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ARE THERE PRODUCTIVITY SPILLOVERS FROM FOREIGN DIRECT INVESTMENT IN CHINA?

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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 firm-level data set from a World Bank survey. 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 6000 specifications that take into account forward and backward linkages, we fail to find evidence of systematic positive productivity spillovers from FDI in China.

1. INTRODUCTION

China has been extremely successful in attracting foreign direct investment (FDI) since economic reforms were commenced at the end of the 1970s. Figure 1 illustrates the breathtaking speed of FDI growth in China. Annual FDI inflow was below $US100 in 1979, but exceeded $US580bn in 2006, with an annual growth rate of close to 30%. This trend is expected to continue in the foreseeable future, especially given the country's entry into the WTO.[1] The rapid growth in FDI inflow has supported by government policies encouraging FDI, as described in detail in Fung *et al*. (2004) and Hale and Long (2007).[2] Some of these policies have aimed to equalize operating conditions for foreign capital inside and outside China, including those relating to foreign trade and foreign exchange control. Other policies have provided monetary incentives for foreign investors, including preferential treatment in taxation, lease of land and environmental regulations. Although policies that level the playing field for foreign firms operating outside and inside China are necessary to attract capital inflow, policies that result in foreign investors being subsidized through lower tax rates

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[1] Walmsley *et al*. (2006) predict that foreign ownership of China's assets will double by 2020 due to its WTO accession.

[2] See Chow (2006) for an overview of China's opening up policies and their effects in general.

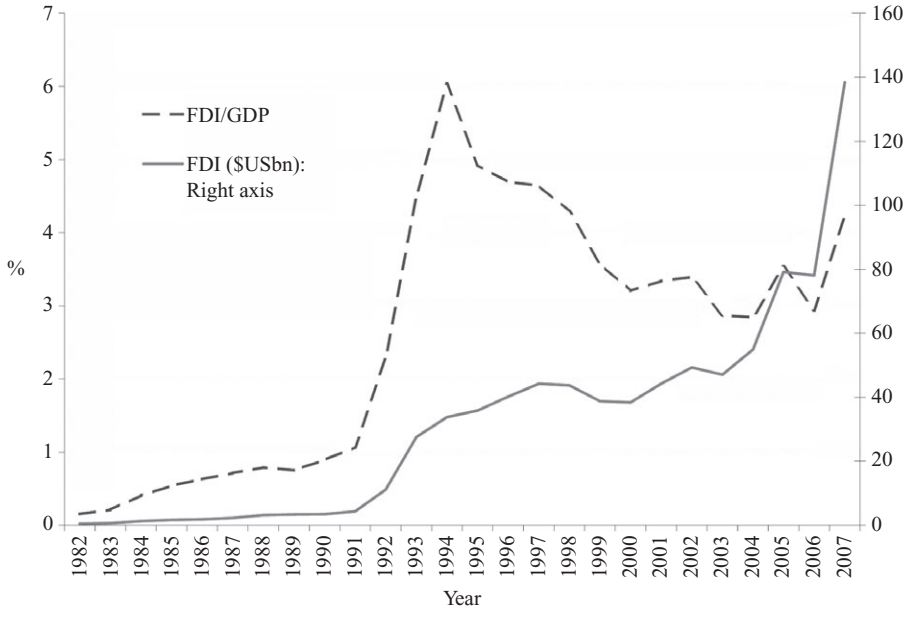

Figure 1. Foreign direct investment (FDI) inflows into China
Source: CEIC China Database, Global Financial Data.

and lenient environmental requirements can only be justified if positive externalities on domestic firms are created with the inflow of FDI (Moran, 2007).

Although the effectiveness of government policies in stimulating growth in FDI are unrefuted, the effects of FDI on domestic firms in China are far from clear. Previous studies of FDI spillover effects on the productivity of Chinese firms have produced mixed results regarding whether domestic firms have benefited from the presence of FDI. With the limited availability of firm-level panel data and the lack of instruments for FDI presence, many positive results obtained by researchers suffer from an upward bias due to aggregation or endogeneity of FDI.

In the present paper, we discuss these and other potential biases that arise in the existing published literature on FDI spillovers in China. We also conduct our own analysis using a data set from a World Bank stratified survey of firms in five cities and 10 industries. Although our data set lacks a time dimension, it contains very rich information on many aspects of firms' conditions and behaviours. Such disaggregated and detailed data enables us to address several potential biases. First, we limit the sample to domestic firms and, therefore, remove the aggregation bias. We find that the aggregation bias is the main driver of the upward biased findings in the current literature. In addition, we apply instrumental variables (IV) analysis to address potential endogeneity of FDI presence, using three variables that do not affect domestic firms' productivity directly. We also control for non-random selection that arises when limiting the sample to

domestic firms and could bias estimates downward. After controlling for these biases, we fail to find any significant FDI spillover effects on total factor productivity (TFP) or labour productivity for domestic firms in the same or in upstream or downstream industries.

