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What Determines Technological Spillovers of Foreign Direct Investment: Evidence from China

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ABSTRACT

Using the World Bank survey of 1500 firms in five Chinese cities, we study whether the presence of foreign firms produces technology spillovers on domestic firms operating in the same city and industry. We find positive spillovers for more technologically advanced firms and no or negative spillovers for more backward firms. We analyze the channels of such spillovers and find that the transfer of technology occurs through movement of high-skilled workers from FDI firms to domestic firms as well as through network externalities among high-skilled workers. Moreover, these two channels fully account for the spillover effects we find, which demonstrate the importance of well-functioning labor market in facilitating FDI spillovers. Insofar as our results can be generalized to other countries, they reconcile conflicting evidence found in other studies.

JEL Codes: F2, O1, O3, J2, J6

Keywords: Foreign direct investment, technological spillovers, labor mobility, network externalities, China

1 Introduction

In recent years China has been actively encouraging the inflow of foreign direct investment (FDI). Such a policy is justified if there are positive spillovers on domestic firms. As of today, empirical literature on FDI spillovers has not reached a consensus on whether there are spillover effects from FDI on domestic firms. In this paper we study the spillover effects of FDI in the case of China and the mechanisms through which such spillovers occur. Insofar as our results can be generalized to other countries, they reconcile conflicting evidence found in other studies.

Specifically, we use firm level data from a World Bank Survey and we obtain the following results:

1. We show that FDI has different spillover effects on different firms. In particular, domestic firms with higher absorptive capacity (higher relative initial total factor productivity) experience positive spillovers, while those with low initial productivity witness negative spillovers.

2. We explore in detail two mechanisms through which FDI exerts positive spillovers on domestic firms with higher initial productivity: the labor mobility channel and the network effect channel. In particular, firms that are able to hire managers and engineers from the foreign firms have higher productivity. This is supporting evidence that labor mobility provides a channel for FDI spillovers. In addition, firms that hire younger and more skilled labor force tend to have higher productivity when there is more presence of FDI in their city and industry. This is consistent with the argument that learning and interaction among employees (especially skilled labor such as managers and engineers) is a mechanism for FDI spillovers — a mechanism we refer to as network externality henceforth.

Our paper contributes to the literature on FDI in multiple ways. First, we provide a detailed study on the effects of FDI in China, a country that has caught attention of the literature and the

media for its record–setting economic growth and FDI inflow. While several studies have offered generally positive views on FDI spillover effects in transition economies, the only other study of FDI spillovers in China that we are aware of is Tong and Hu (2003).[1] They provide evidence that domestic firms benefit in their productivity from foreign firms located in the same province, but not from those located in the same industry. However, because Tong and Hu (2003) do not control for regional and industry fixed effects, it is difficult to know whether these results suffer from the selection issue highlighted in Aitken and Harrison (1999).[2] Indeed, we find positive effect of FDI presence when not controlling for city and industry fixed effects. But once such fixed effects are included, FDI presence no longer has positive effects on domestic firms' productivity. Thus, our results are consistent with Aitken and Harrison (1999) critique.

We further show that the absence of the spillover effect in the basic specification is due to differential effect of FDI on domestic firms with different productivity. Thus, our second contribution is to the debate over how technology gap impacts FDI spillovers. Blomström, Globerman, and Kokko (1999) argue that the technical capacity of domestic firms increases the likelihood of positive spillovers and hence a smaller technology gap between foreign and local firms results in larger spillovers. In contrast, the theoretical model developed in Wang and Blomstrom (1992) predicts that a larger technology gap between foreign and domestic firms leads to larger spillovers. The evidence from Chinese firms in our sample seems to support the technology threshold argument by Blomström, Globerman, and Kokko (1999). Kokko, Tanzini, and Zejan (1996) find evidence in support of this argument using data on Uruguayan manufacturing sector, while Girma, Greenaway, and Wakelin (2001) find for the case of UK that domestic firms with a smaller initial productivity gap benefit

[1] Empirical evidence is still limited on FDI spillovers for transition economies, but generally presents a positive role of FDI. See Kaminski and Riboud (2000) for a glowing evaluation of the positive spillover effects on domestic firms in Hungary, Djankov and Hoekman (2000) for evidence on Czech Republic, Sinani and Meyer (2002) for evidence on Estonia, and Lutz and Talavera (2004) for evidence on Ukraine.

[2] Foreign investors from industrial countries may have chosen firms in regions with higher productivity to invest in, which explains higher productivity of domestic firms within the same province. This positive correlation could be mistakenly interpreted as positive FDI spillovers.

more from FDI spillovers.

Our third contribution is the analysis of specific mechanisms through which FDI spillovers occur. Several channels have been outlined in the theoretical literature, including the demonstration channel, the competition channel, the forward and backward linkages, and the labor mobility channel.[3] While theories are abound, there has been limited empirical evidence to support these arguments. Using the data from China, we offer empirical evidence for two specific mechanisms through which FDI spillovers occur.

We first focus on the labor mobility mechanism, where the movement of skilled personnel from foreign firms to domestic firms helps transfer advanced technology and management skills. Djankov and Hoekman (2000) and Görg and Strobl (2005) present evidence demonstrating the existence of labor mobility effect in Czech and Ghana, respectively. For the case of China, we also find empirical evidence that the labor market channel facilitates FDI spillovers in China.

In addition, we propose a more subtle mechanism through which skills and knowledge get transferred from foreign firms to domestic firms, which we refer to as the network externality channel. By being in contact with people working for foreign firms close by (for example, by attending the same product shows, conferences, and so on), high–skill employees working for domestic firms are exposed to the more advanced technology and management practices adopted in the foreign firms and can then start to implement them in their own firms. To our knowledge, we are first to offer evidence for the network externality channel of FDI spillover.

