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ABSTRACT

We investigate theoretically and empirically the impact of foreign direct investment (FDI) on the product innovation activity of Chinese firms. We extend the existing literature by examining a new type of spillover benefit, as well as new mechanisms by which knowledge spillovers occur. Theoretically, we extend the existing FDI spillover literature that mainly focuses on industry-level spillover effects on productivity by examining FDI spillovers at both firm and location levels, and their impact on product innovations. Using the knowledge-based view of firms we argue that knowledge spillover is likely to occur when foreign firms form joint ventures with local firms and/or when local firms are located in cities with concentrated foreign activities. Empirically, we utilize product innovation information for nearly 40,000 Chinese firms in high technology industries over the period 2000-2005. We find conditional support for our theory. Specifically, we find that in locations with strong clustering of innovative foreign invested firms, local firms benefit from knowledge spillovers and are themselves more likely to introduce product innovations. However, in locations where foreign concentration is measured not by innovations, but by employment or capital local firms do not benefit from foreign knowledge spillovers. These contrasting results suggest that only when foreign invested firms conduct innovative activities can they generate positive locational spillovers. We also find conditional support for knowledge spillover through joint ventures. This spillover benefit becomes weaker if we control for the locational spillover of foreign innovations. These results suggest that relative to location, joint ventures may represent a weaker knowledge spillover mechanism. We discuss the implications of these results for firm strategy and government policy.

Key Words: Chinese firm; FDI spillover; International joint venture; Location; Clusters; Product innovation

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INTRODUCTION

Innovations have long been recognized as the main driver of economic growth and as the ultimate source of competitive advantages for firms and nations (Schumpeter, 1934; Porter, 1990; Grossman and Helpman, 1993). Firms in emerging markets often lack innovative capabilities and typically lag behind western multinational corporations in this regard (Lall, 1992; Bell and Pavitt, 1993). Partially due to their laggard status, some emerging markets such as China have deliberately attempted to attract large amounts of investment by multinational firms that are equipped with advanced technology and management skills. In this study, we assess in depth whether and how FDI generates spillovers that affect the product innovation activity of local (Chinese) firms.

This study contributes to the literature in two major ways. First, we extend the existing literature by analyzing FDI spillovers in terms of innovative activity. Extant empirical studies have mainly focused on the efficiency spillover benefits of FDI, that is, how foreign presence affects the *productivity* of local firms (see Gorodnichenko et al., 2007, for a review). Although these studies, with their focus on productivity, may partially capture the impact of FDI knowledge spillovers on local firms' process innovations, they do not examine directly the impact on innovative activity. In this study we directly investigate the impact of FDI knowledge spillovers on product innovations of local firms. Product innovations are worth studying because they reflect not only a firm's ability to develop new products but also its ability to commercialize

and market the new products (Garcia and Calantone, 2002; Grant, 1996) and represent an important competitive advantage (Lall, 1992; Kim, 1997).

The second contribution of our study is that we examine FDI knowledge spillovers at three levels: industry, firm, and location. While the extant literature has mainly focused on industry-level knowledge spillovers, we argue that industry-level spillovers are only one potential source of knowledge available to local firms. In addition, industry-level spillovers can be positive or negative. This is because at the industry-level, foreign firms may generate positive knowledge spillovers but may also generate negative spillovers by competing with local firms for rare and valuable resources, and for market share. Indeed, in emerging markets the evidence suggests that the negative spillover effect may dominate as most empirical studies that use panel data show a negative or nil impact of foreign presence on the productivity of local firms in the same industry (e.g., Aitken and Harrison, 1999; Gorodnichenko et al., 2007; Meyer and Sinani, 2008).

To gain a better and more complete understanding of the effects of knowledge spillovers, we propose to analyze FDI knowledge spillovers at the firm and location levels, as well as at the industry-level. Specifically, we posit that local firms engaged in joint ventures (JVs) with foreign firms benefit from knowledge spillovers, and that local firms located in areas where there is a strong foreign presence similarly benefit from access to localized knowledge. We support our argument by adopting the knowledge-based view of firms (Kogut and Zander, 1992; Almeida and Kogut, 1999). As we will argue below, the nature of knowledge is often tacit (or non-codified), and such knowledge is difficult to purchase or imitate through observation. Sometimes, acquisition of tacit knowledge requires the active participation of knowledge holders. It follows that tacit knowledge may be easier to obtain at the firm-level (as in a joint venture),

when knowledge transfer is an explicit goal. Similarly, when local firms are located in a city with a large foreign presence in the same industry, they can more easily hire foreign employees or develop business/social networks with foreign firms or with their employees so as to benefit from positive knowledge spillovers. In this way, knowledge is just "in the (near) air", and spillovers are then distance dependent (Jaffe, Trajtenberg, and Henderson 1993; Audretsch and Feldman, 1996; Almeida and Kogut, 1997).

Empirically, we use information on product innovations by over 39,700 Chinese firms in high technology industries in the period 2000-2005, compiled by the National Bureau of Statistics of China, to examine the significance of foreign knowledge spillovers at the industry, firm, and location levels. The rich dataset allows us to measure the three levels of spillover using alternative measures, which adds robustness to our empirical findings. The empirical results provide conditional support for the existence of spillover benefits at the firm and location levels. The exact nature of the benefits depends on the nature of the foreign presence. Our study has important implications on firm strategy and government policy in emerging markets.

THEORY AND HYPOTHESES DEVELOPMENT

The existing literature suggests that foreign direct investment (FDI) can generate two types of benefits for the local economy: *market competition* and *knowledge spillover* (Caves, 1996). First, as foreign firms possess advanced knowledge, they impose strong competitive pressure upon local companies, which provides incentives for local firms to increase their productivity and innovative capacity. Second, foreign firms may generate knowledge spillovers

through demonstration effects, mobility of human resources, supplier-buyer linkages, and international joint ventures. In emerging markets, foreign firms bring technological, managerial, and marketing expertise that often represent the most scarce, inimitable, and valuable knowledge in emerging economies (Luo, 2002). Thus, foreign knowledge spillovers are crucial for improving the innovative capabilities of local firms, at both the process and product levels. To understand these spillovers, we begin with the industry-level analysis that is commonly adopted in the literature, and then analyze the spillover benefits at the firm and location levels, respectively.

