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FDI Spillovers at the National and Subnational Level: The Impact on Product Innovation by Chinese Firms

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ABSTRACT We investigate the degree to which the presence of inward foreign direct investments (FDI) influences product innovation by emerging market firms. We begin with FDI spillover effects at the national level, the common approach in the literature. We further examine spillover effects at the subnational level because knowledge spillovers have been found to be localized. We study both intra-industry and inter-industry FDI spillovers in a subnational location, based on the distinction in the cluster literature between Marshall–Arrow–Romer specialization externalities and Jacobian diversification externalities. Using information from more than 346,000 Chinese manufacturing firms from 2000 to 2006, we find that Chinese firms improve product innovation when they are located in cities with concentrated foreign innovative activities in the same industry. These intra-industry spillover benefits decrease quickly, however, as foreign presence increases and, at high levels of foreign concentration, are dominated by the crowding-out effect. We also find evidence of inter-industry spillover benefits in a city; diversity of industries with a foreign presence contributes to product innovation by Chinese firms.

KEYWORDS Chinese firms, clusters, FDI spillovers, product innovation, subnational FDI spillovers

外国直接投资在国家及地区层面的溢出效应：对中国企业产品创新的影响

摘要

在本文中我们研究在新兴市场中外国直接投资（FDI）对当地企业的产品创新的影响程度。按照现有文献普遍采用的方法，我们首先考察了FDI在国家层面的溢出效应。由于知识的溢出具有本地化的特性，随后我们又考察了FDI在地区层面的溢出效应。根据产业集群文献中关于Marshall-Arrow-Romer（MAR）专业化外生性与Jacobian分散化外生性的区别，我们在地区层面上分别研究了FDI在相同行业内部以及不同行业之间的溢出效应。利用一套2000年至2006年间超过346,000个中国制造业企业的信息，我们发现，与同行业的其他企业相比，那些位于外资企业创新活动更为集中的城市的中国企业更能提高他们的产品创新能力。然而，这种行业内的溢出效应会随着外资企业占比的提高而迅速消减，特别是当外资企业集中度达到较高水平的时候，外资的挤出效应更具决定性影响。我们还发现在同一城市中不同行业的企业之间也存在溢出效应。多样化的外资产业对于中国企业的产品创新具有正面影响。

关键词：中国企业，集群，FDI溢出效应，产品创新，地区化FDI外溢

INTRODUCTION

The innovative capability of firms is widely understood to be a source of competitive advantage as well as an important contributor to economic growth and development (Dutz, Kessides, O'Connell, & Willig, 2011; Porter, 1990). As latecomers to their industries relative to their counterparts in developed markets, emerging market firms must catch up in their innovative capabilities (Mathews, 2002). But where do they acquire the knowledge to do so? One important source is via knowledge spillovers associated with inward foreign direct investment (FDI) (Audretsch & Feldman, 2004; Blomström & Kokko, 1998). In this study, we examine how FDI spillovers, defined as externalities generated by FDI presence (Eden, 2009), affect the innovative activities of emerging market firms. In particular, we focus on the geographic scope of these spillovers and their impact on the product innovation of emerging market firms.

The FDI spillover literature has for some time focused on examining how foreign knowledge becomes available to emerging market firms that typically lack the resources to develop their own competitive capabilities (Li, Chen, & Shapiro, 2010; Zhang, Li, Li, & Zhou, 2010). Foreign firms provide knowledge access and learning opportunities that increase local firms' technological capabilities (Blomström & Kokko, 1998; Meyer & Sinani, 2009). These spillovers are typically studied at the national level. Our study also considers the spatial dimensions of FDI spillovers, which we call *subnational-level FDI spillovers*.

We focus on subnational-level FDI spillovers because knowledge spillovers are often localized (Audretsch & Feldman, 2004; Feldman, 1999; Pouder & St. John, 1996; Tallman, Jenkins, Henry, & Pinch, 2004). We examine two sources of FDI spillovers in a subnational location: intra-industry and inter-industry. The first considers location-based spillover benefits arising from co-location with firms in the same industry. The second considers benefits arising from co-location with firms from diverse industries. The two sources of spillovers are based largely on the distinction in the cluster literature between Marshall–Arrow–Romer (MAR) specialization externalities and Jacobian diversification externalities (Glaeser, Kallal, Scheinkman, & Shleifer, 1992; Jacobs, 1969). We propose that the presence of foreign firms in a subnational location, either in the same industry or in diverse industries, creates spillover benefits for local firms, but only up to the point where foreign firms begin to crowd out local firms by driving up their costs.