Furthermore, the importance of the specific FDI spillover mechanisms we have documented helps reconcile the seemingly contradictory results from different countries. On the one hand, studies on

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

developing countries tend to find negative or no FDI spillovers.[4] On the other hand, new studies on developed countries document positive productivity spillovers even after controlling for industry and regional fixed effects.[5] The two mechanisms presented in this paper suggest that labor market institutions are essential in facilitating FDI spillovers. To the extent that labor market is not as well–functioning and labor regulations are more restrictive in developing countries than in the developed world, we are more likely to observe positive FDI spillovers in developed countries.

We proceed by describing our data and empirical approach in Section 2. In Section 3 we compare the productivity of domestic and foreign–owned firms and analyze differences in productivity among domestic firms. Section 4 presents our results on the spillover effects of foreign–owned firm presence and discusses the mechanism through which these spillovers work. Section 5 concludes.

2 Empirical approach and data

2.1 Empirical approach

Our main focus is on the effects of foreign presence on the total factor productivity of domestically owned firms in the same city–industry. Thus, the sample of our main analysis is limited to domestic firms and is not subject to the endogeneity problem that occurs when comparing foreign and domestic firms — where foreigners may choose to invest in firms that perform better *a priori*. Our main regression specification is therefore:

$$Y_{jic} = \alpha_i + \alpha_c + \beta_1 L_{jic} + \beta_2 K_{jic} + \beta_3 FDI_{ic} + \Gamma Z_{jic} + \epsilon_{jic}, \quad (1)$$

[4] Aitken and Harrison (1999) present evidence that FDI had negative productivity spillovers on domestic firms in Venezuela. Kathuria (2000) also report results that are consistent with FDI having negative productivity spillovers on large Indian domestic firms.

[5] See Haskel, Pereira, and Slaughter (2002) for the study of the UK manufacturing plants between 1973 and 1992 and Girma, Greenaway, and Wakelin (2001) for the study of these firms in the early 1990s, and Keller and Yeaple (2003) for US manufacturing plants between 1987 and 1996.

where α_i and α_c are industry and city fixed effect, Y_{jic} is the log of value added of the firm j operating in industry i and located in city c, L_{jic} is the log of labor input of this firm, K_{jic} is the log of capital input, FDI_{ic} is a measure of foreign firm presence in the city–industry cell where the domestic firm belongs, Z_{jic} is a set of variables capturing other firm characteristics, while ϵ_{jic} is a random error term.

The coefficient β_3 measures the spillover effect of foreign firm presence on an average domestic firm's total factor productivity (referred to as TFP henceforth). By including additional terms to the specification above, we will then study the spillover effects of foreign firm presence on domestic firms with different characteristics. Furthermore, we will investigate the mechanisms through which such spillovers work.

To assure that our findings are not driven by influential observations, we use robust regression throughout the paper.[6] We also include city and industry fixed effects in the estimation unless stated otherwise.

2.2 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 es-

[6]Robust regression de–emphasizes the influence of outliers by assigning lower weights to influential observations. This approach and a number of robustness tests assures that our findings are not driven by influential observations.

tablishments is drawn in each of the following five Chinese cities: Beijing, Chengdu, Guangzhou, Shanghai, and Tianjin, giving a total sample size of 1500. Table 1 gives the city and sector distribution of firms included in the survey. See Figure 1 for the cities covered in the survey and their locations in China.[7]

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. In this study, we utilize 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 included in the survey, with all values referring to year 2000 unless indicated otherwise:

Sales Total sales of the firm (in Year 2000 RMB).

Final product inventory Inventory of the output of the firm (in Year 2000 RMB).

Labor input Number of employees in the firm, total and by category of employees: production workers, engineering personnel, and managerial personnel.

Capital input Value of fixed assets (in Year 2000 RMB).

Firm age Firm's age in year 2000.

Education Average education level of employees in the firm (in years of schooling), total and by category of employees: production workers, engineering personnel, and managerial personnel.

Age Average age of employees in the firm, total and by category of employees: production workers, engineering personnel, and managerial personnel.

Foreign experience Share of employees with foreign experience, by category of employees: production workers, engineering personnel, and managerial personnel.

Sector Industry sector of the firm.

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

City City where the firm is located.

Foreign A binary variable indicating whether the firm had a foreign partner in year 2000.

Largest foreign partner share Share of the ownership of the firm by the largest foreign partner, including FDI and portfolio participation.

In addition, we define and construct the following variables to be used in our analysis:

FDI presence The average of the largest foreign partner's share in the same city–sector cell where the domestic firm is located, weighted by firm employment. Table 3 gives the average foreign share by city and industry sector.

Firm scale Firm sales relative to the average firm sales in the same sector. Due to a number of very large firms, we use natural log of this measure.

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

Employee Skill level The ratio of the total number of managers and engineers to the number of production workers, used in logs.

Foreign experience (skilled) The share of engineers and managers that had worked for foreign firms.

3 Productivity of domestic and foreign firms

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 are foreign firms in 2000. Table 1 gives the break–down of foreign versus domestic firms in each city and each sector.

3.1 Firms with foreign ownership are more productive

We begin by describing the differences between domestically owned firms and foreign firms. Table 2 gives the summary statistics of variables used in the regressions, where the numbers in parentheses are the number of foreign or domestic firms and the t-statistic from the means test, respectively. Using our firm level data, we provide supporting evidence for the claim that foreign firms have higher productivity than domestic firms in China. 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).[8]

Specifically, we conduct the following regression using all firms (including both domestic and foreign firms) to predict the total factor productivity of each firm as the residual term from the regression:

$$Y_j = \beta_0 + \beta_1 L_j + \beta_2 K_j + \epsilon_j, \tag{2}$$

where Y_j, L_j, K_j, and ϵ_j are defined the same as in Equation (1).

The regression is conducted separately for each sector, using year 2000 information. We refer to the residual of the regression in (2) as TFP1. By including additional firm characteristics into the above equation, we also 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 human capital component, as TFP3 (obtained by adding firm age, firm scale, average education, average age and average age squared to the explanatory variables.)