Industry-level Spillovers

The extant literature has focused mainly on industry-level horizontal spillovers, that is, on the degree to which foreign presence in an industry improves the productivity of local competitors in that industry. In the context of developing countries, most studies have been unable to identify positive spillover benefits at the industry-level (e.g., studies of Mexico by Blomstrom, 1986; Morocco by Haddad and Harrison, 1993; Venezuela by Aitken and Harrison, 1999; 17 emerging markets by Gorodnichenko et al., 2007). The main reason is that in addition to any positive knowledge spillovers, foreign firms may also generate negative spillovers because they impose strong competitive pressure upon local firms and may produce a crowd-out effect by reducing the resources available to local firms (Aitken and Harrison, 1999). Thus, the industry-level approach provides only a partial analysis of the possibilities for knowledge spillovers.

To further understand how knowledge spillovers occur, we propose to study FDI knowledge spillovers at the firm and location levels because knowledge is more likely to be

transferred through inter-firm interactions or because of geographic proximity. To support this argument, we first examine the characteristics of knowledge as well as the conditions under which knowledge can be transferred. We rely on the knowledge-based views of firms developed in the management literature (Grant, 1996; Kogut and Zander, 1992). This perspective suggests that knowledge is a key competitive asset for firms and is crucial for improving product innovation (Grant, 1996). Knowledge can be divided into two types according to its characteristics: explicit and tacit (Grant, 1996). Explicit knowledge refers to codified information and quantifiable technologies such as patents, whereas tacit knowledge includes technical knowhow, management, and marketing skills that are not easily codified in formulas or manuals but provide "the glues and integrating mechanisms in learning" (Grant, 1996; Dhanaraj et al., 2004). While explicit knowledge is relatively easier to obtain in the market (e.g., licensing), tacit knowledge is more difficult to observe or purchase and can be transferred only through the active involvement of the knowledge holders (Kogut and Zander, 1992; Dhanaraj et al., 2004; Inkpen and Beamish, 1997). Thus, a main challenge for local firms is to gain access to knowledge holders in foreign firms in order to obtain tacit knowledge. Below we argue that FDI at the firm-level through joint ventures and at the location-level provide local firms with relatively easy access to the knowledge holders and thus generate positive knowledge spillovers.

Firm-level Spillovers

Joint ventures have been viewed as a useful tool of learning for firms (Kogut, 1988; Hamel, 1991) and have been found as a more effective mechanism to transfer tacit knowledge than contract-based mechanisms such as licensing (Mowery et al., 1996; Rosenkopf and Almeida, 2003). The importance of joint ventures is more salient in the context of developing countries

(Lane et al., 2001). In a typical international joint venture in a developing country, the foreign partner has advanced technology as well as managerial and marketing knowledge, whereas the local partner provides its knowledge of the local market and consumers (Yan and Gray, 1994). The local partner often has clear learning objectives when joint venturing with the foreign partner (Yan and Gray, 1994) and the local firm is likely to acquire knowledge for two reasons. First, the equity structure in joint ventures aligns the interests of partners and provides incentives for foreign partners to transfer advanced knowledge to improve performance of joint ventures (Beamish and Banks, 1987). Second, the social and structural mechanisms within joint ventures (e.g., provision of training and technology assistance by foreign partners) foster close interactions between partners that inherently facilitate the transfer of knowledge, in particular tacit knowledge, from foreign to local partners (Dhanaraj et al., 2004; Lane et al., 2001; Lyles & Salk, 1996). Extant literature has provided some empirical evidence to support joint ventures as a useful mechanism for knowledge acquisition by local firms in emerging markets. Using survey data of international joint ventures in Hungary, several studies have found that the commitment, support, and assistance of foreign partners as well as the proper learning structures and processes in joint ventures have all contributed to knowledge acquisition by the joint ventures (Dhanaraj et al., 2004; Lane et al., 2001; Lyles & Salk, 1996). Similarly, Hobday (1995), based on case analyses of several firms in East Asia, found that technology transfer through joint ventures provides opportunities to adapt foreign technology to local applications, and this adaptation process improves local firms' knowledge acquisition. Hence, we reach the following hypothesis regarding the firm-level spillover effect on product innovations by local firms.

H1 (firm-level spillovers): Joint venturing with a foreign firm will have a positive effect on product innovations by a local firm.

Location-level Spillovers

Locating in a city with concentrated foreign investments provides another mechanism for local firms to benefit from foreign knowledge spillovers. The idea that location is an important source of competitive advantage for firms has been well recognized in the literature (Marshall, 1920; Porter, 1990; Almeida, 1996; Frost and Zhou, 2000; Globerman et al., 2005). The underlying mechanism is that by co-locating their production facilitates, firms can gain from proximate supplies, heightened demand, and more importantly, flow of valuable knowledge (Marshall, 1920; Almeida and Kogut, 1999). The literature has provided strong evidence to support the idea that knowledge is essentially localized, and knowledge spillover occurs strongly within a specific location (Jaffe, Trajtenberg, and Henderson, 1993; Audretsch and Feldman, 1996). For instance, Almeida and Kogut (1999) studied the semiconductor clusters in the United States and found that knowledge is highly localized within each cluster and seldom spills across locations. Similarly, Globerman et al. (2005) studied IT clusters in Canada and found that IT knowledge is highly localized in the Toronto area, and the greater the geographic distance from the Toronto area, the less likely that firms will benefit from knowledge spillovers. These studies indicate that geographic proximity reduces the costs and increases the frequency of personal contacts that build social relations between companies in a location, thereby facilitating the flow of knowledge.

This evidence suggests that local firms can acquire substantial knowledge from foreign firms in cities with concentrated foreign activities. Specifically, local firms can acquire knowledge, particularly tacit knowledge, through hiring talented employees from foreign firms or developing valuable networks with foreign firms in the same location. The high mobility of

experienced experts across firms has been found to account for knowledge transfer and innovation diffusion (Almeida and Kogut, 1999; Song et al., 2005). Such mobility does not simply provide a one-time transfer of information, but may also facilitate the transfer of capabilities, allowing further knowledge building (Kim, 1997). Moreover, inter-firm linkages such as supplier-customer networks serves as a critical mechanism for the exchange of tacit knowledge and for new product development (Saxenian, 1991). Hence, we reach the following hypothesis regarding location-level spillovers on product innovations by local firms.

