FDI Knowledge Spillovers and Innovativeness of Chinese Firms

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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 380,000 Chinese manufacturing firms over the period 2000-2006. After controlling for the endogeneity of joint venture formation, we find strong support for knowledge spillovers through joint ventures. We find conditional support for locational level spillovers: In locations with strong clustering of *innovative* foreign firms, local firms benefit from foreign knowledge spillovers; However, in locations where foreign concentration is measured not by innovations, but by sales or capital, local firms do not benefit from foreign knowledge spillovers. Finally, we find that firms with strong absorptive capacity benefit more from FDI knowledge spillovers at the firm and location levels. 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

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 attracted 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 (a notable exception is Girma et al. [2009][1]). 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

[1] Our paper differs from Girma et al. (2009) in three aspects. First, our study employs a broader sample which includes both state-owned and private enterprises. Second, we examine knowledge spillovers to local firms in joint ventures in addition to analyzing FDI spillovers at the industry and location levels. Third, we control for diverse innovation capacity of cities (sometimes referred to as Jacobian externalities [Jacobs, 1969]) in investigating FDI location-level spillovers.

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 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).

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 investigate whether local firms engaged in joint ventures (JVs) with foreign firms benefit from knowledge spillovers, and whether local firms located in areas with 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).

We further investigate how absorptive capacity of a firm affects its benefits from FDI knowledge spillovers at the firm and location levels. Since absorptive capacity represents "the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends" (Cohen & Levinthal, 1990: 128), firms with stronger absorptive capacity can amplify the FDI knowledge spillover benefits and become even more innovative.

Empirically, we use information on product innovations by nearly 380,000 Chinese firms in all manufacturing industries in the period 2000-2006, compiled by the National Bureau of Statistics of China, to examine the significance of foreign knowledge spillovers at the firm and location levels. The rich dataset allows us to measure foreign presence using alternative measures, which adds robustness to our empirical findings. The empirical results provide support for the existence of spillover benefits at the firm and location levels. 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. 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 some 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. Girma et al. (2009), using information on

product innovation by Chinese state-owned enterprises, observed that foreign capital participation at the firm level leads to higher innovative activities of Chinese firms. Hence, we reach the following hypothesis regarding the firm-level spillover effect on product innovations by local firms.

H1 (firm-level spillover): 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; 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 important, 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., 2003). 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 serve 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 spillover): Foreign presence in a city will have a positive effect on product innovation by local firms in that city.

Absorptive Capacity and FDI Spillovers

Absorptive capacity represents a firm's ability to recognize the value of external knowledge, assimilate it, and apply it to commercial ends (Cohen & Levinthal, 1990). With an appropriate level of absorptive capacity, firms become more capable of absorbing, assimilating, and adapting foreign knowledge to local conditions and thus become more innovative. This argument has received some empirical evidence by existing literature. Girma et al. (2009) found that, although FDI in an industry sector on average has a negative effect on innovative activities by Chinese state-owned enterprises, there is a positive spillover effect of industry-level FDI when the state-owned enterprises also engage in activities that increase firms' absorptive capacity, such as investments in human capital and R&D activities. Buckley et al. (2002), using

productivity information of Chinese firms in 1995, observed that state-owned Chinese firms received no spillover benefits from foreign presence and argued that the result was mainly due to the low absorptive capacity of state-owned firms. We thus propose that the stronger a local firm's absorptive capacity, the more knowledge spillover benefits it will gain from joint venturing with a foreign firm or from locating close to foreign firms.

H3a: The stronger a local firm's absorptive capacity, the stronger the positive effect of joint venturing with a foreign firm on product innovations by the local firm.

H3b: The stronger a local firm's absorptive capacity, the stronger the positive effect of foreign presence in the same city on product innovations by the local firm.

METHOD

Data description

To test the hypotheses, we construct a panel data sample of 378,655 Chinese firms by using the 2000-2006 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, value added, 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.

Foreign firms in our sample are those with more than 50% foreign ownership.[2] Our data show that in 2006 about 16.27% of the firms are foreign owned. The information of the foreign firms is used to construct the foreign presence variables. Our sample includes all manufacturing industries with two-digit industry codes from 13 to 43.[3] Table 1 lists these industries and the distribution of firms in these industries.

