	0.204
consumer products	0.365	0.142	0.615	0.889	0.450	0.511
electronic components	0.323	0.144	0.448	0.761	0.365	0.406
electronic equipment	0.283	0.126	0.540	0.753	0.400	0.428
information technology services	0.158	0.051	0.233	0.332	0.195	0.191
vehicles and vehicle parts	0.344	0.104	0.549	0.839	0.505	0.461
Overall	0.226	0.088	0.375	0.571	0.304	0.313

FDI presence downstream

Industry, city	Beijing	Chengdu	Guangzhou	Shanghai	Tianjin	Overall
accounting and related services	0.051	0.014	0.065	0.094	0.054	0.055
advertising and marketing	0.017	0.005	0.018	0.030	0.015	0.017
apparel and leather goods	0.056	0.017	0.067	0.109	0.056	0.060
business logistics services	0.105	0.028	0.116	0.185	0.096	0.107
communication services	0.023	0.004	0.021	0.034	0.017	0.020
consumer products	0.503	0.155	0.706	1.013	0.545	0.600
electronic components	0.460	0.157	0.539	0.885	0.460	0.499
electronic equipment	0.421	0.139	0.632	0.877	0.496	0.523
information technology services	0.018	0.003	0.018	0.024	0.018	0.016
vehicles and vehicle parts	0.481	0.118	0.640	0.963	0.600	0.553
Overall	0.254	0.079	0.350	0.537	0.299	0.304

Table 7: Summary of cell-level instrumental variables

Average tax rate

Industry, city	Beijing	Chengdu	Guangzhou	Shanghai	Tianjin	Overall
accounting and related services	1.42	7.64	0.70	0.71	7.40	3.68
advertising and marketing	0.46	3.75	0.95	0.88	0.47	1.32
apparel and leather goods	0.29	1.21	0.63	0.15	0.48	0.56
business logistics services	0.69	3.96	0.25	0.38	2.50	1.41
communication services	0.04	3.41	0.03	0.27	0.03	0.91
consumer products	0.21	0.74	0.07	0.06	0.26	0.27
electronic components	0.12	0.60	0.74	0.35	0.75	0.51
electronic equipment	0.28	1.46	0.39	0.03	0.15	0.44
information technology services	0.68	2.18	0.48	0.18	1.63	1.05
vehicles and vehicle parts	0.19	0.48	0.21	0.20	0.61	0.35
Overall	0.40	1.97	0.43	0.27	1.22	0.86

Port*export

Industry, city	Beijing	Chengdu	Guangzhou	Shanghai	Tianjin	Overall
accounting and related services	0.00	0.00	1.31	2.25	0.69	0.81
advertising and marketing	0.00	0.00	1.53	2.63	0.81	0.95
apparel and leather goods	0.00	0.00	74.13	127.54	39.24	45.76
business logistics services	0.00	0.00	8.65	14.89	4.58	5.74
communication services	0.00	0.00	0.00	0.00	0.00	0.00
consumer products	0.00	0.00	42.86	73.75	22.69	31.26
electronic components	0.00	0.00	78.38	134.87	41.50	50.02
electronic equipment	0.00	0.00	50.29	86.53	26.63	33.50
information technology services	0.00	0.00	9.56	16.45	5.06	5.96
vehicles and vehicle parts	0.00	0.00	49.11	84.50	26.00	30.73
Overall	0.00	0.00	41.78	70.04	21.86	26.74

Dist*tr.cost

Industry, city	Beijing	Chengdu	Guangzhou	Shanghai	Tianjin	Overall
accounting and related services	0.004	0.001	0.001	0.004	0.004	0.003
advertising and marketing	0.050	0.011	0.009	0.043	0.052	0.035
apparel and leather goods	0.116	0.026	0.021	0.100	0.121	0.076
business logistics services	0.272	0.060	0.050	0.236	0.284	0.170
communication services	0.079	0.018	0.014	0.069	0.083	0.051
consumer products	0.048	0.011	0.009	0.042	0.051	0.031
electronic components	0.104	0.023	0.019	0.090	0.108	0.070
electronic equipment	0.050	0.011	0.009	0.043	0.052	0.033
information technology services	0.055	0.012	0.010	0.048	0.058	0.036
vehicles and vehicle parts	0.082	0.018	0.015	0.071	0.085	0.055
Overall	0.088	0.019	0.017	0.073	0.086	0.057