[8] 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 then conduct t-tests comparing the TFP of domestic firms with that of firms with foreign ownership in year 2000. Table 2 gives the t-test results from using the three measures of TFP. Consistent among all the results, firms with partial or complete foreign ownership are shown to have significantly higher productivity than domestic firms.[9]

The decrease in the TFP gap between foreign and domestic firms from TFP1 to TFP2 and then to TFP3 is explained by the following 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. As shown in Table 2, differences in firm age and firm scale between foreign and domestic firms are statistically significant. Although differences in age and education are not significant for the average employee measure, they are significant for the high–skilled employees (managers and engineers), which arguably matter the most for firm productivity.

Even after controlling for firm vintage, scale, and average employee education and age, foreign firms still exhibit a significant productivity edge over domestic firms. Although the superior productivity of foreign firms is not the focus of this paper, we speculate that the productivity differential may be partially explained by the following additional differences between foreign and local firms. Foreign firms seem to especially value the quality of skilled labor, which is reflected in the fact that they hire better educated and younger managers and engineers. In addition, a significantly higher percent of managers in foreign firms have foreign firm work experience than in domestic firms (4% versus 1%). Finally, although the skill ratio in foreign firms does not seem to differ significantly from that of domestic firms, we find that foreign firms hire significantly more skilled labor once industry and city fixed effects are controlled for. [10]

[9] Addressing the criticism that foreign investors "cherry–pick" domestic firms with higher productivity is beyond the scope of this paper. But our results below apply generally as long as the effects of FDI spillovers are interpreted as that of TFP–driven spillovers.

[10] The OLS estimation with industry and city fixed effects produces the following results:

3.2 Domestic firms' productivity and absorptive capacity

Not only do domestic firms on average have lower productivity than foreign firms, there is also great variation among domestic firms in their productivity. Variation in domestic firms' initial productivity is important because firm productivity may have important influence on how much the firm benefits from the spillover effects of FDI. Blomström, Globerman, and Kokko (1999) argue that the technical capacity of domestic firms increases the likelihood of positive spillovers and hence a smaller technology gap between foreign and local firms results in larger spillovers. In contrast, the theoretical model developed in Wang and Blomstrom (1992) predicts that a larger technology gap between foreign and domestic firms leads to larger spillovers.

We conduct the same regression defined in Equation 2 to compute TFP1 for each domestic firm, but with two differences. Since our focus here is on the productivity variation among domestic firms, we exclude foreign firms from the sample. Because we are interested in the *initial* productivity of the firms, we use data from year 1999.

Following the literature, we construct the absorptive capacity for each firm based on TFP1 to measure technology gap. Specifically, absorptive capacity is computed as the individual firm's TFP relative to the highest TFP of the industry (see for instance, Kathuria (2000)). All the TFP measures are scaled so that the absorptive capacity is between 0 and 1.

Figure 2 presents the distribution of firm absorptive capacity by city. We see significant differences in the distribution of absorptive capacity across cities: It is significantly higher in Guangzhou, Shanghai and Beijing than in Chengdu and Tianjin. Such productivity differences are consistent with expectations: Chengdu's inland location and Tianjin's slow pace in introducing reform explain their inferior productivity performance (see Figure 1).

Log(skilled labor/unskilled labor)= $0.06 + 0.20^{***} \cdot$ I(foreign firm).

To study how a firm's initial technology capacity influences FDI spillovers, we will include its absorptive capacity and the interaction term between absorptive capacity and FDI presence as additional explanatory variables.

4 FDI spillovers in China

Having established the higher productivity of foreign firms, we now turn to explore the spillover effects of such higher productivity by estimating variations of Equation (1). As mentioned previously, the sample includes only domestic firms. Our measure of FDI presence is the average foreign share in each city–industry cell, weighted by firm employment. The values of this variable are reported in Table 3.

4.1 Spillover effects and absorptive capacity

Table 4 presents results from various specifications, where Columns (1) includes labor and capital inputs as well as firm age and firm, Columns (2) adds information on employee education and age, Columns (3) further includes industry and city fixed effects, and Column (4) also includes absorptive capacity and its interaction with foreign firm presence.[11] As shown in Columns (1) and (2), the effect of the FDI presence in the same industry and city where the firm becomes positive only when we control for employee education and age. This is explained by the fact that foreign firms tend to hire younger and more educated workers *away* from neighboring domestic firms.[12] Thus, ignoring the human capital components underestimates FDI's positive *technological* spillovers.

[11]The sample size for Column (2) is substantially smaller than that for Column (1) because age and education information is missing for a large number of firms. Using the smaller sample does not substantially change the results in Column (1).

[12]Indeed, we find that in the presence of foreign firms, domestic firms hire older, less educated and less skilled workers: Corr(FDI, age) =0.15***, Corr(FDI, educ) = -0.12***, Corr(FDI, skill) = -0.14***, where FDI is FDI presence in each industry-city cell, age is average employee age, educ is average employee education and skill is log(skilled labor/unskilled labor).

Although not significant at the conventional level, the positive effects of FDI presence on domestic firms' TFP from Column (2) are in line with previous findings of positive FDI spillovers in China. However, like the earlier study of FDI in China (Tong and Hu, 2003), these results fail to address the issue of foreigners "cherry-picking" high–productivity industry and region to invest in (Aitken and Harrison, 1999). Columns (3) includes industry and region fixed effects to address this concern. As shown in the table, the positive effects of FDI on TFP disappear with the inclusion of such fixed effects.

One might argue that the industry and city fixed effects may have captured the positive spillovers of FDI, thus controlling for such fixed effects obscure the very effects we are interested in. Nevertheless, without further evidence where the spillover effects are disentangled from other industry or regional effects, these results call into question the presence of positive FDI spillovers in China. To further explore the issue, next we attempt to disentangle spillover effects from the industry and regional fixed effects by exploring how various firm characteristics affect FDI spillover effects.