Insert Table 1 about here

Variables and measures

Dependent variable

Following previous research (Girma et al., 2009; 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

[2] Foreign firms also include those from Hong Kong, Macau, and Taiwan (HMT). We investigate whether there are any differences in the knowledge spillovers of HMT firms and other foreign firms in the robustness checks.
[3] In 2003 the NBSC changed its industry classification system. We converted all pre-2003 industry codes according to the 2003 standard.

The first independent variable is *JV*, which takes the value 1 if a Chinese firm is engaged in an international joint venture and 0 otherwise. Consistent with the official definition by the Chinese government, we define international joint ventures as those with over 25% foreign equity investment. As shown in the robustness checks, we also use foreign equity share in a Chinese firm to measure *JV* and find consistent results.

We measure *Foreign presence in a city* as the ratio of the sales revenue by foreign firms in a city-industry to the total sales revenue of the industry, where industries are classified according to the four-digit industry codes in the Census data. In the robustness checks shown later, we use alternative measures for foreign presence in a city and find consistent results.

To measure Chinese firms' absorptive capacity, we construct *Productivity gap*, which is defined as the average labor productivity of foreign firms in an industry divided by the labor productivity of a Chinese firm in the same industry. Here, labor productivity is measured as value added per employee.

Control variables

We include three firm-level control variables. *SOE* is 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 possess more financial and labor resources for innovations than firms that are not state owned (Zhou and Li, 2008). However, SOEs may also have low efficiency in developing new products. In addition, we control for *size*, proxied by the logarithm of total assets of a firm, and *age*, measured as the year of census minus the founding 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 age 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.

We also use several industry-level variables to control for the effect of industry and market structure. We use information of all firms (Chinese and foreign) in constructing the industry level variables. First, we control for *Foreign presence in an industry*, which is calculated as the ratio of sales revenue by all foreign firms to the total sales revenue of the industry. Second, 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 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 third 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 in innovation capacities across cities (Jacob, 1969). 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. Finally, we include a set of industry dummy variables, according to three-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 and a set of provincial dummy variables to control for possible regional differences. The regression results of the dummy variables are not reported in the tables due to space limitation.

Estimation issues

To control for the unobserved time-invariant heterogeneity across firms that affect firms' product innovation, we use panel data method to estimate our models. Hausman tests suggest that the unobserved factors and the variables included in the model are correlated, which implies that the random-effects model is inappropriate. As a result, we choose the fixed-effects method to estimate our models. Given the large variation in firms' size and the wide distribution in firms' industries and geographic locations, heteroskedasticity is a concern. To this end, we use the heteroskedasticity-robust estimator in computing the coefficient estimates' standard errors.

Firms form joint ventures to maximize their expected profits. The factors that determine a Chinese firm's JV formation decision may also affect its product innovation activities. As a result, the joint venture formation process may be endogenous. To correctly estimate the model coefficients and make meaningful inferences, we need to take into account the endogeneity of a firm's JV status. To accommodate the dichotomous feature of *JV*, we adopt a Heckman-style two-step estimation method, as suggested by Shaver (1998). In the first step, we estimate a probit model with *JV* as the left-hand-side variable and the control variables described earlier as the right-hand-side variables. In addition, we include in the equation two more regressors, *JV ratios in an industry* and *JV ratios in a province*, where JV ratios refer to the number of JVs divided by the total number of firms (in an industry or in a province). From the estimation results, we calculate the inverse Mills' ratio. In the second step, we estimate the product innovation model

by including the inverse Mills' ratio as an additional regressor. As our results will show later, joint venture formation is indeed endogenous and there exists a negative partial correlation between the factors that determine Chinese firms' JV formation and those affecting their product innovation.

RESULTS

Descriptive statistics

Table 2 presents the correlation matrix and descriptive statistics for the key variables. During 2000-2006, the average new product ratio (product innovation) was 3.2% for Chinese firms. According to our definition, about 5.2% of Chinese firms were engaged in international joint ventures.[4] As for foreign presence, the average percentage of foreign sales revenue in an industry was 29%, and the average percentage of foreign sales revenue in a city-industry combination to that of the entire industry was 0.3%.