Table 8: Comparison of Foreign and Domestic Firms' TFP

	Foreign	Domestic	Difference
TFP1	0.32	-0.22	0.54***
	(311)	(730)	(7.32)
TFP2	0.14	-0.16	0.30***
	(311)	(722)	(4.48)
TFP3	0.10	-0.13	0.23**
	(189)	(423)	(2.52)

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 9: FDI spillover effects on TFP in our sample

Controls	Sample	OLS (1)	OLS+cluster (2)	FE (3)	FE+cluster (4)	IV-2SLS[a] (5)	IV-GMM[a] (6)	Heckman[a] (7)
β coefficient on FDI presence								
1. TFP controls	Full	0.10	0.10	-0.16	-0.16	2.03	2.27	-0.18
2. TFP controls, X	Full	0.20	0.20	0.06	0.06	1.97	1.94	0.04
3. TFP controls, E	Full	1.01**	1.01	0.36	0.36	1.76	1.80	0.36
4. TFP controls, PR	Full	0.14	0.14	-0.19	-0.19	1.88	2.12	-0.21
5. TFP controls	Private	0.24	0.24	1.70	1.70	-0.35	-0.20[b]	1.68
6. TFP controls	SOE	0.03	0.03	-0.82	-0.82	4.17	4.16	N.A.
7. TFP controls	Manuf.	-0.10	-0.10	-0.42	-0.42	1.90	1.70	-0.44
8. TFP controls	Service	3.35*	3.35	2.35	2.35	-22.92	-22.92	2.79
9. Interacted TFP	Full	N.A.	N.A.	-0.38	-0.38	-4.28	-4.17[c]	-0.43
β coefficient on upstream FDI presence								
1. TFP controls	Full	0.05	0.05	-0.20	-0.20	0.40	0.66	
2. TFP controls, X	Full	0.06	0.06	-0.41	-0.41	-0.22	-0.04	
3. TFP controls, E	Full	0.43**	0.43	-0.06	-0.06	-0.39	-0.13	
4. TFP controls, PR	Full	0.08	0.08	-0.30	-0.30	0.39	0.62	
5. TFP controls	Private	0.04	0.04	-0.23	-0.23	-1.15	0.17[b]	
6. TFP controls	SOE	0.03	0.03	-0.28	-0.28	0.37	0.73	
7. TFP controls	Manuf.	0.02	0.02	-0.39	-0.39	-0.84	-0.71	
8. TFP controls	Service	-0.53	-0.53	0.39	0.39	-4.97	-5.35	
9. Interacted TFP	Full	N.A.	N.A.	0.04	0.04	0.45	0.25[c]	
β coefficient on downstream FDI presence								
1. TFP controls	Full	0.04	0.04	-0.13	-0.13	0.56	0.66	
2. TFP controls, X	Full	0.06	0.06	-0.28	-0.28	0.13	0.21	
3. TFP controls, E	Full	0.38**	0.38	-0.01	-0.01	-0.28	-0.09	
4. TFP controls, PR	Full	0.06	0.06	-0.20	-0.20	0.53	0.62	
5. TFP controls	Private	0.00	0.00	0.07	0.07	-1.20	0.18[b]	
6. TFP controls	SOE	0.03	0.03	-0.23	-0.23	0.73	0.82	
7. TFP controls	Manuf.	0.05	0.05	-0.41	-0.41	-0.65	-0.56	
8. TFP controls	Service	-4.92	-4.92	1.47	1.47	-0.23	117.77	
9. Interacted TFP	Full	N.A.	N.A.	-0.08	-0.08	-0.13	-0.21[c]	