We test our theoretical arguments using a dataset that consists of a comprehensive sample of more than 346,000 Chinese firms in all manufacturing industries over the period 2000–2006. We find positive intra-industry FDI spillover benefits at the national level. At the subnational level, intra-industry FDI spillover effects are more complicated. Local firms benefit from being in a city characterized by concentrated industry-specific innovative activities by foreign firms, but such benefits decline as foreign innovative activities become too highly concentrated in the

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city. Thus, the crowding-out effect associated with foreign competition might dominate the positive effect associated with foreign knowledge spillovers after foreign innovation reaches its optimal concentration level.

We also find evidence of inter-industry spillovers at the city level, suggesting that the diversity of industries with a foreign presence in a particular location enhances the product innovation capabilities of domestic firms in that location. Thus, emerging market firms benefit from the local presence of foreign firms outside their own industry.

We also find that in most cases both intra-industry and inter-industry FDI spillover benefits in a subnational location are more salient when we measure FDI presence using foreign firms' product innovation activities rather than their sales activities in the host country. This finding suggests that using foreign firms' product innovation activities to measure their presence can better capture the availability of foreign knowledge relevant to local firms' product innovation. It also suggests that researchers should pay closer attention to how foreign presence is measured.

Our contributions to the FDI spillover literature are twofold. First, although prior studies have focused on spillover benefits in terms of local firms' productivity improvement (Blomström & Kokko, 1998; Meyer & Sinani, 2009), our study focuses on spillover benefits in terms of local firms' product innovation. Productivity is related to innovative activity (e.g., innovation contributes to productivity growth) but might also include elements of pricing power that reflect market power rather than innovation (Bartelsman & Doms, 2000; Hall, 2011; Parisi, Schiantarelli, & Sembenelli, 2006). Thus, our approach provides a more nuanced and direct understanding of the impact of knowledge spillovers on innovation by emerging market firms.

Second, we consider both national and subnational FDI spillovers, which increases our knowledge of the mechanisms by which spillover benefits are realized. Combining insights from the cluster and FDI spillover literature, our study is among the first to investigate the two types of subnational-location FDI spillovers (intra-industry and inter-industry). Our findings suggest that such spillovers are indeed present, indicating that the traditional focus on FDI spillover effects at the national level does not provide a full understanding of the nature and sources of the spillover benefits and costs.

THEORETICAL BACKGROUND AND HYPOTHESES

Foreign firms are often willing to transfer some advanced knowledge to overcome the liability of 'foreignness' they face in a new environment and are motivated to locate some high-value-added activities in emerging markets to increase their efficiency and effectiveness (Mudambi, 2008; Zaheer, 1995). In addition, foreign firms often face pressure from local governments to transfer technologies in

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exchange for market presence and favourable policies (Huang, 2003). Foreign investments in an emerging market can thus provide knowledge access and learning opportunities for local firms.

FDI Spillovers at the National Level

At the national level, local firms can benefit in several ways from the presence of foreign firms competing in the same industry (Blomström & Kokko, 1998; Caves, 1996; Spencer, 2008). First, through observation and imitation of the products or technologies introduced by foreign firms, local firms can acquire the knowledge necessary for new product development. For instance, many Chinese computer companies developed their product innovation capabilities by reverse-engineering foreign products and adding new technological features to satisfy local consumer demand (Lu, 2000).

Second, as foreign firms often build forward and backward linkages with domestic suppliers and distributors, and transfer knowledge to them through training programs, local firms can acquire some foreign knowledge by building connections with these same suppliers and distributors (Spencer, 2008). Furthermore, local firms can benefit from foreign firms' human capital development efforts in local markets. Foreign firms often invest in training local employees, including technically advanced professionals and top-level managers, and the gains from such activities can spread to local firms through employee turnover (Blomström & Kokko, 1998; Gorg & Strobl, 2005). Empirical evidence in China indicates that foreign firms' employee mobility is positively associated with the innovation performance of local Chinese firms in the same industry (Liu, Lu, Filatotchev, Buck, & Wright, 2010).

Finally, the presence of foreign firms contributes to local firms' product innovation through increased market competition, because such competition can force local firms to engage in product innovation (Caves, 1996). Survey data on 27 emerging market economies show strong evidence of a positive relationship between local firms' perceived pressure from foreign competition and their product and technology innovation (Gorodnichenko, Svejnar, & Terrell, 2010).