Insert Table 2 about Here

Table 2 also shows that, with the privatization of the Chinese state-owned sectors, only 11.5% of the firms in our sample were still controlled by the state during the period of 2000-2006. The average firm age was 10.5 years. The average productivity gap of Chinese firms was about 10. Since productivity gap is defined as the quotient between foreign firms' average labor productivity and a Chinese firm's labor productivity, such a number seems large. This figure, however, is misleading, given the high standard deviation. A more careful examination of the

[4] Joint ventures where foreign firms have more than 50% equity share are not included in our sample because they are considered as foreign firms.

data reveals that the median of Chinese firms' productivity gap was 1.89 and about 25% of Chinese firms actually outperformed an average foreign firm in terms of labor productivity. These results imply that, on average, domestic Chinese firms still lagged behind foreign firms operating in China in terms of productivity during the sample period, but there were very large variations among Chinese firms as well.

Regression results

Tables 3 summarizes our first set of results based on the fixed effects model. The negative estimate for the coefficient of inverse Mills' ratio suggest that there is a negative correlation between the (unobserved) factors that determine whether a Chinese firms is engaged in an international joint venture and those that affect their product innovation. After controlling for the endogeneity of JV formation, the results indicate that, engaging in international joint ventures has a positive and significant impact on Chinese firms' product innovation. This supports our H1. The results also show that foreign presence in an industry positively affect product innovations. However, the estimate for the coefficient of *foreign presence in a city* is positive but insignificant. As a result, H2 which suggests a positive FDI location level spillovers on local innovation is not supported by Model 1. We also note that productivity gap has a negative effect on local firms' product innovations, suggesting the importance of local firms' absorptive capacity in their product innovations.

Insert Table 3 about Here

In Table 4, we present the results of the models that include the interaction terms between productivity gap and foreign presence measures. Models 2 and 3 shows that the effects of *JV * productivity gap* and *Foreign presence in a city * productivity gap* are both negative and

significant. This means that the lower the productivity gap, the more benefits local firms gain from engaging in joint ventures with foreign firms and from locating close to foreign firms. Thus, H3a and H3b are both supported.

Insert Table 4 about Here

It's worth noting that after including the interaction term in Model 3, the coefficient for foreign presence in a city becomes significant and positive. The results suggest that the positive spillover effect at the location level may be concealed in Model 1 by the fact that Chinese firms differed greatly in their productivity gap. The negligible spillovers received by the firms with a wide productivity gap offset the positive spillovers received by the firms with smaller productivity gap. The positive spillover effect stands out when an interaction term is added to the regression model.

For the control variables, all models show that industry innovation and city innovation have a positive effect on local firms' product innovation, which suggests that controlling for innovation capacities of industries and cities is critical for examining FDI spillovers on local innovations. Market concentration has a negative effect on local innovations, suggesting that a competitive market contributes more to local innovations. On average larger firms and firms with a longer operating history tend to have more product innovations. Finally, state-owned enterprises do not seem to differ significantly from non-SOEs in terms of product innovation activities. The positive effect of abundant resources in SOEs is probably offset by the lower efficiency of SOEs in product innovations.

Robustness checks

To check the robustness of our results, we first re-estimate Model 1 by using two alternative measures of foreign presence in a city. The first measure we use is the sales revenue

by foreign firms in a city-industry divided by the total sales revenue in the city-industry. This measure is similar to the one used in Model 1 except that the denominator is different. The second measure is computed as the new product value by foreign firms in a city-industry divided by the total new product value in an industry. The results are presented in Table 5. The FDI location spillover based on the first measure remains insignificant (see Model 4) but it becomes significant using the second measure (see Model 5). This suggests that when local firms are located in cities where foreign firms are actively engaged in innovative activities, the spillover effect is much more salient.

Insert Table 5 about Here

Besides the two measures described above, we also measure foreign presence in a city by capital, asset, and employment, and the results remain largely the same as what we report in Table 2, that is, foreign presence in a city generates no significant spillovers on local innovations. We also measure *JV* by foreign equity share in a Chinese firm (a continuous measure) and the positive and significant effect of JVs on local innovation remains.