Dependent variable in all regressions is log(Value added)
TFP controls = log(Capital), log(Labor), Firm age, Firm scale, Degree of competition
X = I(CEO has college education), I(CEO has graduate degree), I(Good regulatory environment)
E = Average education, Average age, Average age^2 of technical and management personnel
PR = share of private ownership of the firm
Interacted TFP = each of the TFP variables interacted with 10 industry dummy variables
Instruments: Average tax rate in city–industry cell, port*export share in industry,
proximity to major cities*avg. transportation costs in industry
*=significant at 10%, **=significant at 5%, ***=significant at 1%
[a] include industry and city effects and standard errors clustered on city-industry
[b] No industry or city effects due to insufficient number of observations
[c] Robust standard errors, not clustered on city–industry cell, due to insufficient degrees of freedom

Table 10: FDI spillover effects on labor productivity in our sample

Controls	Sample	OLS (1)	OLS+cluster (2)	FE (3)	FE+cluster (4)	IV-2SLS[a] (5)	IV-GMM[a] (6)	Heckman[a] (7)
β coefficient on FDI presence								
1. TFP controls	Full	0.18	0.18	0.49	0.49	-0.77	0.33	0.46
2. TFP controls, X	Full	0.41	0.41	0.88	0.88	-0.54	0.08	0.85
3. TFP controls, E	Full	1.26**	1.26	1.18	1.18	-2.32	-0.53	1.17
4. TFP controls, PR	Full	0.24	0.24	0.46	0.46	-0.95	0.00	0.43
5. TFP controls	Private	0.41	0.41	2.51	2.51	1.97	0.11[b]	2.52
6. TFP controls	SOE	0.08	0.08	-0.20	-0.20	-0.01	1.58	N.A.
7. TFP controls	Manuf.	-1.26**	-1.26	0.28	0.28	-5.57	-5.88	0.28
8. TFP controls	Service	3.78	3.78	3.61	3.61	-26.59	-26.59	4.28
9. Interacted TFP	Full	N.A.	N.A.	0.31	0.31	-6.79	-6.76*[c]	0.28
β coefficient on upstream FDI presence								
1. TFP controls	Full	-0.14	-0.14	0.75	0.75	0.93	0.66	
2. TFP controls, X	Full	-0.07	-0.07	0.28	0.28	-0.37	-0.66	
3. TFP controls, E	Full	0.37	0.37	1.00	1.00*	1.99	1.99	
4. TFP controls, PR	Full	-0.10	-0.10	0.64	0.64	0.91	0.65	
5. TFP controls	Private	-0.76*	-0.76	-0.02	-0.02	-2.57	0.48[b]	
6. TFP controls	SOE	0.06	0.06	0.96	0.96*	0.27	0.29	
7. TFP controls	Manuf.	-0.69***	-0.69*	0.57	0.57	1.07	1.17	
8. TFP controls	Service	0.43	0.43	11.58*	11.58	6.00	4.85	
9. Interacted TFP	Full	N.A.	N.A.	0.45	0.45	0.98	0.85[c]	
β coefficient on downstream FDI presence								
1. TFP controls	Full	0.10	0.10	0.47	0.47	0.68	0.58	
2. TFP controls, X	Full	0.15	0.15	0.15	0.15	-0.22	-0.38	
3. TFP controls, E	Full	0.49**	0.49	0.82	0.82*	1.56	1.61	
4. TFP controls, PR	Full	0.12	0.12	0.40	0.40	0.62	0.52	
5. TFP controls	Private	-0.30	-0.30	0.21	0.21	-2.13	0.72[b]	
6. TFP controls	SOE	0.19	0.19	0.57	0.57	0.25	0.34	
7. TFP controls	Manuf.	-0.49**	-0.49	0.49	0.49	0.82	0.90	
8. TFP controls	Service	4.06	4.06	14.93	14.93	14.43	127.31	
9. Interacted TFP	Full	N.A.	N.A.	0.27	0.27	0.14	-0.04[c]	

Dependent variable in all regressions is log(Value added/labor)
Y/L controls = log(Capital/labor), Firm age, Firm scale, Degree of competition
X = I(CEO has college education), I(CEO has graduate degree), I(Good regulatory environment)
E = Average education, Average age, Average age^2 of technical and management personnel
PR = share of private ownership of the firm
Interacted Y/L = each of the Y/L variables interacted with 10 industry dummy variables
Instruments: Average tax rate in city–industry cell, port*export share in industry,
proximity to major cities*avg. transportation costs in industry
*=significant at 10%, **=significant at 5%, ***=significant at 1%
[a] include industry and city effects and standard errors clustered on city-industry
[b] No industry or city effects due to insufficient number of observations
[c] Robust standard errors, not clustered on country, due to insufficient degrees of freedom
[d] Two–step rather than ML Heckman estimation