H2 (location-level spillovers): Foreign presence in a city will have a positive effect on product innovation by local firms in that city.

METHOD

Data description

To test these hypotheses, we construct a panel data sample of 39,763 Chinese firms by using the 2000-2005 editions of *Annual Census of Industrial Enterprises* (hereafter referred to as the Census data). The Census data, constructed by the National Bureau of Statistics of China (NSBC), contains detailed information about a company's operational profile, including total product value, new product value, number of employees, equity investment by owners and so on. The NSBC has endeavored to maintain high consistency in data collection across time, industries, and regional areas (Zhou and Li, 2008). The Census includes firms with an assessed sales capacity of no less than 5 million Chinese Yuan per year. Chinese firms in our sample are defined as those with at least 50% Chinese ownership. Thus, they include 100% Chinese owned

firms, international joint ventures with majority Chinese equity, and 50/50 joint ventures between Chinese and foreign firms.

We select eight high-technology industries in China for analysis: medical and pharmaceutical products, rubber products, ordinary machinery, special purpose equipment, transport equipment, electronic equipment and machinery, electronic and telecommunications, and instruments and meters. These high-technology industries were selected according to two criteria: one was the list of high-technology industries defined by the Ministry of Science and Technology of China, and the other was that these industries were active in product innovations relative to other industries according to the Census data. Since one objective of our study is to analyze the impact of FDI on product innovation by local firms, including industries with low or no innovative activities will potentially add more unobservable cross-industry heterogeneity without providing more insights.

Variables and measures

Dependent variable.

Following previous research (Zhou and Li, 2008), we construct *product innovation*$_{it}$ as the ratio of new product value to total output value of a Chinese firm *i* at year *t*. According to the NSBC, new products are defined in the Census data as those new to the Chinese market, which either (1) adopt completely new scientific principles, technologies, or designs, or (2) are substantially improved in comparison with existing products in terms of performance and functionality, through significant changes in structure, materials, design, or manufacturing processes (China Statistical Yearbook, 2006: 292). Note that a firm's new products are subject to

local government certification, which is valid for up to three years (China Statistical Yearbook, 2006: 292).

Independent variables.

We have three measures for foreign presence in an industry. *Foreign emp_ind* is calculated as the ratio of the employment by foreign invested firms to the total employment of the industry. Here, foreign invested firms are those with at least 5% foreign equity share.[1] *Foreign cap_ind* is measured as the ratio of the capital investment by foreign invested firms to the total capital investment of the industry. *Foreign inno_ind* is the ratio of new product value by foreign invested firms to the total product value of the industry. In this study, industries are classified according to the three-digit industry codes in the Census data, which are similar to the four-digit SIC codes in the United States[2].

Similarly, we construct a set of three alternative measures for foreign presence in a city. These measures capture how foreign invested firms contribute to the total employment, capital, or production in a city. Specifically, *Foreign emp_city1* is calculated as the ratio of the employment by foreign invested firms of a city-industry combination to the total employment of that city-industry combination. *Foreign cap_city1* is calculated as the ratio of the capital investment by foreign invested firms of a city-industry combination to the total capital investment of that city-industry combination. *Foreign inno_city1* is defined as the ratio of new product value by foreign invested firms of a city-industry combination to the total product value of that city-industry combination.

[1] We also used 50% foreign equity share to define foreign invested firms and the results remain largely the same.
[2] In 2003 the NBSC changed its industry classification system. We converted all pre-2003 industry codes according to the 2003 standard.

We also construct another set of measures for foreign presence in a city. Different from the first set that captures the extent to which foreign invested firms contribute to a city's employment, capital, or production, the second set captures in which cities foreign invested firms in an industry are concentrated. Specifically, *Foreign emp_city2* is calculated as the ratio of the employment by foreign invested firms of a city-industry combination to the total employment of the industry. *Foreign cap_city2* is calculated as the ratio of the capital investment by foreign invested firms of a city-industry combination to the total capital investment of the industry. *Foreign inno_city2* is defined as the ratio of new product value by foreign invested firms of a city-industry combination to the total product value of the industry. To accommodate the fact that foreign spillovers may take some time to realize, we follow the literature by using a one-year lag for all the measures of foreign presence at the industry as well as the city level.

To measure international joint ventures, we define *JV*, a dummy variable taking the value of 1 if a Chinese firm is engaged in an international joint venture and 0 otherwise. In this study, since we focus on Chinese firms, the foreign partner's equity share is between 5% and 50%.[3] Besides the dummy variable, we also use foreign equity share in a firm to capture the effect of international joint ventures in the robustness tests.

Control variables.

We include five firm-level control variables. *Labor quality* is measured by the log of the average wage rate of a firm, that is, the total wage paid by a firm divided by its total employment. Labor quality is expected to positively affect product innovation. We measure *SOE* as a dummy variable that is equal to 1 if the state equity share is higher than that of any other type of ownership recorded in the Census, SOEs may have more product innovations because they

[3] Once the foreign partner's equity share is above 50%, the firm is considered as a foreign firm, thus it is excluded from our regression analysis. However, these firms' information is used in constructing the foreign presence variables.

possess more financial and labor resources for innovations than firms that are not state owned (Zhou and Li, 2008). Also, we control for *size,* proxied by the logarithm of total assets of a firm, and *age*, computed by the year of census minus the opening year of the firm. Firm size may be a proxy for economies of scale and thus we expect it to have a positive impact on a firm's product innovation. The effect of the age variable is more ambiguous—a longer history of operation may suggest stronger capability in innovation, but the older firms may be more likely to inherit the legacies of the centrally-planned economy in China and thus be less innovative. The last firm-level control variable is *productivity gap*, measured as the average labor productivity of wholly foreign owned firms in China divided by the labor productivity of a local firm. Productivity gap is used to capture the technology level of a local firm in comparison with foreign firms. We use a one-year lag measure for this variable and predict that it has a negative effect on product innovation.