We believe that there are two reasons for our failure to find spillover effects. First, as by Liu (2008), short-run spillovers from FDI presence might be limited or even negative as a result of learning, managerial or other expenses associated with technology adoption. Second, there might be institutional factors that explain the lack of productivity spillovers of FDI in China. For instance, many state-owned enterprises (SOE) still face limited competition pressure or do not have sufficient incentives to maximize profit, thus weakening their incentives to adopt new technology and managerial practices that are introduced by nearby foreign firms (Moran, 2007). In addition, wage restrictions on SOE might prevent these firms from obtaining high quality managerial and technical personnel, which might limit their ability to absorb new technology and prevent technology transfer through labour mobility (Hale and Long, 2008). Private firms might have better access to human capital but have limited access to credit and, therefore, might lack the physical and the financial capital necessary to benefit from FDI spillovers.

The present paper relates closely to the published 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 the following ways. 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 include service sector firms in addition to manufacturing firms in the analysis. Third, we use the input–output table for China to study vertical spillover effects of FDI; that is, spillover effects of FDI in upstream and downstream industries, in addition to horizontal spillovers, or spillovers to firms in the same industry. Finally, we examine the impact of ownership structure on the FDI spillover effects on domestic firms.

The structure of the paper is as follows: Section 2 reviews previous published literature on productivity spillovers of FDI in China and identifies potential biases in the estimates. Section 3 describes the data used in the study. Section 4 presents the empirical results and Section 5 concludes.

2. REVIEW OF EMPIRICAL LITERATURE

Theoretical work has generally predicted positive effects of FDI presence on domestic firms' productivity.[3] However, results from empirical studies are

[3] Kaufmann (1997), Haaker (1999), Fosfuri *et al*. (2001) and Glass and Saggi (2002) predict same-industry, or horizontal, spillovers through the labour mobility channel, whereas Wang and Blomstrom (1992) use competition and demonstration effects. In addition, Rodriguez-Clare (1996) outlines forward and backward linkages between foreign firms and domestic firms as a possible mechanism for positive spillovers.

mixed.[4] Furthermore, studies producing supportive evidence of FDI spillovers might overestimate the effects for three reasons, discussed in detail in Hale and Long (2007). First, given that foreign-invested firms are more productive than domestic firms, studies using aggregate data that include foreign firms might exaggerate the positive effects of FDI on domestic firms' productivity (aggregation bias). In addition, studies that include only domestic firms (with firm-level data or aggregate data) might face the endogeneity problem: Because FDI is more likely to go to places with higher domestic productivity to begin with, the positive correlation between FDI and productivity of domestic firms might simply reflect the location decision by foreign investors rather than the positive spillover effects of their investment. Finally, studies using firm-level data might underestimate the standard errors and, therefore, might mistakenly conclude that the estimates are significant even when they are not, unless robust standard errors are computed (clustered at the level of FDI presence).[5]

Similarly, studies on FDI spillover effects in China have obtained a wide range of estimates and some might be subject to the three biases discussed above. Table 1 summarizes studies published on FDI spillover effects in China, comparing the performance measure, the FDI measure, the estimated coefficient, the sample used and the potential bias in the various papers. Taking into consideration the three potential biases outlined above, we argue that although many of the studies included in Table 1 find positive and significant FDI spillovers, most of these studies tend to overestimate the FDI spillover effects on Chinese domestic firms.

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. As shown in Table 1, both studies at the provincial-level (listed in the top panel of the table) (Cheung and Lin, 2004; Huang, 2004) suffer from an upward aggregation bias because they are not able to distinguish domestic firms from foreign-invested firms. This is also the case for one of the industry-level studies (Liu *et al.*, 2001). In addition, one of the industry-level studies (Liu, 2002) underestimates the standard error on the coefficient of interest, when using the average level of FDI for the manufacturing sector in the city of Shenzhen for all 29 industries in the sample (Moulton, 1990).

More importantly, all but two studies included in the table suffer from potential endogeneity bias, where the correlation obtained between the level of FDI

[4] For example, among the 42 studies on intraindustry (horizontal) productivity spillovers of FDI summarized in Gorg and Greenaway (2004), only 20 studies report unambiguously positive and significant results, out of which 14 might be subject to biases that lead to overestimates. The results appear more conclusive for vertical spillovers. Among the 5 studies discussed in Gorg and Greenaway (2004) that focus on vertical FDI spillover effects, 3 find positive backward FDI spillovers and 1 finds positive forward FDI spillovers. In addition, Javorcik (2004) and Blalock and Gertler (2008) find positive vertical FDI spillovers in Latvia and Indonesia, respectively.