Prior studies suggest that the presence of foreign firms in the same industry generates positive spillovers in emerging markets that increase local firms' productivity (Blomström & Kokko, 1998; Meyer & Sinani, 2009). For instance, a meta-analysis of 66 empirical studies on FDI spillovers concluded that FDI spillover benefits (in terms of productivity improvement of local firms) are salient and positive in low-income countries because of the abundant learning opportunities provided by foreign firms (Meyer & Sinani, 2009). Similarly, we expect that the presence of foreign firms in an industry in an emerging market, through knowledge spillovers and competition, will also benefit local firms' product innovation activities. Note that the large presence of foreign firms in an industry might also have a

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negative crowding-out effect on local firms; that is, competition from foreign firms might reduce resources available to local firms and thus their ability to innovate (Meyer & Sinani, 2009; Spencer, 2008). However, we expect this crowding-out effect to be limited when we consider nationwide, industry-level spillovers, because most industries in emerging markets have not established national markets, and nationwide competition between foreign and local firms is therefore not that fierce (Peng, Tan, & Tong, 2004; Prahalad & Lieberthal, 1998). We therefore propose the following hypothesis to capture industry-level FDI spillover effects at the national level:

Hypothesis 1 (Intra-industry FDI spillovers at the national level): All else being equal, the greater the presence of foreign firms in an industry, the greater the product innovation activity of emerging market firms in that industry will be.

FDI Spillovers at the Subnational Level

Knowledge tends to be localized, and knowledge spillover is particularly significant within a specific location (Audretsch & Feldman, 2004; Feldman, 1999). For instance, a study that used patent citation information to track knowledge flows across companies in the U.S. found evidence of the localization of patent citations; that is, patents more frequently cited other patents that originated in the same city (Jaffe, Trajtenberg, & Henderson, 1993). Similarly, a study of patenting in the semiconductor clusters in the U.S. found that patent citations were highly localized, indicating that knowledge spillovers are geographically limited (Almeida & Kogut, 1999). A study of information technology (IT) clusters in Canada also concluded that IT knowledge was highly localized in the Toronto area; the further a firm was located from the Toronto area, the less likely it was to benefit from cluster spillovers (Globerman, Shapiro, & Vining, 2005).

Because knowledge spillovers are often geographically confined, we are interested in examining the effects on the product innovation activities of local firms in the same area where foreign firms are geographically concentrated. Studies have focused on two types of location-level spillovers: intra-industry and inter-industry (Feldman, 1999; Feldman & Audretsch, 1999). The concept of intra-industry spillovers, where knowledge spillovers arise from industry specialization in a location, originates in the work of Marshall (1890), Arrow (1962), and Romer (1986), and is called *MAR externalities* (Glaeser et al., 1992). This view suggests that locational knowledge spillovers primarily occur within the same industry. For example, in the computer chip industry in Silicon Valley, ideas were quickly disseminated among neighbouring firms through observation, imitation, and rapid inter-firm movement of skilled labour (Arthur, 1989). Jacobs (1969) proposed the second kind of location-level spillover, inter-industry spillovers, stressing the importance of cross-industry transfer of ideas and explaining that important knowledge

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transfers often come from outside the core industry. Therefore, diversity of geographically proximate industries promotes innovation and economic growth, effects called *Jacobian externalities.*

Following this literature, we consider two types of subnational-location spillover generated by foreign firms. The first type of spillover is related to industry-specific clusters formed by foreign firms and the second type is related to the diversity of industries in which foreign firms participate in a location. Below, we examine the two types of spillover benefits and their impact on the product innovation activities of emerging market firms.

Intra-industry FDI spillovers at the subnational level. Industry-specific clusters that foreign firms form generate positive spillovers and improve local firms' product innovation activities in four ways. First, when foreign firms in an industry are geographically concentrated, they create a market for high-quality labour with similar skills, help local firms cope with the underdeveloped labour markets in an emerging market, and reduce their search costs for specialized labour critical for innovative activities (Khanna, 2007; Marshall, 1890). Second, the clustered foreign firms facilitate the development of related industries in a value chain that also benefits local firms (Porter, 1990).