We also use two industry-level variables to control for the effect of industry and market structure.[4] First, we employ a standard Herfindahl measure (Raghunathan, 1995) for *market concentration* by utilizing firm-level information for local market sales (total sales minus export value) contained in the Census data. For a given firm *i* in industry *k*, we calculated the Herfindahl measure as follows:

$$Market\ concentration_{ik} = \sum_{i=1}^{n_k} \left(Sales_{ik} / \sum_{j=1}^{n_k} Sales_{jk} \right)^2$$

The effect of market concentration is ambiguous. It may have a negative effect because firms may face less competitive pressure to improve product innovations in more concentrated

[4] When constructing both industry-level variables, information from all firms, including Chinese and foreign firms, is used.

industries (Davies & Caves, 1987), while on the other hand, firms in industries with higher concentration may possess more resources, which facilitates more product innovations.

The second industry control is *industry innovation*, which is measured as the ratio of new product value to total product value of an industry. We expect industry innovation to have a positive effect on product innovation of a local firm. We also construct *city innovation* to capture potential differences across cities. This variable is computed as the total new product value of a city-industry combination divided by the total new product value of the industry. Last, we include a set of industry dummy variables, according to two-digit industry codes, to control for other possible cross-industry heterogeneity. We also include a set of year dummies to control for any temporal effects.

Estimation issues

A notable feature of the data is that a large proportion of firms in our sample had no new product in some or all sampled years. Denote the (unconstrained) optimal product innovation for firm *i* at time *t* by $product\ innovation_{it}^{*}$, which has the following functional form,

$$product\ innovation_{it}^{*} = x_{it}^{'}\beta + u_i + \varepsilon_{it}, \qquad (1)$$

where $\mathbf{x}_{it}$ is a vector of covariants, u_i is the unobserved cross-firm heterogeneity, and ε_{it} is the error term. However, $product\ innovation_{it}^{*}$ can be fully observed only when it is greater than zero. Hence, what we actually have in the sample is the variable $product\ innovation_{it}^{*}$ such that

$$product\ innovation_{it} = \begin{cases} product\ innovation_{it}^{*} & if\ \ product\ innovation_{it}^{*} > 0, \\ 0 & if\ \ product\ innovation_{it}^{*} \le 0. \end{cases}$$

To accommodate the censored nature of the dependent variable, we use the Tobit model to estimate equation (1). A random effect method is applied. The reasons to apply a random, rather than a fixed effects model are twofold. First, as Maddala (1983) argues, since both u_i and ε_{it} are assumed to represent unobserved factors that have an impact on the dependent variable, it is hard to justify treating ε_{it} as a random variable but u_i as a fixed parameter. Second, the traditional fixed effects method in linear models cannot be applied to nonlinear models (e.g., the Tobit model used in our study). Unconditional fixed effects models with firm-specific dummy variables will yield biased estimator for the coefficients.

RESULTS AND IMPLICATIONS

Descriptive statistics

Table 1 presents the correlation matrix and descriptive statistics for the key variables. During 2000-2005, the average new product ratio (product innovation) is 5.6% for Chinese firms. As for foreign presence in an industry, the average percentage of foreign employment in an industry is 17.4% and that of foreign capital in an industry is 26.4%, whereas new product value produced by foreign invested firms in an industry accounts for only 1.7% of total product value in the industry. These figures suggest that despite the strong foreign presence in an industry, the majority of foreign activities in China are not concentrated on new product development.

As for the first set of measures for foreign presence in a city, Table 1 suggests that the average percentage of foreign employment in a city is about 10%, and that of foreign capital in a city is about 14.8%, while new product value produced by foreign invested firms accounts for only 1% of total product value of an industry in a city. Similar to the measures for foreign

presence in an industry, these figures indicate that although there is strong foreign presence in a city, the majority of foreign activities are not focused on product innovations.

Table 1 also suggests that about 7% of Chinese firms in our sample are joint ventures with foreign partners according to our previous definition. With the privatization of the Chinese state-owned sectors, only 13.6% of the firms in our sample were still controlled by the state during the period of 2000-2005. The average firm age is 15.5 years. The average productivity gap of Chinese firms is 6.44, which implies that many domestic Chinese firms still lag behind wholly foreign owned firms operating in China in terms of productivity.

Among the first set of measures for foreign presence in a city, the employment and capital measures are negatively correlated with product innovation, but the innovation measure is positively correlated with product innovation. The contrasting signs show some support for the use of these alternative measures. The correlation table also shows that the employment and capital measures of foreign presence in a city are highly correlated (0.85 or 0.81 depending on different measures), but the correlation between foreign employment and innovation in a city is relatively low (0.33 or 0.27 depending on different measures). These correlations indicate that foreign employment/capital may be concentrated in different cities from foreign innovation.

Regression results

Tables 2, 3, and 4 summarize the results based on the Tobit random effects regression technique. Tables 2 and 3 are based on the whole sample while Table 4 is based on various sub-samples. Table 2 uses the first set of measures for foreign presence in a city while Table 3 uses the second set. We first analyze the results of the three models in Table 2. Model 1 is based on employment measures of foreign presence, model 2 on capital measures, and model 3 on

innovation measures. All three models indicate that foreign presence in an industry, regardless of the measure, has no significant effect on product innovations of local firms. This result is not surprising given that industry-level spillover captures both knowledge transfer and the market competition effect. Although there are some knowledge spillover benefits, foreign competitors in an industry may reduce the resources available to local firms and thus mitigate the industry-level spillover benefits for local firms.

Regarding firm-level spillovers, models 1 and 2 show that joint venturing with foreign firms contributes to more product innovations of local firms, a result which shows support for Hypothesis 1. Interestingly, the results of model 3 do not indicate a significant impact of joint ventures, although the sign of the estimate remains positive. A similar pattern is observed in Table 3 when we use the second set of measure for foreign presence in a city. As we shall discuss later, this may suggest that the effectiveness of joint ventures as a knowledge transfer mechanism is less salient when foreign activities in a city are innovation-oriented.