Table 11: Effects of ownership and FDI on domestic firms innovation

LHS variable	Value added	I(Patent)	# Patent app.	I(New products)	R&D/Sales	R&D empl.
Model	FE	Probit	Neg.bin.	Probit	Tobit	Tobit
	(1)	(2)	(3)	(4)	(5)	(6)
FDI presence (1)	0.116	-0.229	-0.879	1.406**	1.997	0.301*
	(0.11)	(0.33)	(0.31)	(2.08)	(1.17)	(1.90)
Private share (2)	0.178	0.475**	0.127	0.081	0.623*	0.003
	(0.69)	(2.03)	(0.22)	(0.50)	(1.75)	(0.08)
(1)*(2)	1.118	-3.828**	-3.863	-1.801	-2.955	-0.257
	(0.82)	(2.40)	(0.90)	(1.51)	(1.23)	(1.12)
Log(capital)	0.262***					
	(7.41)					
Log(labor)	0.513***					
	(8.08)					
Capital/labor		0.054	-0.119	0.076**	-0.008	-0.001
		(1.31)	(1.10)	(2.01)	(0.11)	(0.17)
Firm age	-0.004	0.002	0.009	0.008*	0.010	0.001
	(1.30)	(0.51)	(1.11)	(1.83)	(1.46)	(0.79)
Firm scale	0.136***	0.046**	0.259**	0.013	0.062*	0.006*
	(3.94)	(2.41)	(2.57)	(0.92)	(1.80)	(1.89)
Degree of comp.	-0.025**	-0.012	0.011	-0.013	0.005	0.000
	(2.40)	(0.70)	(0.70)	(1.14)	(0.23)	(0.12)
CEO-college	0.161	0.005	-0.841	-0.047	0.500	-0.014
	(1.21)	(0.03)	(1.23)	(0.34)	(1.42)	(0.44)
CEO-graduate	0.066	0.306*	1.277***	0.025	0.230	0.055**
	(0.49)	(1.77)	(3.06)	(0.17)	(0.94)	(2.23)
Average education	0.163***	0.135**	0.278**	0.145***	0.133	0.044***
	(3.84)	(2.21)	(2.22)	(3.26)	(1.56)	(5.05)
Average age	-0.019	-0.008	0.074	-0.076	-0.049	-0.018
	(0.30)	(0.08)	(0.25)	(1.16)	(0.32)	(1.33)
Average age^2	-0.000	-0.000	-0.002	0.001	0.000	0.000
	(0.25)	(0.03)	(0.56)	(0.95)	(0.08)	(1.04)
Pr((1)+(1)*(2)=0)	0.34	0.019	0.23	0.74	0.67	0.84
FDI range[a]	None	$\geq$ 24%	None	$\geq$18%	None	None
Constant	2.046	-3.329*	-4.560	-1.649	-4.009	-0.276
N.observations	563	730	748	748	691	718
N.obs. (LHS≠0)		182	90	309	228	348

Robust t statistics in parentheses. Errors are clustered on city–industry cell in (1)-(4).
* significant at 10%; ** significant at 5%; *** significant at 1%
[a] range for FDI share such that $Pr((2) + (1) * (2) * \text{FDI\%} \leq 0) < 0.10$

Table 12: Effects of ownership and FDI on domestic firms innovation (IV estimation)