Next, we employ alternative estimation methods. Specifically, we use Tobit method to accommodate the large number of zeros in the dependent variable (product innovation). Due to the fact that Tobit estimation with panel data is extremely computational intensive, we are not able to conduct Tobit regressions with the full sample. Instead, the models are estimated on a by-industry subsample basis. For most industries, the general patterns are consistent with what we have found with the linear model.

In addition, we treat "pure" foreign firms and firms with investments from Hong Kong, Macau, and Taiwan (HMT) separately. Extant literature suggests that HMT firms and other foreign firms may generate different levels of spillover benefits to local firms; the spillover effect

of HMT firms on local firms may be curvilinear whereas that of other foreign firms linear (Buckley et al., 2007). Our results, however, do not show significant differences of the effects of HMT and other firms on local firms' product innovation. We find that establishing JVs with either type of foreign firms results in strong positive spillovers on local firms' innovations, and that the presence of either type of firms in a city has no effect on local innovations. We do not find a curvilinear effect of HMT firms in a city on local innovations.

Finally, since existing studies indicate that the FDI spillover benefits for local firms may be stronger in high technology industries (Buckley et al., 2007), we estimate Model 1 in the high-tech and low-tech industry subsamples, respectively. We follow the definitions by NBSC and classify the following as high-tech industries: nuclear fuel, special purpose chemicals (e.g., for cameras, semiconductors), pharmaceuticals, aircraft, electronics and telecommunications equipment, computer and office equipment, and medical device.[5] Table 6 summarizes the results. We find that FDI spillovers at firm and location levels are similar in the high-tech and low-tech samples: JVs have significant and positive effects on local innovation in both samples, and foreign presence in a city (measured by sales revenue) has no effect on local innovations in either sample. The effect of foreign presence in an industry (measured by sales revenue) is significant only for the low-tech sample. These results suggest that since innovation in high-tech industries require more tacit knowledge, high-tech firms benefit more from close interactions in a JV for such knowledge transfer than from observations of technologies and products that foreign firms use in an industry.

Insert Table 6 about Here

[5] http://www.stats.gov.cn

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 370,000 Chinese firms in the manufacturing industries to test the impact of foreign presence at the firm and location levels on the product innovation activity of local Chinese firms. We have found strong support for the

existence of positive knowledge spillovers within joint ventures and conditional support for knowledge spillovers from locational proximity.

Specifically, we have found that there is a self-selection effect in joint venture formation -- less innovative Chinese firms tend to enter joint ventures with foreign firms. After controlling for the endogeneity of joint venture formation, we found that engaging in joint ventures contributes significantly to a local firm's product innovation. This result is robust to different measures of joint ventures (a dummy variable or foreign equity share in a joint venture) and to different types of subsamples (high tech or low tech industries). The positive spillover effect of joint ventures on local firm innovation is stronger when local firms have lower technology gaps from foreign firms and thus stronger absorptive capacity.

After controlling for the innovative capacity of the industry and the location, we found that the effects of FDI locational spillovers on innovations by local firms vary contingent on the activities that foreign firms conduct. 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 sales, capital, or employment, local firms do not benefit from foreign spillovers. Thus, the occurrence of locational innovation spillovers critically depends on whether foreign firms focus on innovative activities. In addition, we found that the extent to which local firms can benefit from locational spillovers also depends on their absorptive capacity; the stronger the absorptive capacity, the more spillover benefits that local firms gain from geographic proximity to local firms.

Finally, after controlling for both firm- and location-effects, we find general evidence of industry-level spillovers. At least for product innovations, our evidence suggests that previous

studies that have focused primarily at the industry level have not fully captured the mechanisms by which knowledge spillovers from FDI occur.

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 product innovation, it can choose to enter a JV with a foreign firm. This is a particularly important strategic choice for firms in high tech industries because our findings suggest that joint venturing is the main channel for local firms to benefit from foreign knowledge transfer and to improve innovative capabilities. Firms in low tech industries can also benefit from observation of foreign technologies and products in an industry. The difference between high and low tech firms in their foreign knowledge acquisition channels is likely due to the fact that more tacit knowledge is needed for high tech innovation and thus close interactions with foreign firms at the firm level that facilitate tacit knowledge transfer become critical for high tech firms.