Regarding the locational spillover effects of FDI, the results are mixed. Recall that the measures in Table 2 are used to capture the extent to which foreign firms contribute to the employment, capital, and innovations in a city. Specifically, models 1 and 2 show that when foreign presence in a city is measured by employment or capital, it, surprisingly, has a negative impact on product innovations by local firms. On the contrary, model 3 shows that foreign innovation in a city has a significant positive effect on product innovations of local firms. Only the result in model 3 provides support for Hypothesis 2, that is, foreign presence in a city positively affects product innovations of local firms in the city.

The results in Table 3 further confirm those in Table 2. In Table 3, the measures for foreign presence in a city are different from those in Table 2, and they capture where foreign

invested firms in an industry are concentrated. Models 4, 5, and 6 include measures at the levels of employment, capital, and innovation, respectively. Models 4 and 5 indicate that in cities with concentrated foreign employment or capital, local firms tend to have fewer product innovations. Model 6, however, indicates that local firms tend to have more product innovations in cities with strong foreign innovations. The results with respect to JVs are also similar to those in Table 2.

We further divide the whole sample into five subsamples and present the results in Tables 4a and 4b. Tables 4a and 4b suggest that in each subsample industry (machinery, transportation, electronics, rubber, pharmaceuticals), the results for locational spillover are generally consistent with those in Tables 2 and 3.[5] Thus, tables 4a and 4b further confirm the contrasting patterns regarding locational spillover.

These contrasting results regarding locational spillover have the following implications. First, Chinese cities with a high concentration of foreign employment or capital tend to have a low presence of foreign innovation. To further illustrate this, we list in Table 5 the top 10 cities in two industries (electronics equipment and telecommunications equipment) where foreign employment or innovation contributes substantially to the employment or production in a city in China.[6] Table 5 shows that for each industry, the top 10 cities for foreign employment are very different from those for foreign innovations.

The second implication of the contrasting results is that only when local firms are located in cities with strong foreign innovations can they benefit from the knowledge spillover. If local Chinese firms are located in cities with a high presence of foreign employment or capital, they actually may have fewer product innovations. A possible explanation is that, in those cases, local

[5] In the subsamples, machinery industry includes ordinary machinery and special purpose equipment, while electronics industry includes electronic equipment and machinery, electronic and telecommunications, and instruments and meters. We also use the second set of measures for foreign presence in a city and find similar patterns of results as in tables 4a and 4b.
[6] The top 10 cities are obtained according to the second set of measures for foreign presence in a city.

firms likely become suppliers for foreign invested firms and are expected to produce standardized components to achieve efficiency and economy of scale. As a result, local firms are less motivated to develop new products and become passive in terms of product innovation. It is also possible that the strong competition effect posed by foreign invested firms in a city reduces valuable resources for local firms in the city and thus reduces their ability to develop new products. These results also indicate that the type of foreign activity matters in knowledge spillovers—only when foreign firms conduct innovative activities will they generate positive innovation spillovers.

The third implication from these results, combined with the previous findings concerns joint ventures. We find that in general joint ventures may be used as an effective knowledge transfer mechanism, but the impact becomes less salient compared to the locational effect when foreign invested firms are active in innovative activities. In this case, the spillover effect from neighboring foreign invested firms is so strong that it can overshadow the benefits brought by joint ventures. In other words, where innovative foreign invested firms cluster in a location, joint ventures represent a weaker knowledge spillover mechanism compared with locational effects. This is probably because foreign partners are afraid of losing their core competitive knowledge to local partners and restrain the transfer of their most advanced technology to the joint ventures.

Regarding joint ventures, Tables 4a and 4b also suggest that the impact of joint ventures varies across industries. Joint ventures generate positive spillovers in the machinery and rubber industry but not in the transportation, electronics, and pharmaceutical industries. We also find some interesting results for the control variables. Firms with strong labor quality tend to have more product innovations than firms with weak labor quality. Large or old firms have more product innovations than small or young firms. This is probably because large or old firms tend

to have more resources for innovative activities. We also find that state owned enterprises have more product innovations than non-state owned enterprises. This is probably because state owned companies often possess abundant financial and human resources, have strong government support, and own access to external resources such as bank loans (Tan and Peng, 2003). These resources are particularly valuable in emerging markets such as China, which is characterized by the absence of sophisticated financial markets and regulatory systems (Khanna and Palepu, 1997). Last, city innovation has a positive effect on product innovations of firms in the city, which suggests that localized knowledge spillovers are not confined to foreign invested firms.

CONCLUSION

Contributions

In this study, we have examined theoretically and empirically the impact of FDI knowledge spillovers on product innovation by Chinese firms. Unlike most previous studies that have focused on the impact of FDI spillovers on productivity of local firms (Gorodnichenko et al., 2007), we focus on product innovation. We also extend the existing literature by focusing not only on industry-level spillovers but by also investigating knowledge spillovers at the firm and location levels. Thus, we examine a new type of spillover benefit, and new mechanisms by which knowledge spillovers occur.

Theoretically, we have introduced the knowledge-based view of firms into the FDI spillover literature (Kogut and Zander, 1992; Almeida and Kogut, 1999), and linked it to the literature on joint ventures and the locational benefits of clustering. The knowledge-based view

indicates that knowledge is often tacit in nature, and successful knowledge transfer requires close interactions with knowledge holders. We have then argued that such interactions are likely to occur when local firms engage in joint ventures with foreign firms and/or when local firms are located in cities with concentrated foreign activities. Thus, by adding the firm- and location-level of analysis, we advance the understanding of potential benefits to local firms arising from knowledge spillovers generated by FDI.

Empirically, we have utilized information on a panel of over 39,700 Chinese firms in high technology industries to test the impact of foreign presence at the industry, firm, and location levels on the product innovation activity of local Chinese firms. We have found conditional support for the existence of positive knowledge spillovers within joint ventures and from locational proximity.

First, the effects of locational spillovers on innovations by local firms vary contingent on the activities that foreign firms conduct. We have found that in cities where foreign firms concentrate on innovative activities, local firms benefit from knowledge spillovers and introduce more product innovations. In contrast, in cities with a large proportion of foreign employment or capital (but a relatively lower concentration of foreign innovations), local firms tend to have lower product innovations. A plausible explanation is that in these cities, local firms likely become suppliers to foreign invested firms and focus on producing standardized inputs for them. As a result, local firms pay less attention to new product development. Moreover, a large presence of less innovative foreign firms in a city may generate weak knowledge spillovers but strong competition effects that limit local firms' resources for innovative activities. Therefore, the occurrence of innovation spillover depends on the type of activities undertaken by foreign firms. Only when foreign firms focus on innovative activities do they generate positive

knowledge spillovers. Importantly, these results are obtained after controlling for the innovative capacity of the industry and the location.