[5] Because the measure of FDI presence is, by necessity, an aggregate measure, the standard errors in the firm-level regressions are potentially correlated (Moulton, 1990), causing the standard errors to be underestimated.

Table 1. Foreign direct investment spillover effects on total factor productivity, labour productivity and innovation: Survey of literature on China

Reference (1)	Measure (2)	Aggregation (3)	Coefficient† (4)	Method (5)	Sample (6)	Domestic firms (7)	Bias‡ (8)
Huang (2004)	TFP	Province average	–0.007 to 0.006**	OLS	1993, 1994, 1997	No	A, E
	Y/L		–0.012* to 0.013*		26 provinces		
Cheung and Lin (2004)	Patents	Province average	0.01 to 0.48***	OLS, FE, RE	1995–2000, 26 provinces	No	A, E
Liu (2002)	TFP	Industry average	0.02 to 0.04	Weighted RE, FE	1993–1998, 29 industries in Shenzhen	Yes	E, S
	Y/L		–0.13 to 0.02				
	TFP	Overall average	–0.149 to 0.462**	weighted RE, FE	1993–1998, 29 industries in Shenzhen	Yes	E, M
	Y/L		0.310 to 0.843**				
Li *et al.* (2001)	Y/L	Industry average	0.00** to 0.0001**	3SLS	1995, 182 industries	Yes	E, S
Liu *et al.* (2001)	Y/L	Industry average	0.13** to 0.16**	3SLS	1996–1997, electronics	No	A, E
Buckley *et al.* (2002)	Y/L	Industry average	0.044** to 0.098**	OLS	1995, 130 industries	Yes	E, S
	High-technology		0.43** to 0.51**				
	New product		0.31** to 0.38**				
	Export		0.25** to 0.48***				
Hu and Jefferson (2002)	TFP	Industry average	–1.36* to –0.27	OLS, FE	1995–1999, 8917 textile firms and 2289 electronic firms	Yes	
Wei and Liu (2006)	TFP	Industry–province average	0.25*** to 0.30***	FE (not firm)	1998–2001, 7697 firms	Yes	E, S
		Industry average	0.012 to 0.12				
		Province average	0.48*** to 1.24***				
Chuang and Hsu (2004)	Y/L	Industry average	0.36 to 0.96**	OLS	1995, 455 689 firms	Yes	E, S
Liu (2008)	TFP (in logs)	Industry average	–0.003*** to –0.004	Firm FE	1995–1999, 17 675 manufacturing firms	Yes	

Notes: †Foreign direct investment (FDI) is measured in percentage, while all other variables are in logs, except in Buckley *et al.* (2002) and Liu *et al.* (2001), where FDI share is also in log, and in Li *et al.* (2001) where all values are in levels. ‡Potential bias in the paper: A = upward aggregation bias; E = upward bias due to endogeneity; S = downward selection bias; and M = downward bias in standard errors. ***$P < 0.01$, **$P < 0.05$, *$P < 0.1$. FE, fixed effects; OLS, ordinary least squares; RE, random effects; TFP, total factor productivity; Y/L, output per worker; 2SLS, two-stage least squares; 3SLS, three-stage least squares.

and productivity might merely reflect the location choice of foreign investors.[6] To control for the endogeneity of the level of FDI, one either adopts the IV approach by instrumenting the level of FDI or estimates the firm fixed-effects model using panel data for domestic firms. Several studies use the three-stage least squares model but address the endogeneity of variables other than FDI (Li *et al*., 2001; Liu *et al*., 2001), whereas others use the fixed effects model but not with firm fixed effects (Cheung and Lin, 2004; Liu, 2002; Wei and Liu, 2006). Chuang and Hsu (2004) use a cross-section of half a million firms, limiting their analysis to domestic firms, and aggregate their data to 673 industry–province-level cells. Their analysis is not subject to the aggregation bias discussed above, but the positive effect that they find might reflect the endogeneity bias.

As a result, Hu and Jefferson (2002) and Liu (2008) are the only studies we are aware of that include estimates not subject to the endogeneity problem. They both find negative or no FDI spillover effects. Hu and Jefferson's study includes 8917 domestic textile firms and 2289 domestic electronic firms and finds negative and significant effects of FDI presence on the TFP of domestic electronic firms. However, 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 estimates of FDI spillovers in Hu and Jefferson (2002) do not suffer from the upward biases outlined above. The results from the fixed effects estimation show negative but insignificant FDI spillover effects.