One possible explanation why we do not observe average domestic firm productivity benefiting from FDI presence is that the spillover effects might be distributed unevenly among different firms. The effects of FDI might be positive for some firms but negative for others. For example, the degree to which a domestic firm benefits from FDI presence may depend on the firm's capacity to absorb new technology and management practices. As referred to previously, Blomström, Globerman, and Kokko (1999) argue that some minimum level of technological sophistication is required for a domestic firm to learn from and take advantage of the advanced technology and management practices adopted by foreign firms. In other words, domestic firms may be constrained by their limited absorptive capacity. To test this hypothesis, we include absorptive capacity and the interaction term between absorptive capacity and average foreign share as additional explanatory variables in Equation (1). We also include industry fixed effects and city fixed effects, as in all other regressions

henceforth.

Column (4) in Table 4 presents the regression results. As shown in the table, domestic firms with higher initial absorptive capacity indeed benefit more from FDI presence. Because FDI presence now has a negative and significant effect on firm TFP, the coefficient estimates imply that domestic firms with absorptive capacity over 0.56 enjoy positive spillovers from FDI, while those with capacity below 0.56 suffer negative spillover effects. Figure 3 illustrates the distribution of firms by their absorptive capacity, where the solid line represents the spillover effects. According to the figure, about two-thirds of the firms enjoy positive spillovers from FDI while one-third of the firms suffer the negative effects of FDI presence.

The requirement of a minimum level of technology sophistication can explain the lack of positive spillover effects for firms with low initial TFP. However, theoretical models usually do not clarify the specific mechanisms for such a requirement. In the next section, we suggest and test two mechanisms for why initial TFP may impact spillover effects in the fashions observed above.

4.2 Mechanisms for FDI spillovers

We explore two mechanisms for FDI spillovers in this section: the labor mobility channel and the network externality channel. We show that when these two mechanisms are taken into consideration, the effect of firm absorptive capacity on FDI spillovers disappears. This suggests that the impact of firm initial productivity on FDI spillovers is exerted through these labor market channels, at least for Chinese domestic firms.

4.2.1 Labor mobility as spillover mechanism

One mechanism for FDI spillovers that has been offered in the literature is through labor mobility (Kaufmann (1997), Haaker (1999), Fosfuri, Motta, and Rønde (2001) and Glass and Saggi (2002)). If foreign firms provide training to their employees, the employees can then transfer their skills and experience thus developed to domestic firms when departing the foreign firm.

To the extent that there is skill-technology complementarity, such effects will be most significant for skilled labor. Our data indeed provide evidence consistent with substantial mobility of skilled labor from foreign firms to domestic firms. In particular, for our sample of firms, the percentage of managers in domestic firms who have foreign firm experience is positively and significantly associated with the FDI presence in the same industry-city cell, even after controlling for industry fixed effects and city fixed effects.[13] This result is consistent with skilled labor moving from foreign firms to domestic firms. Because Chinese firms generally lack modern managerial skills and proper training programs for managers have just started to emerge, the potential for managerial knowledge spillovers is particularly important and thus this movement is particularly beneficial to Chinese firms.[14]

Does such movement bring about positive effects on domestic firm's productivity in reality? We explore this possibility by adding the percentage of managers and engineers with foreign work experience to the estimation above. Column (1) in Table 5 gives the results. In addition to the previously significant results for variables related to absorptive capacity, the percentage of managers and engineers with foreign firm work experience also has positive and significant effects on the TFP of the firm. Therefore, we have found evidence that skilled labor mobility enhances

[13] We obtain the following estimates using OLS with industry and city fixed effects:
Share of managers with foreign firm experience $= 0.03^{***} + 0.038^{*} \cdot$ (FDI presence).

[14] The relationship between FDI presence and the percentage of engineers with foreign experience in domestic firms, although positive, is not significant. Nevertheless, we include engineers in our measure of foreign experience of skilled workers because of overlapping between managerial personnel and engineering personnel.

positive productivity spillovers from FDI.

4.2.2 Network externality as spillover mechanism

In addition to movement of managers and engineers from foreign firms to domestic firms, a more subtle mechanism may also be at work. The skills and knowledge obtained by employees working for foreign firms can be spread throughout the same industry and location in a more indirect way. By being in contact with people working for foreign firms close by (for example, by attending the same product shows, conferences, and so on), employees working for domestic firms are exposed to the more advanced technology and management practices adopted in the foreign firms and can then implement them in their own firms. In other words, there may be network externality between foreign and domestic firms through social interactions among employees located in the same city and working in the same industry.

This mechanism brings about interesting implications that can be tested empirically. First of all, because the advanced technology possessed by foreign firms is embodied in the skilled labor they employ and skilled labor tends to network more with other skilled labor, domestic firms that hire more skilled employees are more likely to benefit from positive FDI spillovers through network externality.[15] In addition, since it is easier for younger employees to develop new knowledge and learn new skills, domestic firms with younger employees are more likely to enjoy positive FDI spillovers via the employee network externality channel.

We thus study how these additional factors affect FDI spillovers on firm productivity: the skill level of employees and the average age of employees, where the skill level of employees is measured as the ratio of managerial and technical personnel to the other employees (entered in logarithm).

[15] As discussed earlier, the share of skilled labor in foreign firms is indeed larger than in domestic firms. See Footnote 10.

Specifically, we include in our regression the interaction term between FDI presence and employee skill level as well as the interaction between FDI presence and average employee age.

Columns (2) in Table 5 gives the following results: Higher skill level of employees increases value added, which is consistent with expectation. In addition, as shown by a significant and positive coefficient on the interaction term of the skill level and the FDI presence, higher skill level increases the spillover effects of FDI on firm productivity. In fact, firms with employee skill ratio greater than 1.5 enjoy positive spillovers from FDI presence, while those with employee skill ratio lower than 1.5 suffer negative FDI spillovers.[16]Likewise, column (3) shows that average employee age, when interacted with FDI presence, has a significant and negative effect on value added: The younger the workers in the firm, the more likely it will benefit from FDI spillover effects. In particular, the total effect of FDI is positive only for firms whose average worker is under the age of 33, but negative for firms where the average worker age is older than 33.