The results also suggest that joint ventures represent a weaker knowledge transfer mechanism as compared to locations. If we do not control for the locational spillovers of foreign innovations, engaging in joint ventures leads to more product innovations. However, the positive effect of joint ventures becomes less salient when local firms are located in a city with strong foreign innovations. In other words, spillover benefits associated with co-located foreign invested firms may be stronger than the benefits brought by joint ventures. The weaker effect of joint ventures reflects some fundamental issues in joint ventures, that is, foreign partners may be reluctant to transfer the most advanced technology to local partners due to the concern that local partners may misuse the technology for its own benefits or become strong competitors after the joint ventures are terminated.

Strategic and policy implications

Our study has important implications for the knowledge acquisition strategies of local firms. If a local firm aims to improve its capability in product innovation, it can choose to locate (or to establish subsidiaries) in cities with strong foreign (and domestic) innovative activities. This strategy may be more effective than entering a JV. Local firms should carefully distinguish cities with a large presence of foreign firms measured in terms of employment or capital, and those where foreign firms concentrate their innovative activities. These may not be the same. For example, Table 5 shows that for the electronic equipment industry in China, the top 10 cities with concentrated foreign employment are quite different from the top 10 cities with strong foreign innovations.

Thus, locational choice is an important strategic variable for Chinese firms. Choosing the wrong location may result in a negative impact on the on product innovations by local firms. Therefore, local firms should consider both the innovative potential of the city, and the innovative activities of foreign firms, in order to benefit from location-based knowledge spillovers.

Although the literature has always suggested that ownership is an important strategic choice, our study suggests a more nuanced approach to JV benefits. Knowledge acquisition through JVs is more likely when such knowledge is less available by other means, including location. This can vary by industry. Thus, local Chinese firms that engage in joint ventures with foreign firms are more likely to improve product innovation in industries such as the machinery and rubber industries. However, local firms should also understand that joint venturing with foreign firms might be a weaker knowledge acquisition mechanism compared with locating in a city with concentrated foreign innovations.

Our study has important implications for government policy in emerging markets. First, governments in emerging economies should encourage the formation of innovation clusters in the domestic markets. We have found that innovation clusters contribute significantly to product innovations of local firms. Government in emerging economies such as China has long supported the establishment of science parks, incubators and facilitated the development of regional clusters of high value-added activities. Our study shows strong support for such a policy.

Second, governments in emerging markets need to design policies to encourage foreign firms to expand the innovative dimensions of their activities. Many foreign firms in emerging economies such as China are interested in exploiting low labor costs rather than performing innovative activities. Our study shows that local firms are less likely to benefit from foreign

knowledge spillovers if the co-located foreign firms do not concentrate on innovative activities. A large presence of foreign firms in a city may even generate negative spillovers on innovations by local firms. Therefore, it is quite urgent for government in emerging economies to attract foreign firms into innovation clusters by providing an institutional environment that facilitates foreign innovations.

An important limitation of this study is that we focus on product innovations. While product innovations are certainly important, they do not cover the full range of innovative activities undertaken by firms. In particular we ignore process innovations. In addition the definition of a new product innovation may be too broad. Thus future studies should attempt to develop broader and more sophisticated measures of innovative activity. Another limitation is that we only consider horizontal knowledge spillovers at the industry or location levels but do not control for knowledge spillovers through vertical linkages such as forward and backward linkages. Future studies should take into consideration the impact of vertical linkages with foreign firms on innovations of local firms.

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Table 1: Descriptive Statistics and Correlation Matrix

	Variables	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	Product innovation	0.056	0.18	1																		
2	JV	0.070	0.25	0.04	1																	
3	Foreign emp_ind	0.174	0.14	0.05	0.11	1																
4	Foreign cap_ind	0.264	0.15	0.01	0.10	0.89	1															
5	Foreign inno_ind	0.017	0.02	0.05	0.08	0.59	0.59	1														
6	Foreign emp_city1	0.100	0.19	-0.01	0.11	0.33	0.30	0.23	1													
7	Foreign cap_city1	0.148	0.23	-0.02	0.18	0.30	0.31	0.21	0.85	1												
8	Foreign inno_city1	0.010	0.05	0.08	0.05	0.15	0.12	0.16	0.33	0.27	1											
9	Foreign emp_city2	0.001	0.01	0.00	0.06	0.27	0.23	0.17	0.48	0.40	0.13	1										
10	Foreign cap_city2	0.002	0.01	0.02	0.08	0.25	0.25	0.17	0.51	0.52	0.19	0.81	1									
11	Foreign inno_city2	0.000	0.00	0.07	0.04	0.16	0.13	0.17	0.23	0.17	0.66	0.27	0.29	1								
12	Labor quality	2.167	0.69	0.11	0.12	0.07	0.06	0.05	0.15	0.17	0.08	0.07	0.11	0.08	1							
13	Size	9.735	1.37	0.26	0.14	0.01	-0.05	0.07	-0.01	-0.02	0.03	0.02	0.04	0.04	0.18	1						
14	Age	15.52	14.21	0.08	-0.07	-0.13	-0.14	-0.07	-0.10	-0.12	0.00	-0.07	-0.07	-0.01	-0.11	0.29	1					
15	SOE	0.136	0.34	0.07	0.01	-0.06	-0.10	-0.02	-0.05	-0.09	0.02	-0.04	-0.04	0.01	-0.10	0.19	0.39	1				
16	Productivity gap	6.439	510.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.02	0.00	0.02	0.01	1			
17	Market concentration	0.004	0.01	0.04	0.00	-0.02	-0.08	0.00	-0.01	-0.03	0.00	0.02	0.01	0.02	0.03	0.10	0.04	0.08	0.00	1		
18	Industry innovation	0.134	0.06	0.08	0.00	-0.12	-0.26	0.32	0.01	-0.02	0.07	0.02	0.00	0.05	0.04	0.15	0.08	0.11	0.01	0.31	1	
19	City innovation	0.011	0.03	0.13	0.02	0.07	0.07	0.11	0.02	0.02	0.18	0.17	0.29	0.35	0.10	0.10	-0.02	0.00	0.00	0.04	0.05	1