Similarly, Liu (2008) finds negative contemporaneous effects of FDI presence in the same as well as upstream and downstream industries on firms' TFP when controlling for firm fixed effects in a 5-year panel of almost 20 000 industrial firms. In fact, he presents a model for which he argues that such results are to be expected.[7]

In summary, the empirical evidence of FDI spillovers on Chinese domestic firms is mixed, largely because data limitations have hampered the effort to control for the endogenous location of FDI. Therefore, although many of the studies reviewed find positive spillover effects of FDI, the estimates are likely to be biased upward. In fact, the studies that address the endogeneity problem (Hu and Jefferson, 2002; Liu, 2008) do not find positive effects. Therefore, the message that we take from the literature is that the evidence of FDI spillovers on domestic firms' productivity in China is inconclusive, at least in the short run.

In the rest of the paper, we describe our own analysis, which addresses the potential biases in searching for FDI spillover effects using a firm-level data set from a World Bank survey. First, we limit our sample to firms without any foreign partners to eliminate aggregation bias. Second, although we do not have

[6] In fact, studies that analyze the location of FDI in China, including Sun *et al*. (2002) and Cheng and Kwan (2000), tend to find a positive correlation between per capita GDP (positively related to productivity) and FDI. See Gao (2005) for a study that emphasizes the importance of geography and cultural ties in FDI in China.

[7] He further argues that FDI is more likely to have positive long-term effects, an issue that we will not address here, as the focus of the current study is on short-term effects.

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. In addition, we study both manufacturing firms and service firms, and we explore the potential spillover effects of FDI presence in upstream and downstream industries as well as in those the same industry.[8] We now describe the data.

3. DATA

We use data from the Study of Competitiveness, Technology and Firm Linkages conducted by the World Bank in 2001, 8 years after the FDI surge to China began. Although the data lacks a time dimension, it provides detailed information at the firm level, covering a very wide range of issues related to firms and their operation environment. The survey consists of two questionnaires, one filled in by the senior manager of the main production facility of the firm, and the other filled in by the accountant or personnel manager of the firm. The firms were requested to provide information as of year 2000, but for many accounting measures, information from up to 3 previous years was also collected.[9]

The methodology of the survey was stratified random sampling, with the stratification based on subsectors, including accounting and related services, advertising and marketing, apparel and leather goods, business logistics services, communication services, consumer products, electronic equipment and components, information technology, 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.[10] 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. Among the 1500 firms interviewed during the survey, 382 were foreign firms in 2000.

In addition to the comprehensive scope of information collected and the high response rate, our survey data has another advantage. A major concern of researchers studying FDI in China is round-tripping FDI, domestic capital disguised as FDI. Firms are registered at offshore financial centers that have lax controls on capital movements, which then invest in China. In our sample, however, only 3 out of the 381 firms with foreign partners list the British Virgin Islands as the FDI source country and only 1 lists the Cayman Islands. There are two of the most used offshore financial centers for round-tripping FDI. Excluding these 4 firms from our sample does not substantially change the results. In

[8] 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 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, which have been shown to be important for other transition economies (Javorcik, 2004).

[9] For a detailed description of the survey, see Hallward-Driemeier *et al*. (2003).

[10] See Hale and Long (2007) for the city and industry distribution of firms included in the survey.

other words, our data seems to suffer little from the bias associated with round-tripping FDI.[11]

The crucial variable in our study is the measure for FDI presence. Following the published literature (e.g. Aitken and Harrison, 1999), we define and construct the measure of FDI presence in the same city–industry as the average of foreign ownership share in the same city–industry as the domestic firm, weighted by firm employment.[12] Specifically, we use the sample of firms in our World Bank survey data to construct the FDI measure for both manufacturing and service sectors. Because we use the largest foreign partner's share to compute the FDI measure, foreign portfolio investment is not included.[13]

To allow for interindustry FDI spillover effects, we construct an input–output table for industries included in our sample based on the 2000 Input–Output Table for China.[14] Using this table, we compute the upstream FDI presence for firm *j* 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 *j*'s industry. The downstream FDI presence, in contrast, is computed as the sum of FDI presence in all other industries weighted by the output coefficients of firm *j*'s industry to these other industries.[15]

In addition to the FDI measure, we also use a small portion of the survey that gives information on firms' input, output, ownership and other characteristics related to productivity. The following variables from outside of the survey are also used to construct the instruments for FDI presence: the total number of berths located in the city, the distance between the capital city of each province or autonomous region and the cities in our sample, as well as the population of each province.

Table 2 shows summary statistics for the variables used in the analysis and their detailed definitions, with all values referring to year 2000 unless indicated otherwise. For some variables, values are given in Hale and Long (2007). The sample in 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 SOE, while others are listed as private.[16] Table 2 indicates that foreign firms are substantially different from domestic firms in age, scale, capital intensity, employee age and education,

[11] 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 the GCA includes Hong Kong, Macao and Taiwan.