Both the skill and the age effects attest to the possible spillovers through network externalities — more skilled and younger employees are more likely to meet and learn from foreign firm employees in their city and industry, especially from those skilled employees who embody more advanced technology and management practices.

Columns (4) in Table 5 checks the robustness of the above results by combining all of the variables added to Equation 1 so far. All the results discussed above are preserved. Therefore, both labor mobility and employee network externality are shown to have independent roles in facilitating the positive spillovers of FDI.[17]

[16]Girma, Greenaway, and Wakelin (2001) also find significant positive effect of skill level on FDI spillovers for British firms. But the skill level is measured at the sector level and they interpret the results as supporting the role of technology capacity on FDI spillovers.

[17]One possibility is that the higher quality employees speed up the process of learning from managers who joined the domestic firm from foreign firms. But the interaction between the percentage of managers with foreign work experience and the skill ratio of the firm does not have significant effect on productivity spillovers. Its inclusion also does not substantially change the other results.

After the additional terms are included, the interaction term between FDI presence and the firm's absorptive capacity loses its significant effects. It appears that the mechanisms discussed above, the labor mobility effect and the employee network externality effect, are the channels through which firms with different absorptive capacities receive different impacts from FDI.[18]

Indeed, firms with higher absorptive capacity tend to hire younger and more skilled workers.[19] Thus one way to explain why firms with higher initial TFP benefit more from FDI presence is that these firms are able to hire employees who are more capable of learning and transferring knowledge and technology from foreign firms close by through networking with foreign firm employees.

This mechanism also plays an important role in explaining why domestic firms with the lowest absorptive capacity suffer negative spillover effects from FDI presence: The percentage of foreign ownership in an industry–city cell is negatively and significantly correlated with the average education and skill level of employees, but positively correlated with average age of employees in domestic firms located in the same cell (see footnote 12). This means that foreign firms hire "better" workers away from domestic firms, which in turn leads to lower productivity. Correlation results show that although such effects affect all domestic firms, they are especially acute for domestic firms with lower initial TFP.[20] The more severe "stealing" effects, exacerbated by the lack of positive employee network externality (due to lack of young and skilled labor), thus result in even lower productivity for domestic firms with lower initial productivity.

[18]The coefficient on FDI is now positive and significant. But because we have included interactions of FDI with a number of variables, the positive coefficient on FDI is just an artifact of the specification, but not the actual effect. In particular, the coefficient of the interaction between age and FDI is negative and age is strictly positive, whereas the coefficient of the interaction between skill ratio and FDI is positive and skill ratio (measured in logs) is negative for 85% of the firms in our sample.

[19]Corr(abc, age) =-0.18***, Corr(abc, skill) = 0.24***, where abc is absorptive capacity, age is average employee age, and skill is log(skilled labor/unskilled labor).

[20]For firms with $abc < 0.56$, Corr(FDI, age) =0.17**, Corr(FDI, educem) = -0.15**, and Corr(FDI, skill) = -0.28***, where abc is absorptive capacity, FDI is FDI presence in each industry-city cell, age is average employee age, educem is average education for engineers and managers and skill is log(skilled labor/unskilled labor). In contrast, for firms with $abc > 0.56$, Corr(FDI, age) =0.09**, Corr(FDI, educem) = -0.05, and Corr(FDI, skill) = -0.05*.

To summarize, we have identified two distinct channels through which FDI affects the productivity of domestic firms. Firstly, the movement of managerial and technical personnel from foreign firms to domestic firms improves domestic firms' productivity and hence facilitate positive FDI spillovers. Secondly, domestic firms with younger and more skilled labor benefit more from the presence of FDI. We argue that this is consistent with the network externality story where employees at domestic firms mingle with and learn from employees working for foreign firms located in the same industry and region.

4.3 Robustness tests

We conduct the following robustness tests. The results are not reported, but are available from the authors upon request.

To see whether our results are driven by the specification of the production function, we estimate all our regressions with labor productivity instead of value added as the dependent variable and capital intensity instead of capital input among the explanatory variables. This specification has an advantage of being independent of firm size, but it imposes more restrictive relationship between capital and labor. All our results remain valid qualitatively and quantitatively with this alternative approach.

Since TFP plays such an important role in our analysis, we redefine the absorptive capacity using alternative definitions of TFP (TFP2 and TFP3, as described above). We find that our results are not sensitive to such alterations.

We use an alternative definition of the FDI presence: instead of using the share of largest foreign partner to construct the measure, we use the total foreign share. Because part of the total foreign share may be portfolio investment, it is not as appropriate a measure for FDI as the largest foreign

partner share. Nevertheless, the two measures are highly correlated (the correlation coefficient is 0.77) and produce very similar results to the ones we obtained with the original measure.

In order to make sure that our results are not driven by just one city, we re–estimate all the regressions dropping one city at a time. We find that in all the cases the coefficients are within the same confidence interval, thus our results still hold qualitatively and quantitatively.

5 Conclusion

Using firm level data from a World Bank survey, we study the effects of FDI on Chinese domestic firms and obtain the following results: (i) FDI has positive spillover effects on domestic firms when employee age and education are taken into account, but such positive spillovers disappear once industry and regional fixed effects are controlled for; (ii) Although an average domestic firm does not experience positive FDI spillover effects, domestic firms with high initial productivity enjoy positive spillovers while those with low initial productivity witness negative spillovers; (iii) Two mechanisms are discovered to facilitate FDI spillovers: Movement of managers and engineers from foreign firms to domestic firms enhances the productivity of domestic firms, and younger and more skilled workers increases the FDI spillover effects; (iv) The two above mechanisms account for the differences in FDI spillovers among domestic firms with different initial productivity: Domestic firms with high initial productivity tend to hire younger and more skilled workers, which helps facilitate technological transfer and FDI spillovers.