Table 2. The Impact of FDI on Product Innovations of Chinese Firms, 2000-2005: Tobit Random Effects Models (based on the first set of measures for foreign presence in a city)

	Model 1	Model 2	Model 3
	Employment	Capital	Innovation
Foreign emp_ind	0.029		
	(0.75)		
Foreign emp_city1	-0.189***		
	(7.94)		
Foreign cap_ind		0.034	
		(1.05)	
Foreign cap_city1		-0.169***	
		(8.57)	
Foreign inno_ind			-0.068
			(0.23)
Foreign inno_city1			0.540***
			(7.51)
JV	0.023*	0.032**	0.012
	(1.88)	(2.56)	(0.94)
Labor quality	0.024***	0.025***	0.020***
	(5.19)	(5.34)	(4.28)
Size	0.187***	0.187***	0.188***
	(59.27)	(59.18)	(59.51)
Age	0.002***	0.002***	0.002***
	(6.37)	(6.37)	(6.56)
SOE	0.018**	0.017*	0.019**
	(2.07)	(1.94)	(2.16)
Market concentration	-0.128	-0.134	-0.070
	(0.53)	(0.55)	(0.29)
Industry innovation	0.526***	0.529***	0.517***
	(7.06)	(7.02)	(6.87)
City innovation	1.420***	1.424***	1.342***
	(15.09)	(15.12)	(14.12)
Productivity gap	-0.000	-0.000	-0.000
	(1.20)	(1.25)	(1.21)
Constant	-2.599***	-2.597***	-2.606***
	(66.91)	(66.39)	(67.61)
Observations	86919	86919	86919
Number of obs.	39763	39763	39763
Wald Chi2 statistic	5533.70	5541.21	5536.67

Absolute value of z statistics in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%
Coefficient estimates for year and industry dummy variables not reported

Table 3. The Impact of FDI on Product Innovations of Chinese Firms, 2000-2005: Tobit Random Effects Models (based on the second set of measures for foreign presence in a city)

	Model 4	Model 5	Model 6
	Employment	Capital	Innovation
Foreign emp_ind	0.019		
	(0.75)		
Foreign emp_city2	-7.399***		
	(12.28)		
Foreign cap_ind		0.026	
		(1.27)	
Foreign cap_city2		-5.839***	
		(11.65)	
Foreign inno_ind			-0.243
			(1.38)
Foreign inno_city2			4.149**
			(2.13)
JV	0.011	0.013*	0.006
	(1.42)	(1.71)	(0.76)
Labor quality	0.030***	0.032***	0.029***
	(9.47)	(9.83)	(9.04)
Size	0.132***	0.132***	0.132***
	(74.45)	(74.42)	(74.34)
Age	0.001***	0.001***	0.002***
	(9.86)	(10.17)	(10.28)
SOE	0.010*	0.010*	0.011*
	(1.70)	(1.70)	(1.85)
Market concentration	-0.224	-0.254*	-0.244
	(1.50)	(1.70)	(1.61)
Industry innovation	0.429***	0.433***	0.433***
	(9.53)	(9.49)	(9.58)
City innovation	1.242***	1.322***	1.088***
	(22.28)	(22.97)	(19.15)
Productivity gap	-0.000	-0.000	-0.000*
	(1.64)	(1.63)	(1.67)
Constant	-1.783***	-1.790***	-1.777***
	(82.29)	(81.69)	(83.30)
Observations	86919	86919	86919
Number of obs.	39763	39763	39763
Wald Chi2 statistics	9312.40	9270.98	9211.65

Absolute value of z statistics in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%
Coefficient estimates for year and industry dummy variables not reported

Table 4a. The Impact of FDI on Product Innovations of Chinese Firms in Subsamples, 2000-2005: Tobit Random Effects Models

	Machinery			Transportation			Electronics		
	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12	Model 13	Model 14	Model 15
	Employment	Capital	Innovation	Employmen	Capital	Innovation	Employment	Capital	Innovation
Foreign emp_ind	0.176***			0.082			-0.035		
	(3.21)			(0.92)			(0.96)		
Foreign emp_city1	-0.147***			-0.084**			-0.191***		
	(5.52)			(2.29)			(9.61)		
Foreign cap_ind		0.152***			0.012			-0.021	
		(4.27)			(0.20)			(0.66)	
Foreign cap_city1		-0.114***			-0.036			-0.184***	
		(6.20)			(1.21)			(10.47)	
Foreign inno_ind			0.118			0.838**			-0.595**
			(0.33)			(2.18)			(2.07)
Foreign inno_city1			0.305***			0.539***			0.416***
			(3.55)			(4.78)			(6.76)
JV	0.030**	0.038***	0.027**	-0.016	-0.015	-0.023	-0.003	0.008	-0.019
	(2.46)	(3.03)	(2.16)	(0.76)	(0.73)	(1.14)	(0.20)	(0.64)	(1.48)
Labor quality	0.028***	0.029***	0.024***	0.002	0.000	-0.003	0.039***	0.039***	0.031***
	(5.41)	(5.56)	(4.73)	(0.21)	(0.05)	(0.35)	(6.41)	(6.43)	(5.24)
Size	0.128***	0.129***	0.129***	0.137***	0.137***	0.137***	0.130***	0.129***	0.131***
	(46.47)	(46.51)	(46.73)	(33.84)	(33.78)	(33.84)	(38.45)	(38.22)	(38.88)
Age	0.002***	0.002***	0.002***	0.001***	0.001***	0.001***	0.002***	0.002***	0.002***
	(8.35)	(8.45)	(8.40)	(3.45)	(3.45)	(3.90)	(5.42)	(5.51)	(5.50)
SOE	0.005	0.004	0.005	0.013	0.012	0.015	0.039***	0.037***	0.043***
	(0.62)	(0.51)	(0.52)	(0.96)	(0.93)	(1.12)	(3.30)	(3.10)	(3.64)
Market concentration	-4.652***	-4.358***	-4.954***	0.121	0.143	0.247	-7.049***	-7.193***	-8.071***
	(3.53)	(3.28)	(3.61)	(0.73)	(0.86)	(1.47)	(5.99)	(6.17)	(7.23)
Industry innovation	0.341***	0.374***	0.310***	0.183	0.136	0.142	0.814***	0.821***	0.943***
	(5.42)	(5.84)	(4.62)	(1.48)	(1.11)	(1.33)	(8.16)	(8.16)	(10.00)
City innovation	2.090***	2.070***	2.049***	0.282***	0.288***	0.242***	1.509***	1.494***	1.344***
	(15.82)	(15.66)	(15.43)	(3.25)	(3.34)	(2.75)	(14.63)	(14.50)	(12.70)
Productivity gap	-0.002***	-0.002***	-0.002***	-0.006***	-0.006***	-0.007***	0.000*	0.000	0.000
	(3.31)	(3.39)	(3.39)	(4.23)	(4.28)	(4.40)	(1.68)	(1.63)	(1.62)
Constant	-1.715***	-1.733***	-1.701***	-1.801***	-1.783***	-1.809***	-1.723***	-1.710***	-1.753***
	(53.48)	(52.83)	(54.47)	(32.56)	(31.48)	(35.76)	(42.95)	(42.12)	(45.64)
Observations	35442	35442	35442	14350	14350	14350	26214	26214	26214
Number of firms	16737	16737	16737	6913	6913	6913	12615	12615	12615
Wald Chi2 statistics	2281.14	2285.21	2271.24	1008.65	1007.77	1016.86	1725.17	1733.99	1711.61