[12] To test the robustness of our finding we also use assets, sales and value-added as weights, as described in Subsection 4.2.

[13] Although the measure might be noisy due to the small sample size, we find it to be highly correlated with the similar measure computed from the China Industrial Survey for only manufacturing firms.

[14] The 2000 Input–Output Table for China was accessed at http://www.stats.gov.cn/tjsj/ndsj/yb2004-c/html/C0322ac.htm on 30 December 2006.

[15] See Hale and Long (2007) for the values for the same-cell, upstream and downstream FDI presence by city and industry sector for the China Industrial Survey and the World Bank survey data, respectively.

[16] This split corresponds most closely to the ownership characterisations provided by the firms.

Table 2. Summary statistics of the firm variables

Variable	Foreign			Domestic-state-owned enterprises			Domestic, private		
	Number of observations.	Mean	Standard deviation	Number of observations	Mean	Standard deviation	Number of observations	Mean	Standard deviation
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
Log(capital)	382	10.0	2.18	773	8.92	2.58	333	7.95	2.32
Log(labour)	382	5.41	1.46	779	5.17	1.60	339	4.63	1.44
Capital/Labour	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
Exporter	382	0.59	0.49	779	0.17	0.38	339	0.29	0.45
CEO: college	382	0.91	0.29	779	0.83	0.37	339	0.79	0.41
CEO: graduate degree	382	0.23	0.42	779	0.15	0.36	339	0.15	0.36
Favourable 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
TFP1	311	0.28	1.00	509	–0.32	1.20	221	0.14	1.10
TFP2	311	0.07	1.17	509	–0.20	1.06	220	0.01	1.04
TFP3	189	0.09	0.92	318	–0.14	1.03	112	0.05	1.19

Notes: CEO, chief executive officer; TFP, total factor productivity.

as well as labour productivity, especially compared to domestic SOE, and that these differences are statistically significant.

Table 2 also shows that foreign-invested firms also have higher TFP than domestic firms, where TFP1 is constructed as the residual from the following regression, conducted separately for each industry:

$$y_{jic} = \beta_0 + \beta_1 l_{jic} + \beta_2 k_{jic} + \varepsilon_{jic}, \quad (1)$$

where y_{jic} is the value-added of firm j in industry i and city c, l_{jic} is the labour input, k_{jic} the capital input of the firm (all in logs) and ε_{jic} is a random error term.

By including additional firm characteristics, we compute two alternative measures of TFP: TFP2 (the TFP measure net of firm age and firm economy of scale) and TFP3 (that net of firm age and firm scale as well as employee average, education, age and age squared). 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 and more educated workers (see Table 2).

Even after controlling for firm vintage, scale, and average employee education and age, foreign firms 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 have positive effects on the productivity of domestic firms located close to the foreign firms (geographically or technologically).[17] Given that the assumption of superior productivity of foreign firms seems justified for our sample, we now turn to testing the hypothesis that these productivity advantages spill over to domestic firms.[18]

4. EMPIRICAL APPROACH AND ESTIMATION RESULTS

We now present the results of our empirical analysis. Although we attempted more than 6000 specifications, we will limit our discussion to just the set of results reported in Table 3 (170 regressions) and then discuss how various permutations affect them. A complete set of regression results is available from the authors upon request.

[17] 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 to enjoy the preferential treatment offered to foreigners. We address this potential concern by using a measure of non-GCA FDI presence.

[18] Note that these results do not necessarily imply that foreign capital increases firm productivity. Because of the 'cherry-picking' nature of FDI, establishing such a causal relationship, which is not a goal of the present paper, would require panel data and more sophisticated analysis. See Arnold and Javorcik (2005) for such a study in the case of Indonesia.

Table 3. Foreign direct investment spillover effects on total factor productivity in our sample: World Bank measure

Controls	Sample	OLS (1)	OLS + cluster (2)	FE (3)	FE + cluster (4)	IV-2SLS† (5)	IV-GMM† (6)	Heckman† (7)
0. Including foreign firms		0.80**	0.80	0.58	0.58	1.83	1.88	NA
Domestic firms only:								
β coefficient on foreign direct investment 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‡	1.68
6. TFP controls	SOE	0.03	0.03	–0.82	–0.82	4.17	4.16	NA
7. TFP controls	Manufacturing	–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	NA	NA	–0.38	–0.38	–4.28	–4.17[c]	–0.43
β coefficient on upstream foreign direct investment 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	Manufacturing	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	NA	NA	0.04	0.04	0.45	0.25§	
β coefficient on downstream foreign direct investment 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‡	
6. TFP controls	SOE	0.03	0.03	–0.23	–0.23	0.73	0.82	
7. TFP controls	Manufacturing	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	NA	NA	–0.08	–0.08	–0.13	–0.21§	