Our findings of specific mechanisms for positive FDI spillovers in China are consistent with the belief that foreign direct investment is superior to foreign portfolio investment, in that they produce positive spillover effects not internalized by any agents in the economy. Thus, they provide justification for government policies encouraging FDI that have been adopted in many countries.

In addition, our results help reconcile the seemingly contradictory findings on FDI spillovers in previous studies. The two mechanisms that facilitate FDI spillover effects in China both require a reasonably well–functioning labor market where labor mobility is undeterred and accumulation of human capital is rewarded. To the extent that labor market institutions in emerging economies impose more restrictions on labor movement and wages, it is then not too surprising to find no or negative spillover effects of FDI in developing countries, but positive FDI spillovers in developed countries, as documented in previous studies.

Finally, the importance of labor market factors in influencing FDI spillovers highlighted in our results also helps shed light on the appropriate government policies to pursue regarding FDI. To fully benefit from the positive FDI spillovers not captured by any agents in the economy, countries should implement policies that help enhance such spillovers as well as those designed to attract FDI. Results from this paper suggest that a well-functioning labor market where labor mobility is undeterred and incentives for human capital accumulation are ample is essential for the transfer of technology and management expertise from foreign firms to domestic firms. Thus policies and reforms aimed at building efficient labor market institutions will have the additional benefit of enhancing FDI spillovers.

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Table 1: 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. Guang Zhou	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 2: Comparison of Foreign and Domestic Firms

	Foreign	Domestic	Difference
Value added (log)	10.0	8.82	1.19***
	(311)	(734)	(8.87)
Labor input (log)	5.40	5.00	0.40***
	(382)	(1118)	(4.39)
Capital input (log)	10.01	8.63	1.38***
	(382)	(1106)	(9.47)
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)
Firm age	8.30	13.96	-5.66***
	(382)	(1117)	(8.50)
Scale	2.36	0.53	1.82***
	(381)	(1110)	(3.09)
Employee average education	16.70	16.50	0.20
	(221)	(610)	(1.54)
Employee average age	34.45	34.73	0.28
	(219)	(603)	(0.28)
Engineer average education	13.57	13.46	0.21**
	(320)	(837)	(1.99)
Manager average education	13.14	12.69	0.46***
	(375)	(1088)	(4.97)
Engineer average age	32.81	35.21	-2.40***
	(320)	(836)	(5.34)
Manager average age	35.09	36.86	-1.78***
	(375)	(1087)	(4.40)
Foreign experience (skilled)	0.02	0.01	0.01***
	(317)	(816)	(5.46)
Employee skill level	0.89	1.19	-0.29
	(366)	(1025)	(0.70)

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

Table 3: Foreign share by city and industry sector

Sector, city	Beijing	Chengdu	Guang Zhou	Shanghai	Tianjin
Accounting and related services	0.182	0.000	0.007	0.030	0.019
Advertising and marketing	0.037	0.010	0.014	0.098	0.193
Apparel and leather goods	0.169	0.010	0.207	0.178	0.278
Business logistics services	0.006	0.000	0.062	0.041	0.041
Communication services	0.000	0.010	0.000	0.003	0.002
Consumer products	0.099	0.065	0.113	0.156	0.310
Electronic components	0.165	0.029	0.219	0.306	0.473
Electronic equipment	0.244	0.018	0.108	0.360	0.262
Information technology services	0.076	0.047	0.029	0.332	0.006
Vehicles and vehicle parts	0.113	0.093	0.135	0.255	0.121

Table 4: The effects of foreign presence on the domestic firms' productivity

	(1)	(2)	(3)	(4)
FDI presence (#1)	-0.491	0.504	-0.652	-1.108
	(0.315)	(0.409)	(0.663)	(0.839)
Log of labor input	0.362***	0.332***	0.357***	0.473***
	(0.044)	(0.060)	(0.060)	(0.042)
Log of capital input	0.284***	0.224***	0.203***	0.261***
	(0.027)	(0.039)	(0.038)	(0.027)
Log scale	1.728***	1.609***	1.495***	0.715***
	(0.095)	(0.105)	(0.105)	(0.076)
Firm age	-0.011***	-0.005*	-0.003	0.001
	(0.002)	(0.003)	(0.003)	(0.002)
Education		0.087***	0.092***	0.041**
		(0.028)	(0.029)	(0.019)
Age		-0.098	-0.088	0.006
		(0.074)	(0.073)	(0.048)
Age squared		0.001	0.001	-0.000
		(0.001)	(0.001)	(0.001)
Absorptive capacity (#2)				4.044***
				(0.247)
(#1) * (#2)				1.971
				(1.221)
City FE	No	No	Yes	Yes
Industry FE	No	No	Yes	Yes
Constant	4.174***	5.442***	4.177***	2.037**
	(0.172)	(1.356)	(1.429)	(0.958)
Observations	729	430	430	395
Adjusted R^2	0.78	0.77	0.78	0.91