LHS variable	Value added	I(Patent)	# Patent app.	I(New products)	R&D/Sales	R&D empl.
Model	2SLS/GMM	IVprobit[a]	IVtobit	IVprobit	IVtobit	IVtobit
	(1)	(2)	(3)	(4)	(5)	(6)
FDI presence (1)	4.412	0.114	9.611	1.397	10.816**	-0.924*
	(1.18)	(0.04)	(1.20)	(0.55)	(2.01)	(1.84)
Private share (2)	0.259	0.690**	1.333**	0.407*	1.108**	0.053
	(1.18)	(2.50)	(2.05)	(1.75)	(2.46)	(1.15)
(1)*(2)	0.583	-5.798***	-14.770***	-4.825***	-7.395**	-0.759**
	(0.43)	(2.84)	(2.86)	(2.83)	(2.10)	(2.26)
Log(capital)	0.272***					
	(6.76)					
Log(labor)	0.479***					
	(7.18)					
Capital/labor		0.060	0.099	0.079**	0.002	-0.001
		(1.54)	(0.92)	(1.97)	(0.02)	(0.18)
Firm age	-0.006*	0.002	-0.009	0.007**	0.010	0.000
	(1.71)	(0.47)	(0.90)	(2.07)	(1.37)	(0.60)
Firm scale	0.149***	0.040***	0.107***	0.013	0.064*	0.004
	(4.65)	(2.63)	(2.79)	(0.77)	(1.80)	(1.36)
Degree of comp.	-0.016	-0.014	0.003	-0.017	0.012	-0.002
	(1.41)	(1.07)	(0.10)	(1.19)	(0.52)	(0.90)
CEO-college	0.231*	0.110	-0.138	-0.042	0.566	-0.021
	(1.76)	(0.72)	(0.28)	(0.26)	(1.57)	(0.61)
CEO-grauate	0.101	0.403***	0.927***	0.013	0.262	0.044
	(0.71)	(2.90)	(2.69)	(0.09)	(1.03)	(1.64)
Average education	0.162***		0.359***	0.152***	0.124	0.045***
	(4.54)		(2.73)	(3.39)	(1.41)	(4.92)
Average age	0.055		-0.079	-0.101	-0.033	-0.032**
	(0.69)		(0.34)	(1.31)	(0.20)	(2.09)
Average age^2	-0.001		0.000	0.001	-0.000	0.000*
	(1.07)		(0.06)	(1.12)	(0.02)	(1.81)
Pr((1)+(1)*(2)=0)	0.16	0.060	0.63	0.25	0.48	0.002
FDI range[b]	None	≥17%	≥14%	≥14%	≥35%	≥13%
Constant	-0.006	-2.314***	-6.183	-1.354	-4.735	-0.001
N.observations	563	1012	748	748	691	718
N.obs. (LHS≠0)		200	90	309	228	348

Robust z statistics in parentheses. Errors are clustered on city–industry cell in (1).
* significant at 10%; ** significant at 5%; *** significant at 1%
[a] We have to exclude average education and average age from this regression because the smaller sample would not converge (due to insufficient number of firms that possess patents).
[b] range for FDI share such that $Pr((2) + (1) * (2) * \text{FDI\%} \leq 0) < 0.10$

Table 13: Effects of ownership and FDI on domestic firms innovation (Heckman estimation)