Notes: Dependent variable in all regressions is log(value-added). TFP controls = log(capital), log(labour), 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 total factor productivity (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 * average transportation costs in industry. †Include industry and city effects and standard errors clustered on city–industry. ‡No industry or city effects due to insufficient number of observations. §Robust standard errors, not clustered on city–industry cell, due to insufficient degrees of freedom. FE, fixed effects; GMM, generalized method of moments; IV, instrumental variables; NA, not applicable; OLS, ordinary least squares; SOE, state-owned enterprise; TFP, total factor productivity; 2SLS, two-stage least squares. * = significant at 10%, ** = significant at 5% and *** = significant at 1%.

4.1. *Main results*

We use the following main regression specification:

$$Y_{jic} = \alpha_i + \alpha_c + \beta_1 FDI_{ic} + \beta_K K_{jic} + \beta_L L_{jic} + Z'_{jic}\Gamma + \varepsilon_{jic}, \quad (2)$$

where Y_{jic} is the logarithm of value-added 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; K_{jic} is the logarithm of capital input; K_{jic} is the logarithm of labour input; Z_{jic} is a set of firm-level control variables; and ε_{jic} is a random error term. Therefore, the coefficient β_1 measures the relationship between foreign presence in a city–industry cell and the TFP of an average domestic firm.

Because value-added is the difference between sales and material costs, it measures firms' value-added in terms of revenues, not physical output. Therefore, the measure includes the effects of both quantity produced and sale prices. As Klenow and Hsieh (2006) point out, in a monopolistically competitive environment the two effects are likely to cancel each other out. To address this problem, we always control for the degree of competition faced by the firm.

To measure the extent of potential aggregation bias if we were to aggregate firms in our sample, we first include foreign-invested firms along with domestic firms in our regressions. The results are reported in Row (0) of Table 3. We can see by comparing it with Row (1), which provides results for the same set of regressions for the sample limited to domestic firms only, that, as we expected, the estimated spillovers from FDI are substantially higher in ordinary least squares (OLS) and fixed effects regressions (first four columns) when we include foreign firms in the sample. This is because, as we demonstrate in Table 2, foreign firms themselves are more productive. Having established this, we limit the sample to domestic firms for the rest of our analysis.

Columns (1)–(4) in Table 3 report the results of estimation of equation 2, with Column (1) presenting results from OLS estimation and Column (2) computing robust standard errors clustered on city–industry to avoid downward bias in the standard error associated with β_1. We also attempt various specifications in different rows: Row (1) includes labour 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 chief executive officer education and the regulatory environment; Row (3) adds information on age and education of technical and managerial personnel to account for human capital; and Row (4) adds information on private ownership share. Rows (5)–(6) separate private firms from SOE to further study how they might respond differently to the presence of FDI. Rows (7)–(8) also split the sample into manufacturing and service sectors, while the last row uses the full sample and includes the variables in Row (1) and their interaction terms with industry dummy variables to allow for different production functions in different industries.

Of the estimates in Columns (1) and (2), two are positive and significant (when we control for human capital quality and estimate β_1 using simple OLS on the full sample and when we estimate β_1 using simple OLS on service firms, in

Column 1). However, these effects are not longer significant if we cluster standard errors at city–industry level (Column 2). All other estimates are insignificant.

As discussed above, the biggest challenge in accurately estimating FDI spillover effects is the potential endogeneity of FDI. Column (3) includes industry and city fixed effects as crude controls for endogeneity of FDI, while Column (4) further computes robust standard errors clustered on the city–industry for the fixed effects estimates of Column (3). Adding city and industry fixed effects lowers the coefficient and makes it insignificant with or without clustered standard errors (Columns 3 and 4), suggesting upward bias in the OLS estimation, potentially due to the endogeneity of FDI at industry and regional levels.

Given the cross-sectional nature of our data, our preferred approach to address the issue of endogeneity is instrumental variable estimation. In particular, we 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 a 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 the population of all other provinces weighted by the inverse of the distance between the provincial capital and the city squared (*Dist * trcost*).[19]

The average tax rate in the city–industry proxies for preferential tax treatments some locations and sectors receive and, therefore, 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. Therefore, *Port * export* measures the access to overseas markets and the attractiveness to FDI of the particular city–industry cell. The sum of the 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. Therefore, *Dist * trcost* measures the access to the domestic market and the attractiveness to FDI of the city–industry.[20]

Specifically, we estimate, using two-stage least squares (2SLS) and generalized method of moments (GMM), the following system:

[19] Empirical studies demonstrating the importance of these factors include de Mooij and Ederveen (2003) (tax rate), Coughlin *et al.* (1991) (tax rate and infrastructure), Ma (2006) (access to international market), Bagchi-Sen (1989) (population size, population growth and per capita sales), and Kravis and Lipsey (1982) and Blomstrom (1991) (size of domestic market). Razin *et al.* (2005) shows the importance of the tax rate in determining FDI flow both theoretically and empirically using EU data. Other studies on location of FDI in China include Cheng and Kwan (2000) and Sun *et al.* (2002).