Local firms can also choose to locate (or to establish subsidiaries) in cities with strong foreign (and domestic) innovative activities in order to improve their product innovations. Local firms should carefully distinguish cities with a large presence of foreign firms measured in terms of capital or sales, and those where foreign firms concentrate their innovative activities. These may not be the same. Our findings also suggest that local firms should strive for improving their absorptive capacity and shortening their technology gaps from foreign firms in order to benefit more from foreign presence at the city or firm levels. They should invest more in human capital and research and development activities for enhancing absorptive capacity.

Our study has important implications for government policy in emerging markets. Governments in emerging economies should encourage the formation of innovation clusters in the domestic markets by supporting the establishment of science parks, incubators and facilitating the development of regional clusters of high value-added activities. Moreover, 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. 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.

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Table 1: Industry Distribution (2000-2006 Average)

Industry	Number of firms	Percentage
13-Food Processing	10763	6.46%
14-Food Production	3970	2.38%
15-Beverage Production	2903	1.74%
16-Tobacco Processing	230	0.14%
17-Textile	14507	8.71%
18-Garments and Other Fiber Products	6263	3.76%
19-Leather, Furs, Down and Related Products	3138	1.88%
20-Timber Processing	3449	2.07%
21-Furniture Manufacturing	1713	1.03%
22-Papermaking and Paper Products	5312	3.19%
23-Printing and Record Medium Reproduction	3813	2.29%
24-Cultural, Educational and Sports Goods	1525	0.92%
25-Petroleum Refining and Coking	1384	0.83%
26-Raw Chemical Materials and Chemical Products	13218	7.94%
27-Medical and Pharmaceutical Products	3727	2.24%
28-Chemical Fiber	934	0.56%
29-Rubber Products	1937	1.16%
30-Plastic Products	7316	4.39%
31-Nonmetal Mineral Products	15629	9.39%
32-Smelting and Pressing of Ferrous Metals	4534	2.72%
33-Smelting and Pressing of Nonferrous Metals	3500	2.10%
34-Metal Products	9187	5.52%
35-Ordinary Machinery	13474	8.09%
36-Special Purposes Equipment	7162	4.30%
37-Transport Equipment	8051	4.84%
39-Electric Equipment and Machinery	9773	5.87%
40-Electronic and Telecommunications	3830	2.30%
41-Instruments, Meters, and Office Equipment	2077	1.25%
42-Other Manufacturing	1981	1.19%
43-Treatment and Recycling of Waste Gas and Waste Material	1210	0.73%

Notes: we followed the industry classifications system issued by the National Bureau of Statistics of China in 2003.

Table 2: Descriptive Statistics and Correlation Matrix

	Variable	Mean	Sd.	1	2	3	4	5	6	7	8	9	10	11
1	Product innovation	0.032	0.143	1.00										
2	JV	0.052	0.222	0.03	1.00									
3	Foreign presence in an industry	0.290	0.177	0.06	0.11	1.00								
4	Foreign presence in city	0.003	0.014	0.04	0.12	0.17	1.00							
5	Productivity gap	10.003	670.853	0.00	0.00	0.00	0.00	1.00						
6	Industry innovation	0.066	0.068	0.17	0.02	0.13	0.05	0.01	1.00					
7	City innovation	0.089	0.106	0.19	0.05	0.10	0.06	0.00	0.15	1.00				
8	Size	9.522	1.413	0.17	0.11	-0.04	0.04	0.00	0.17	0.08	1.00			
9	Age	10.519	12.045	0.04	-0.06	-0.09	-0.05	0.01	0.05	0.04	0.21	1.00		
10	SOE	0.115	0.319	0.02	-0.01	-0.09	-0.04	0.02	0.01	0.02	0.11	0.40	1.00	
11	Market concentration	0.032	0.089	0.01	0.00	-0.01	-0.01	0.00	0.02	0.01	0.03	-0.02	-0.02	1.00