LHS variable	Value added	I(Patent)	# Patent app.	I(New products)	R&D/Sales	R&D empl.
Model	ML	Heck-Prob	Two-step	Heck-Prob	Two-step	ML
	(1)	(2)	(3)	(4)	(5)	(6)
FDI presence (1)	0.116	-0.135	-0.445	1.524***	0.415	0.203
	(0.11)	(0.18)	(0.22)	(2.73)	(0.63)	(1.48)
Private share (2)	0.178	0.448*	-0.305	-0.005	0.247*	-0.004
	(0.70)	(1.85)	(0.65)	(0.04)	(1.66)	(0.18)
(1)*(2)	1.132	-2.664	-5.624	1.799***	-1.508	-0.057
	(0.79)	(0.86)	(1.27)	(2.74)	(1.07)	(0.41)
Log(capital)	0.263***					
	(6.90)					
Log(labor)	0.512***					
	(7.71)					
Capital/labor		0.093	-0.058	0.164***	-0.049	-0.001
		(1.22)	(0.38)	(6.29)	(0.93)	(0.12)
Firm age	-0.004	-0.001	0.004	0.000	0.004	-0.000
	(1.28)	(0.11)	(0.35)	(0.07)	(0.99)	(1.50)
Firm scale	0.136***	0.046**	0.147***	0.012	0.000	0.002
	(4.01)	(2.36)	(3.72)	(0.77)	(0.03)	(1.32)
Degree of comp.	-0.025**	-0.012	-0.005	-0.010	-0.007	-0.000
	(2.47)	(0.73)	(0.17)	(0.91)	(0.79)	(0.01)
CEO-college	0.161	0.022	-0.424	0.033	0.037	-0.007
	(1.24)	(0.14)	(1.06)	(0.26)	(0.29)	(0.43)
CEO-grauate	0.066	0.312*	0.909***	0.107	-0.024	0.028**
	(0.50)	(1.77)	(2.64)	(1.14)	(0.22)	(2.39)
Average education	0.163***	0.140**	0.072	0.134***	-0.019	0.022***
	(3.83)	(2.31)	(0.66)	(3.97)	(0.56)	(3.88)
Average age	-0.019	0.013	-0.241	0.009	-0.083	-0.006
	(0.31)	(0.11)	(1.29)	(0.13)	(1.40)	(0.76)
Average age^2	-0.000	-0.000	0.002	-0.000	0.001	0.000
	(0.26)	(0.21)	(0.98)	(0.34)	(1.33)	(0.51)
Pr((1)+(1)*(2)=0)	0.40	0.37	0.15	0.00	0.50	0.49
FDI range[a]	None	None	≥6%	None	None	None
Constant	2.040	-3.774*	5.154	-3.003**	1.668	-0.048
Observations	859	1044	1044	1044	987	1014
Uncensored obs.	563	748	748	748	691	718

Robust z statistics in parentheses. Errors are clustered on city–industry cell in (1), (2), (4), (6).
* significant at 10%; ** significant at 5%; ***significant at 1%
[a] range for FDI share such that $Pr((2) + (1) * (2) * \text{FDI\%} \leq 0) < 0.10$

Table 14: Effects of ownership and upstream FDI on domestic firms innovation (IV estimation)

LHS variable Model	Value added 2SLS/GMM (1)	I(Patent) IVprobit[a] (2)	# Patent app. IVtobit (3)	I(New products) IVprobit (4)	R&D/Sales IVtobit (5)	R&D empl. IVtobit (6)
FDI presence (1)	-0.055	-2.720	-3.895	-1.909	3.646	-1.190***
	(0.05)	(0.73)	(0.57)	(0.86)	(0.87)	(2.75)
Private share (2)	0.180	1.005***	2.220**	0.657**	1.048*	0.137**
	(0.71)	(2.74)	(2.47)	(2.17)	(1.85)	(2.37)
(1)*(2)	0.392	-3.403***	-8.632***	-2.639***	-2.758	-0.482***
	(0.58)	(2.86)	(3.00)	(2.88)	(1.52)	(2.81)
Log(capital)	0.281***					
	(7.38)					
Log(labor)	0.500***					
	(7.90)					
Capital/labor		0.042	0.056	0.068*	-0.024	-0.001
		(1.03)	(0.50)	(1.68)	(0.32)	(0.11)
Firm age	-0.007*	0.001	-0.008	0.007*	0.014*	-0.000
	(1.89)	(0.23)	(0.67)	(1.81)	(1.81)	(0.16)
Firm scale	0.141***	0.044***	0.107***	0.013	0.060*	0.005
	(4.36)	(2.73)	(2.66)	(0.79)	(1.74)	(1.46)
Degree of comp.	-0.022**	-0.008	0.003	-0.013	0.007	0.000
	(2.03)	(0.62)	(0.10)	(0.93)	(0.36)	(0.02)
CEO-college	0.183	0.162	-0.125	0.000	0.444	0.009
	(1.43)	(1.02)	(0.24)	(0.00)	(1.25)	(0.25)
CEO-grauate	0.065	0.446***	1.014***	0.048	0.232	0.057**
	(0.47)	(2.98)	(2.82)	(0.34)	(0.95)	(2.08)
Average education	0.163***		0.323**	0.142***	0.131	0.043***
	(4.59)		(2.36)	(3.09)	(1.53)	(4.56)
Average age	-0.004		0.013	-0.075	-0.061	-0.011
	(0.05)		(0.05)	(0.97)	(0.38)	(0.70)
Average age^2	-0.000		-0.001	0.001	0.000	0.000
	(0.39)		(0.35)	(0.77)	(0.14)	(0.42)
Pr((1)+(1)*(2)=0)	0.81	0.125	0.116	0.072	0.86	0.001
FDI range[b]	None	≥39%	≥34%	≥35%	None	≥41%
Constant	1.612	-2.464***	-7.202	-1.737	-3.765	-0.406
N.observations	563	1012	748	748	691	718
N.obs. (LHS≠0)		200	90	309	228	348