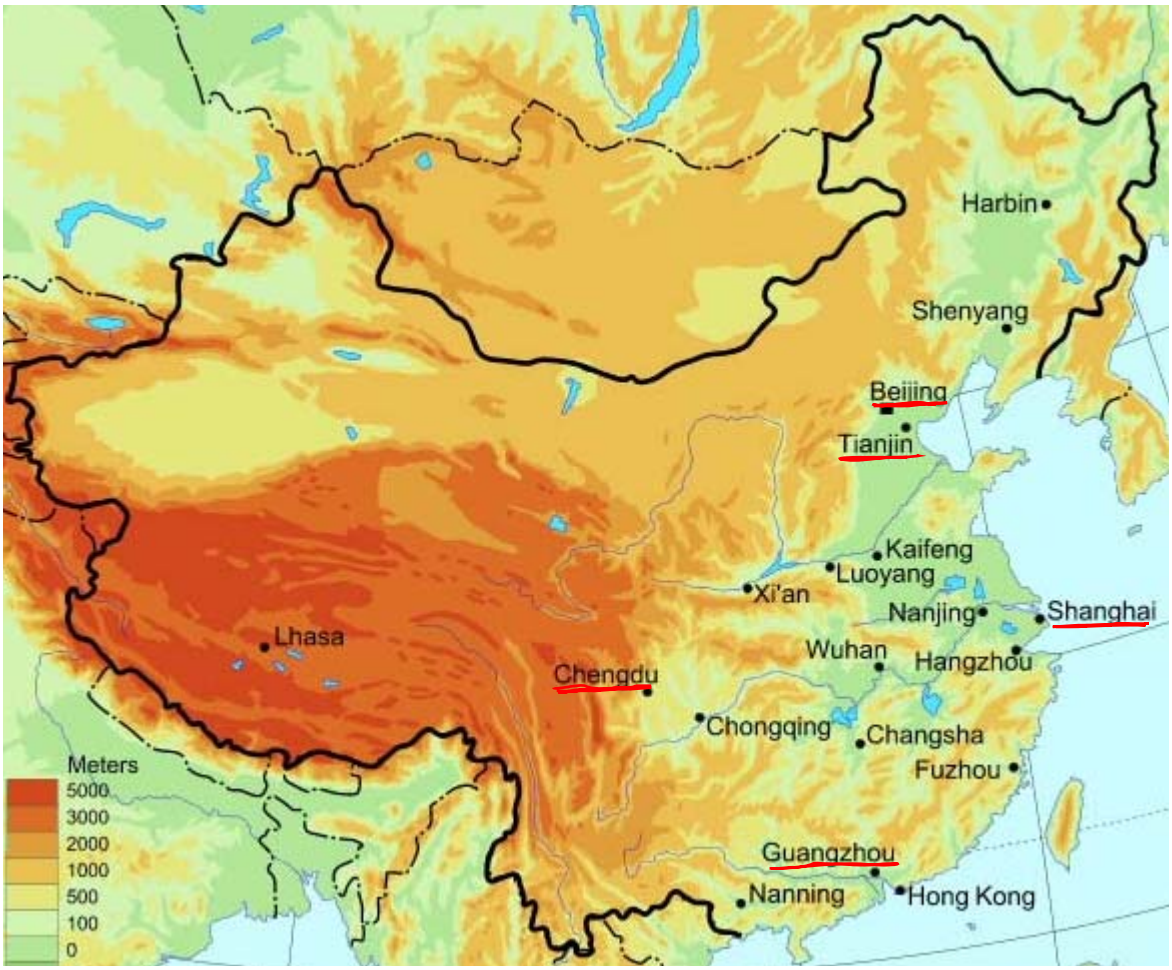
Robust regression estimates
Dependent variable is log of value added
Standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 5: Channels for FDI spillover effects

	(1)	(2)	(3)	(4)
FDI presence (#1)	-0.957	1.874**	4.291**	5.798***
	(0.856)	(0.908)	(1.716)	(1.762)
Absorptive capacity (#2)	4.059***	4.226***	4.141***	4.340***
	(0.261)	(0.247)	(0.247)	(0.261)
(#1) * (#2)	2.209*	-1.603	0.829	-2.027
	(1.264)	(1.256)	(1.232)	(1.314)
Age (#3)	0.032	-0.006	0.007	0.018
	(0.049)	(0.047)	(0.048)	(0.048)
Foreign experience (skilled)	2.683**			2.293*
	(1.218)			(1.191)
(#1)*(#3)			-0.131***	-0.104**
			(0.039)	(0.040)
Skill ratio (#4)		0.060		0.090*
		(0.045)		(0.048)
(#1)*(#4)		0.741***		0.496**
		(0.229)		(0.243)
Log of labor input	0.470***	0.523***	0.469***	0.515***
	(0.044)	(0.043)	(0.042)	(0.045)
Log of capital input	0.254***	0.257***	0.246***	0.239***
	(0.028)	(0.027)	(0.028)	(0.028)
Log scale	0.755***	0.708***	0.746***	0.766***
	(0.083)	(0.078)	(0.076)	(0.085)
Firm age	0.001	0.000	0.001	0.001
	(0.002)	(0.002)	(0.002)	(0.002)
Education	0.025	0.028	0.044**	0.018
	(0.020)	(0.019)	(0.019)	(0.020)
Age squared	-0.001	-0.000	-0.000	-0.000
	(0.001)	(0.001)	(0.001)	(0.001)
Constant	1.604	1.586*	1.796*	1.185
	(1.005)	(0.950)	(0.956)	(0.979)
Observations	371	384	395	363
Adjusted R^2	0.90	0.91	0.91	0.91