Table 3. The Impact of FDI on Product Innovations of Chinese Firms, 2000-2006

Dependent variable: Product innovation	Model 1
JV	2.733***
	(0.883)
Foreign presence in an city	2.410
	(2.646)
Productivity gap	-0.007*
	(0.004)
Foreign presence in an industry	0.742***
	(0.246)
Industry innovation	6.074***
	(0.744)
City innovation	23.756***
	(0.565)
Size	0.664***
	(0.041)
Age	0.799**
	(0.345)
SOE	0.081
	(0.106)
Market concentration	-0.354**
	(0.158)
Inverse Mills' ratio	-1.231***
	(0.403)
Observations	948681
R-squared	0.017
Number of id	378655

Notes: Results for year, industry, and province dummy variables are not reported due to space limitation. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 4. The Moderating Effects of Productivity Gap on FDI Spillovers to Chinese Firms, 2000-2006

Dependent variable: Product innovation	Model 2	Model 3
JV	2.707***	2.723***
	(0.598)	(0.598)
JV * Productivity gap	-0.123***	
	(0.035)	
Foreign presence in a city	2.410	2.756*
	(1.612)	(1.614)
Foreign presence in a city * Productivity gap		-7.558***
		(1.566)
Productivity gap	-0.005	-0.003
	(0.004)	(0.004)
Foreign presence in an industry	0.744***	0.747***
	(0.191)	(0.191)
Industry innovation	6.073***	6.085***
	(0.460)	(0.460)
City innovation	23.755***	23.758***
	(0.284)	(0.284)
Size	0.664***	0.664***
	(0.034)	(0.034)
Age	0.795***	0.798***
	(0.294)	(0.294)
SOE	0.081	0.081
	(0.082)	(0.082)
Market concentration	-0.354**	-0.353**
	(0.157)	(0.157)
Inverse Mills' ratio	-1.217***	-1.227***
	(0.287)	(0.287)
Observations	948681	948681
R-squared	0.017	0.017
Number of id	378655	378655

Notes: Results for year, industry, and province dummy variables are not reported due to space limitation. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 5. The Impact of FDI on Product Innovations of Chinese Firms, 2000-2006: Alternative Measures of Foreign Presence in a City

Dependent variable: Product innovation	Model 4	Model 5
JV	2.817***	2.137**
	(0.887)	(0.877)
Foreign presence in a city (alt. measure 1)	-0.113	
	(0.120)	
Foreign presence in a city (alt. measure 2)		18.287***
		(1.483)
Productivity gap	-0.007*	-0.007*
	(0.004)	(0.004)
Foreign presence in an industry	0.770***	0.589**
	(0.246)	(0.247)
Industry innovation	6.061***	6.126***
	(0.745)	(0.748)
City innovation	23.735***	23.491***
	(0.565)	(0.565)
Size	0.668***	0.673***
	(0.041)	(0.041)
Age	0.803**	0.692**
	(0.346)	(0.346)
SOE	0.078	0.086
	(0.106)	(0.106)
Market concentration	-0.357**	-0.296*
	(0.158)	(0.158)
Inverse Mills' ratio	-1.243***	-0.981**
	(0.403)	(0.401)
Observations	948076	946509
Number of id	378456	378181
R-squared	0.017	0.019

Notes: Results for year, industry, and province dummy variables are not reported due to space limitation. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 6: The Impact of FDI on Product Innovations of Chinese Firms, 2000-2006: Subsample Results in High-tech and Low-tech Industries

Dependent variable: Product innovation	Model 6 High-tech	Model 7 Low-tech
JV	8.141*	2.560***
	(4.839)	(0.848)
Foreign presence in a city	2.812	2.966
	(10.337)	(2.541)
Productivity gap	-0.010	-0.005
	(0.011)	(0.004)
Foreign presence in an industry	2.336	0.611**
	(1.616)	(0.242)
Industry innovation	4.725**	6.323***
	(2.113)	(0.782)
City innovation	25.787***	23.369***
	(2.634)	(0.574)
Size	1.648***	0.588***
	(0.286)	(0.040)
Age	2.561	0.742**
	(2.055)	(0.344)
SOE	-0.392	0.176*
	(0.477)	(0.104)
Market concentration	1.988	-0.304*
	(3.009)	(0.157)
Inverse Mills' ratio	-3.429	-1.214***
	(2.344)	(0.388)
Observations	55914	892606
R-squared	0.016	0.018
Number of id	23061	359633

Notes: Results for year, industry, and province dummy variables are not reported due to space limitation. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.