Robust z statistics in parentheses. Errors are clustered on city–industry cell in (1).
* significant at 10%; ** significant at 5%; *** significant at 1%

[a] We have to exclude average education and average age from this regression because the smaller sample would not converge (due to insufficient number of firms that possess patents).

[b] range for FDI share such that $Pr((2) + (1) * (2) * \text{FDI\%} \leq 0) < 0.10$

Table 15: Effects of ownership and downstream FDI on domestic firms innovation (IV estimation)

LHS variable	Value added	I(Patent)	# Patent app.	I(New products)	R&D/Sales	R&D empl.
Model	2SLS/GMM	IVprobit[a]	IVtobit	IVprobit	IVtobit	IVtobit
	(1)	(2)	(3)	(4)	(5)	(6)
FDI presence (1)	0.213	-0.851	0.475	-0.659	4.011*	-0.736***
	(0.24)	(0.56)	(0.13)	(0.57)	(1.82)	(3.24)
Private share (2)	0.251	0.739***	1.660**	0.533**	0.877*	0.114**
	(1.04)	(2.60)	(2.13)	(1.98)	(1.77)	(2.23)
(1)*(2)	0.168	-2.662***	-6.920***	-2.297***	-2.222	-0.418***
	(0.28)	(2.82)	(2.80)	(2.85)	(1.42)	(2.83)
Log(capital)	0.281***					
	(7.41)					
Log(labor)	0.495***					
	(7.79)					
Capital/labor		0.046	0.057	0.070*	-0.018	-0.001
		(1.16)	(0.52)	(1.74)	(0.24)	(0.15)
Firm age	-0.006*	0.001	-0.006	0.007*	0.015**	-0.000
	(1.77)	(0.29)	(0.52)	(1.90)	(2.00)	(0.11)
Firm scale	0.141***	0.042***	0.105***	0.012	0.061*	0.005
	(4.37)	(2.68)	(2.65)	(0.70)	(1.79)	(1.38)
Degree of comp.	-0.022**	-0.010	-0.004	-0.016	0.007	-0.001
	(2.04)	(0.80)	(0.13)	(1.10)	(0.36)	(0.31)
CEO-college	0.174	0.133	-0.239	-0.024	0.405	0.002
	(1.35)	(0.86)	(0.47)	(0.14)	(1.15)	(0.05)
CEO-grauate	0.063	0.448***	0.987***	0.047	0.226	0.058**
	(0.45)	(3.08)	(2.82)	(0.33)	(0.93)	(2.14)
Average education	0.166***		0.335**	0.142***	0.133	0.043***
	(4.59)		(2.48)	(3.12)	(1.55)	(4.62)
Average age	-0.004		-0.018	-0.082	-0.056	-0.016
	(0.06)		(0.08)	(1.09)	(0.36)	(1.07)
Average age^2	-0.000		-0.001	0.001	0.000	0.000
	(0.38)		(0.22)	(0.89)	(0.10)	(0.80)
Pr((1)+(1)*(2)=0)	0.75	0.054	0.187	0.049	0.53	0.000
FDI range[b]	None	≥39%	≥34%	≥34%	None	≥40%
Constant	1.580	-2.506***	-6.742	-1.680	-3.714	-0.355
N.observations	563	1012	748	748	691	718
N.obs. (LHS≠0)		200	90	309	228	348

Robust z statistics in parentheses. Errors are clustered on city–industry cell in (1).
* significant at 10%; ** significant at 5%; *** significant at 1%
[a] We have to exclude average education and average age from this regression because the smaller sample would not converge (due to insufficient number of firms that possess patents).
[b] range for FDI share such that $Pr((2) + (1) * (2) * \text{FDI\%} \leq 0) < 0.10$