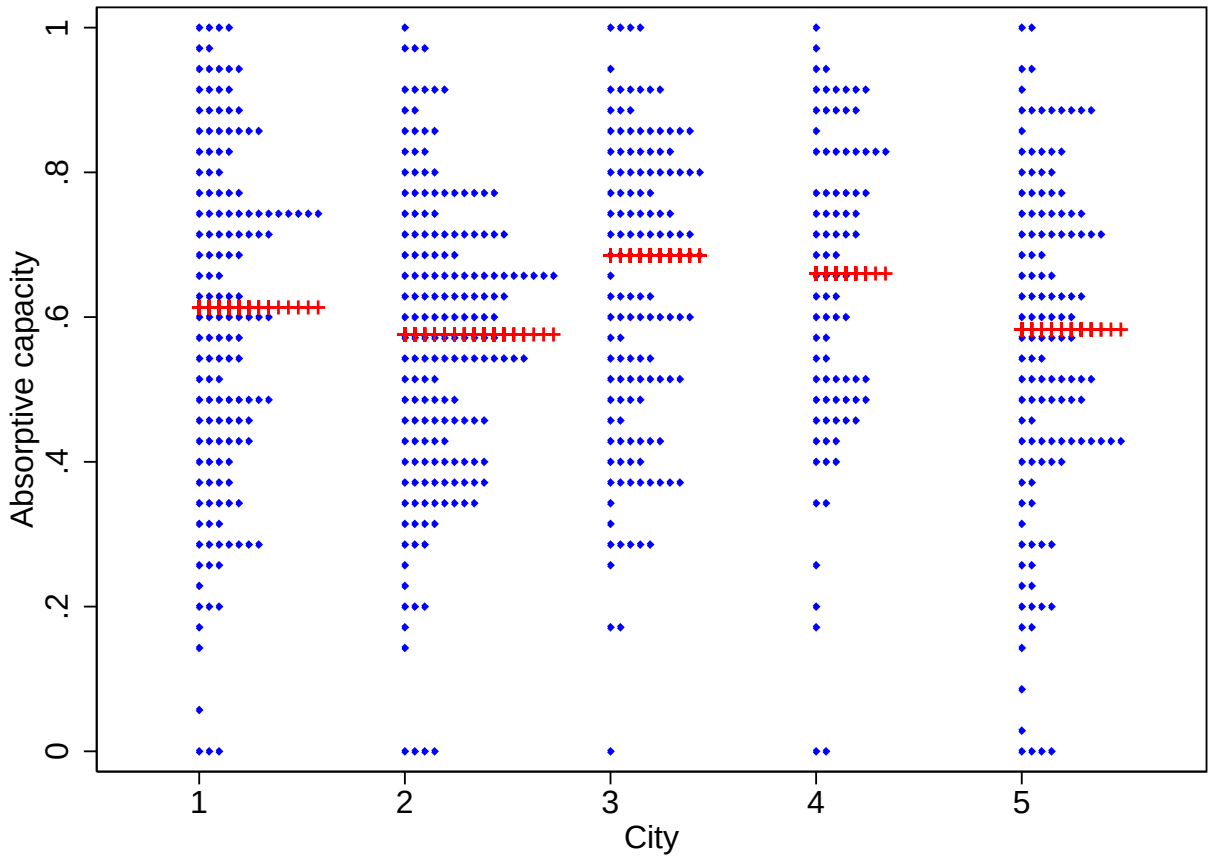
Robust regression estimates with city and industry fixed effects
Dependent variable is log of value added
Standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Figure 1: Cities included in the sample



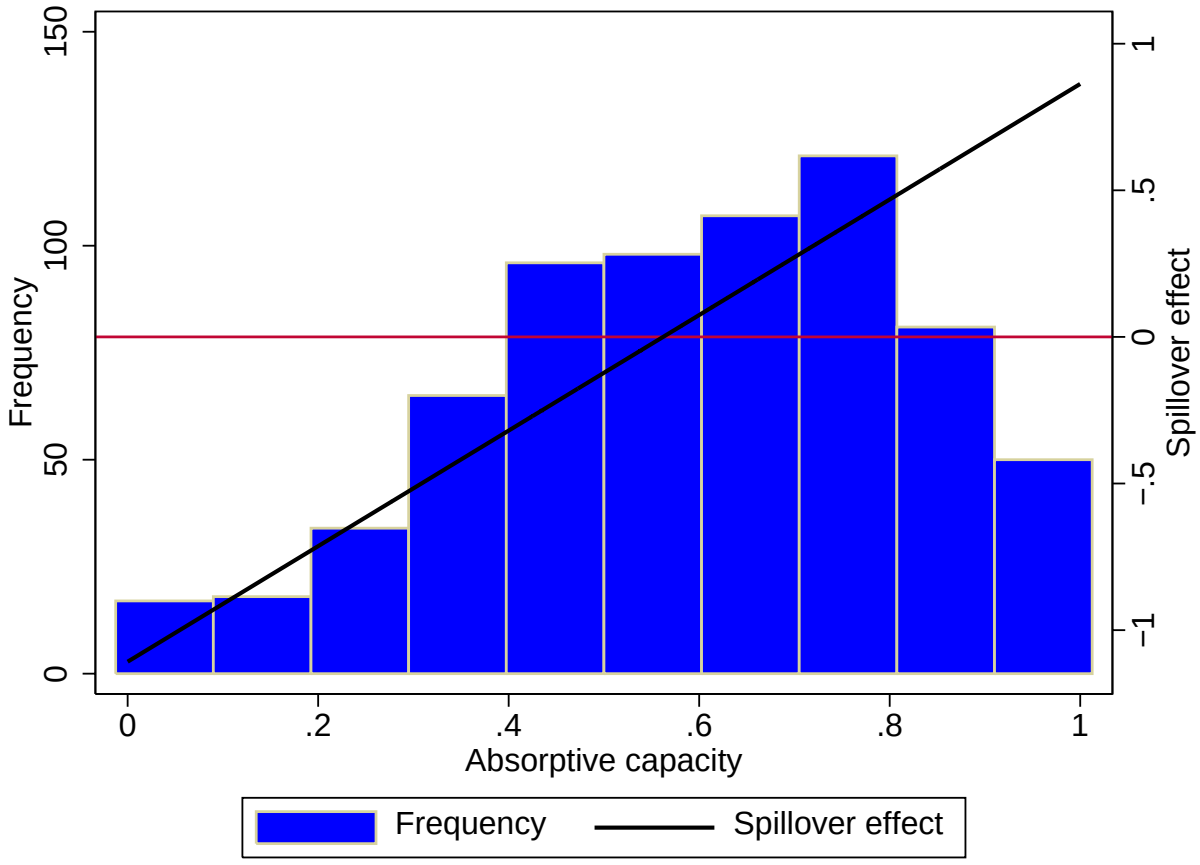
Underlined are the five cities included in the sample

Figure 2: Absorptive capacity and location



See Table 1 for the city codes.
Horizontal lines indicate the median of the distribution within the group.

Figure 3: Spillover effect



Size is measured as firm's employment