Third and more importantly, foreign firms, when concentrated in a subnational location, generate positive externalities related to the transmission of knowledge from foreign to local firms. Co-location allows not only direct observation of foreign technologies and products but also the development of valuable business and personal employee networks with foreign firms. Such networks are most critical for increasing knowledge transfer among firms in clusters (Almeida & Kogut, 1999; Zhang & Li, 2010). These networks increase the frequency and intensity of information exchange and collaboration between local firms and foreign knowledge holders, and provide opportunities for local firms to identify and recruit talented foreign employees, both of which facilitate intensive knowledge transfer from foreign to local firms and thus contribute to local firms' product innovation (Almeida & Kogut, 1999; Porter, 1990; Saxenian, 1991; Zhang & Li, 2010; Zucker, Darby, & Brewer, 1998).

Finally, in locations with a high concentration of foreign firms in the same industry, local firms face increased competitive pressure and thus have more incentive to pursue and rapidly adopt innovation (Porter, 1990). To illustrate the idea that local competition accelerates imitation and improvement of the innovator's ideas, Porter (1990) cited the Italian ceramics and gold jewellery industries, in which hundreds of firms were located close together and fiercely competed to innovate because the alternative to innovation was demise.

Although intensified competition from foreign firms increases local firms' incentives to innovate, it can also limit resources available to local firms, thus hindering their ability to innovate. For instance, increased competition in the output market

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might reduce the financial performance of local firms and thus the availability of financial resources for innovative projects. Increased competition for valuable inputs such as highly skilled labour and specialized intermediate goods might also limit supply or raise input costs for local firms. The cluster literature has recognized these 'congestion' costs, which can exceed the clustering benefits as a cluster grows (Pouder & St. John, 1996). The negative effect of foreign competition has also been recognized in the FDI spillover literature as the crowding-out effect (Meyer & Sinani, 2009; Spencer, 2008). This crowding-out effect might be particularly salient at the subnational level in an emerging market because firms often compete in regional markets (Peng et al., 2004). This conclusion is supported by findings that foreign presence at the national level increases the likelihood of domestic firm survival but has no significant effect at the provincial level (Chang & Xu, 2008). At the subnational level, the negative crowding-out effect associated with a large foreign presence can offset the positive knowledge spillover effect.

The above arguments suggest that the geographic concentration of foreign firms in the same industry has both positive and negative spillover effects on the product innovation of local firms. We expect to find an optimal level of foreign presence in a subnational location that has the highest positive impact on local firms' product innovation. Before the optimal level (i.e., before the location becomes too crowded with foreign firms), the concentration of foreign firms in a location will have a positive effect on product innovation by local firms. After the optimal level, the negative effects associated with intensified competition from the foreign firms in a location exceed the benefits associated with foreign knowledge spillovers, and thus we expect a negative effect of the concentration of foreign firms in a location on local firms' product innovation. We propose the following hypothesis to capture intra-industry FDI spillover effects at the subnational level:

> *Hypothesis 2 (Intra-industry FDI spillovers at the subnational level): All else being equal, industry-specific foreign presence in a subnational location will have an inverted U-shaped effect (first increasing, then decreasing) on the product innovation activity of emerging market firms in the same industry and location.*

Inter-industry FDI spillovers at the subnational level. We now examine the second type of subnational-level FDI spillovers, that is, the effect of industry diversity of foreign presence in a location on local firms' product innovation. In a pioneering study of the growth of cities, Jacobs (1969) argued that important sources of knowledge spillover are often external to the industry in which a firm operates, and that the variety of industries within a city promotes knowledge externalities and ultimately innovative activity that in turn promotes the city's economic growth.

A wide scope of businesses in an area can benefit local firms' innovative activity primarily because it generates diversified industry knowledge. Cross-fertilization of ideas among different industries occurs frequently. Scherer (1982), for instance,

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traced industrial R&D expenditures from their industries of origin to industries in which the use of the resulting products and processes was anticipated, and found that 70 percent of the inventions in a given industry were expected to be applied in other industries. Jaffe et al. (1993) also observed that knowledge spillovers are not confined to closely related technologies, as approximately 40 percent of patent citations in their sample did not come from the same primary patent class as the originating patent.

Firms or industries in cities with a diversity of industries exhibit stronger innovative capabilities or higher growth rates. For instance, industry diversity in a city was found to contribute to a focal industry's higher employment growth rate (Glaeser et al., 1992). Firm-level data in the information and communication technology industry also showed that proximity to a cluster within a diverse metropolitan area was associated with firms' superior growth performance (Maine, Shapiro, & Vining, 2010). A study of industry diversification and firm innovation found that product innovation of firms in a city were positively associated with the city's diversity in complementary industries that shared a common science base (Feldman & Audretsch, 1999).