Absolute value of z statistics in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%; Coefficient estimates for year and industry dummy variables not reported

Table 4b. The Impact of FDI on Product Innovations of Chinese Firms in Subsamples, 2000-2005: Tobit Random Effects Models

	Rubber			Pharmaceuticals		
	Model 16	Model 17	Model 18	Model 19	Model 20	Model 21
	Employment	Capital	Innovation	Employmen	Capital	Innovation
Foreign emp_ind	0.109			0.611***		
	(0.96)			(3.35)		
Foreign emp_city1	-0.175**			-0.036		
	(2.11)			(0.62)		
Foreign cap_ind		0.069			0.267**	
		(0.73)			(2.00)	
Foreign cap_city1		-0.193***			-0.008	
		(2.59)			(0.16)	
Foreign inno_ind			-2.141*			3.032*
			(1.92)			(1.92)
Foreign inno_city1			0.045			0.413*
			(0.17)			(1.94)
JV	0.138***	0.165***	0.116***	0.013	0.013	0.010
	(3.45)	(3.86)	(2.91)	(0.54)	(0.51)	(0.43)
Labor quality	0.042**	0.044**	0.038*	0.017*	0.019*	0.018*
	(1.97)	(2.06)	(1.76)	(1.65)	(1.79)	(1.72)
Size	0.107***	0.107***	0.114***	0.125***	0.123***	0.122***
	(9.26)	(9.23)	(9.55)	(19.49)	(19.34)	(19.38)
Age	0.003***	0.003***	0.002**	0.000	0.000	0.000
	(2.83)	(2.82)	(2.47)	(0.79)	(0.63)	(0.64)
SOE	0.117***	0.115***	0.113***	-0.049***	-0.050***	-0.051***
	(3.04)	(2.99)	(2.92)	(2.67)	(2.73)	(2.81)
Market concentration	-0.639	-0.479	-2.298	-7.475**	-7.108*	-5.117
	(0.37)	(0.28)	(1.18)	(2.02)	(1.92)	(1.32)
Industry innovation	-0.259	-0.349	0.540	1.907***	1.905***	1.488***
	(0.52)	(0.70)	(0.80)	(5.41)	(5.35)	(3.41)
City innovation	1.974***	1.987***	1.945***	2.079***	2.124***	2.043***
	(8.80)	(8.83)	(8.60)	(6.90)	(7.08)	(6.70)
Productivity gap	-0.013**	-0.013**	-0.011**	-0.003	-0.003	-0.003
	(2.21)	(2.27)	(1.97)	(1.59)	(1.45)	(1.52)
Constant	-1.711***	-1.698***	-1.770***	-1.900***	-1.863***	-1.815***
	(12.80)	(12.74)	(12.90)	(23.27)	(23.17)	(23.05)
Observations	3511	3511	3511	7402	7402	7402
Number of firms	1659	1659	1659	466.24	462.63	464.91
Wald Chi2 statistics	185.14	185.99	183.13	3355	3355	3355

Absolute value of z statistics in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%; Coefficient estimates for year and industry dummy variables not reported

Table 5. List of Top 10 Cities of Foreign Presence for Electronic Equipment and Telecommunications in China

Electronic Equipment and Machinery				Telecommunications Equipment			
Foreign employment		Foreign innovation		Foreign employment		Foreign innovation	
City	Province	City	Province	City	Province	City	Province
Shenzhen	Guangdong	Xinxiang	Henan	Shenzhen	Guangdong	Shenzhen	Guangdong
Dongguan	Guangdong	Suzhou	Jiangsu	Xiamen	Fujian	Tianjin	Tianjin
Foshan	Guangdong	Jiangmen	Guangdong	Suzhou	Jiangsu	Beijing	Beijing
Dalian	Liaoning	Xiamen	Fujian	Zhuhai	Guangdong	Huizhou	Guangdong
Guangzhou	Guangdong	Shenyang	Liaoning	Zhongshan	Guangdong	Jiaxing	Zhejiang
Xiamen	Fujian	Beijing	Beijing	Huizhou	Guangdong	Meizhou	Guangdong
Zhongshan	Guangdong	Tianjin	Tianjin	Dongguan	Guangdong	Suizhou	Jiangsu
Huizhou	Guangdong	Ningbo	Zhejiang	Guangzhou	Guangdong	Nanjing	Jiangsu
Shanghai	Shanghai	Foshan	Guangdong	Wuxi	Jiangsu	Wuxi	Jiangsu
Suzhou	Jiangsu	Shenzhen	Guangdong	Tianjin	Tianjin	Shanghai	Shanghai