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

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

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

Column (5) presents results from using the 2SLS method. The first-stage results are largely consistent with our expectations, with the average tax rate having a negative and significant effect on FDI and *Port* * *export* having a positive and significant effect. The Shea-R^2 is approximately 0.30 and the *J*-test does not reject the validity of instruments. Column (6) gives results when using the GMM. Compared with 2SLS, GMM produces more efficient estimates (Hayashi, 2000). Although IV regressions mostly lead to higher estimated coefficients in the top panel, these coefficients are not statistically significant. In fact, none of the IV estimates are significantly different from zero and many of them are, in fact, negative.

Although 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. Because the majority of FDI into China takes the form of mergers and acquisition, the sample of domestic firms is not likely to be randomly formed.[21] Rather, domestic firms without foreign investment are more likely to have lower productivity and, therefore, are less attractive to foreign investors. As a result, if for some reason unrelated to productivity a given city–industry cell is more attractive to foreign investors, foreign-invested firms will be distributed over a larger upper tail of the productivity distribution, thus lowering the mean productivity of remaining domestic firms. Because in the regression analysis we limit ourselves to the sample of domestic firms, we thus might be underestimating the effects of FDI presence.[22] We test whether the selection bias is present in our sample by estimating the effects of FDI on productivity using the maximum likelihood Heckman selection model (Heckman, 1979), where in the selection equation we use as instruments the same variables as in our IV analysis.

Specifically, we estimate the following system using the maximum likelihood or the two-step procedure:

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

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

The results are presented in Column (7) of Table 3. We use the same set of instruments in the selection equation as we do in the IV regressions. We find that

[21] Sole foreign ownership was not allowed until the passage in 1986 of the *Law of the Peoples Republic of China on Enterprises Operated Exclusively with Foreign Capital*.

[22] 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.

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), because 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 fixed effects estimation. In particular, they are not higher than the fixed effects coefficients, as correcting selection bias would imply.[23]

We present the spillover effects of FDI presence in upstream industries and those from FDI presence in downstream industries in the middle and bottom panels of Table 3, where the FDI measure is computed using the input–output table. Similar to our previous results, we only find positive significant spillovers in the OLS specification, in which the coefficients are likely to be biased up and the errors are likely to be biased down.

4.2. *Alternative measures of foreign direct investment*

Computing the FDI presence measure from the World Bank survey data, one might worry about the small sample size and the constructed FDI measure (the World Bank measure) being too noisy. As an alternative, we use the FDI measure from the 2000 China Industrial Survey data (the China Industrial Survey measure). Results from using the two alternative FDI measures are very similar. This assures us that the measure based on our survey data is not misleading, which is also demonstrated by its high correlation with the census measure.[24]

It is also possible that we fail to uncover significant positive FDI spillovers because the FDI measures used above are too aggregate and, therefore, certain types of FDI spillovers are obscured.

First of all, because the degree of connection with local firms might be influenced by whether a firm has majority foreign ownership, it is possible that the sign and magnitude of FDI spillover effects vary depending on the presence of firms with majority foreign ownership.[25] To test this hypothesis, we construct the following alternative FDI measure, the FDI-majority presence measure, by including only the foreign shares of firms with majority foreign ownership in our computation of both the World Bank measure and the China Industrial Survey measure of FDI presence.

Second, the source region of foreign ownership might also be relevant in determining FDI spillover effects. Several studies find that foreign investment

[23] 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.

[24] The same-cell measures have a correlation of 0.54, the upstream measures have a correlation of 0.79 and the downstream measures have a correlation of 0.82.

[25] Xu and Lu (2006) find that the impact of foreign firms' presence on the sophistication of Chinese exports differs depending on whether the foreign-invested firms have majority foreign ownership. Moran (2007) further argues that only wholly foreign-owned firms are likely to transfer technology because the headquarters tend to withdraw advanced technology from joint ventures. However, in our sample, we do not find a significant difference in the instances of technology transfer from the headquarters between the wholly and partially foreign-owned firms.

from the Greater China Area (GCA) tends to be less technology intensive compared to FDI from other countries and regions.[26] Therefore, we construct the measures of non-GCA FDI presence, by excluding GCA ownership share from computations of both measures.

In addition, many foreign-invested firms in China use their factories primarily as export platforms.[27] Although they might be using more advanced technologies, their interaction with domestic firms is likely to be limited. Consequently, it would make sense to focus on firms that are more present in the domestic markets and actually compete with domestic firms. Alternatively, Moran (2007) argues that foreign-invested firms that are more export oriented tend to have more positive spillovers on domestic firms, because they put competition pressure on domestic firms (especially domestic suppliers) to match quality and efficiency requirements by clients overseas. To take into consideration the domestic market presence of foreign firms, we compute both measures of FDI presence using the product of their domestic sales to total sales ratio and their employment as weights.

Finally, many of the foreign-invested firms are located in the special economic zones (or the Chinese style export processing zones (EPZ)) that are designed for producing export products. It can be argued that these firms are isolated from the rest of the firms in the city and are unlikely to impact on technological spillovers for domestic firms (Moran, 2007). To address this concern, we construct measures of FDI presence that exclude the firms located in the EPZ.

For all of the above variables, we also construct corresponding measures of the upstream and downstream FDI presence, using the input–output table.

The results of these regressions are not reported due to space limitations, but are available from the authors upon requests. Our findings are essentially the same as in Table 3, with two exceptions. First, when the FDI-majority World Bank measure is used, we find positive horizontal spillovers on the service sector TFP, 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 in OLS and fixed effects 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 the IV approach is adopted.

We further adjusted our analysis along several additional dimensions. First, we estimated all of the above regressions using levels of the FDI presence measures instead of logs. Our results remain basically the same, except fewer coefficients are positive and significant in OLS specification than when logs are used. However, the significance goes away and the coefficients become smaller

[26] See, for instance, Buckley *et al.* (2002), Huang (2004), Hu and Jefferson (2002), Tong and Hu (2003), Wei and Liu (2006) and Xu and Lu (2006).

[27] Our calculation based on the First Economic Census of China indicates that 64% of foreign-invested firms exported in 2004, whereas only 21% of domestic firms exported in the same year.

when fixed effects are included and standard errors are clustered. Again, none of the coefficients are significant when we control for the endogeneity of FDI presence using thw IV approach. We also used three alternative weights (assets, sales and value-added) in computing FDI measures, and again failed to find significant FDI spillovers on domestic firms' TFP. Finally, we use an alternative productivity measure, labour productivity, as the outcome variable. Once again, we failed to find any consistent FDI effects on domestic firms.

In summary, we do not find evidence of positive or negative FDI spillover effects on domestic firms' productivity after estimating over 6000 regressions. We also find that some of the positive results obtained in previous studies hold in our sample when the empirical model is misspecified. Once we control for endogeneity, however, these positive FDI spillovers lose statistical significance.

5. CONCLUSION

In the present paper we surveyed the existing published literature on the productivity spillovers of FDI presence in China and conducted our own analysis of these effects. Our discussion suggests that many of the empirical estimates of productivity spillover from FDI to domestic firms in China are biased upward. When controlling for these biases, our firm-level analysis using a large number of specifications and FDI measures from two different data sets failed to find evidence of spillovers in properly specified estimations. Although we are aware of the data-related limitations of our analysis, our results lead us to believe that one is unlikely to find evidence of productivity spillovers from FDI, even with a richer data set.[28]

In explaining the lack of productivity spillovers of FDI in China, we believe that institutional factors are important. On the one hand, SOE might lack human capital and the ability to hire skilled workers previously employed by foreign-invested firms, which would limit the channel for technological spillovers and the ability of SOE to adopt new technologies.[29] Private firms, on the other hand, might have the flexibility and mechanisms to hire sufficient human capital, but might lack access to the financial capital necessary to adopt new technologies.

Nevertheless, there might be FDI spillover effects in other forms that studies using conventional productivity measures are unable to reveal. For instance, quality improvement and export growth might result due to FDI presence.[30] In addition, there might be broader implications for the whole economy, such as improvement in the infrastructure, the quality of the labour force, and the R&D activities of domestic firms, which would have long-term positive effects. In the

[28] As Liu (2008) suggests, there might be long-run productivity spillovers. However, one would need a rather long panel to properly identify them without having to worry about the simultaneity problem.

[29] Kato and Long (2006) discuss the hiring and compensation rigidity in SOE.

[30] Moran (2007) points out that the quality of output by domestic firms might improve when they supply foreign-invested companies in downstream industries because of enhanced competition between such firms.

specific case of China and in transition economies in general, the regulatory environment might also improve in response to the presence of FDI. We leave the exploration of these issues to future research.

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