The above arguments and evidence taken together suggest that local firms can more likely access diversified knowledge the more foreign firms in the same locale involve themselves in diversification of industries. This, in turn, contributes to local firm innovation activity. We thus expect that Jacobian externalities are likely to be a source of knowledge for emerging market firms. Stated formally:

Hypothesis 3 (Inter-industry FDI spillovers at the subnational level): All else being equal, the greater the industry diversity of foreign presence in a subnational location, the greater the product innovation activity of emerging market firms in that location will be.

METHOD

Data and Sample

To test the hypotheses, we constructed a panel data sample using the 2000–2006 editions of *Annual Census of Industrial Enterprises*.[1] The Census data, constructed by the National Bureau of Statistics of China (NBSC), contain detailed information about a company's operational profile, including total product value, value added, new product value, number of employees, and equity investment by owners. The Census data include firms with an assessed sales capacity of no less than five million Chinese Yuan per year. Unlike Girma, Gong, and Gorg (2009), who focused on FDI spillovers on product innovation of state-owned firms in China, we also included non-state-owned Chinese firms in our study because non-state-owned firms are also important innovators (Hu & Jefferson, 2009).

After deleting observations with missing or dubious values,[2] we had a sample of 416,602 firms. Of these, 346,111 were Chinese firms, that is, those with 100

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percent Chinese ownership. As a robustness check, we constructed an alternative sample in which we treated firms with at least 75 percent Chinese ownership as Chinese firms (according to the 2001 Joint Venture Law, firms with less than 25 percent foreign ownership are not treated as joint ventures and are classified as Chinese firms) and we found similar results. Foreign firms in our sample were those with more than 50 percent foreign ownership.[3] Our data show that during the period 2000–2006 about 12 percent of the firms were foreign owned.

Our regression analyses focused on Chinese firms. Information on foreign firms was used to construct the foreign presence and control variables. Our sample included firms in all manufacturing industries located in 31 provinces or municipalities.[4]

Variables and Measures

Dependent variable. Following previous research (Girma et al., 2009; Zhou & Li, 2008), we constructed *product innovation* as the ratio of new product value to total product value of a Chinese firm at year *t*. This measure is firm and year specific. According to the NBSC, new products are defined as those new to the Chinese market, which either (i) adopt completely new scientific principles, technologies, or designs, or (ii) 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).

Independent variables. We constructed two measures to capture foreign presence in an industry or location, one based on sales revenues and the other based on the value of new products introduced into the Chinese market by foreign firms. Sales of foreign firms or some related output measures are typically used in the FDI spillover literature to measure foreign presence (e.g., Girma et al., 2009). Foreign sales are a good proxy for the general knowledge brought by foreign firms to the host market including product, process, managerial, and marketing knowledge. Foreign sales might therefore reflect knowledge not directly related to product innovation, the concern of our paper. Accordingly, we also used an alternative measure of foreign presence, the value of new products by foreign firms, to capture directly foreign knowledge related to product innovation activity in the host market. This measure might be more appropriate for understanding spillovers in the context of product innovation.

Specifically, we have two alternative measures for foreign presence in an industry at the national level: (i) *industry-specific foreign presence in China (sales)*, calculated as the ratio of sales by all foreign firms to the total sales of the industry at year *t*, where industries are classified according to the four-digit industry codes in the Census data, and (ii) *industry-specific foreign presence in China (innovation)*, calculated as the ratio

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of new product value by all foreign firms to the total product value of the industry at year *t*. These measures are industry and year specific.

At the subnational level, we constructed four measures to capture foreign presence in a city. Prior studies have treated cities as an appropriate geographic area to study location-level knowledge spillovers because communications between people are most extensive within cities (e.g., Almeida & Kogut, 1999; Feldman & Audretsch, 1999; Gilbert, McDougall, & Audretsch, 2008; Glaeser et al., 1992; Jaffe et al., 1993). *Industry-specific foreign presence in a city (sales)* is measured by the ratio of the sales of foreign firms in an industry in a city to the total sales of the industry at year *t*, and *industry-specific foreign presence in a city (innovation)* is measured by the ratio of new product value of foreign firms in an industry in a city to the total new product value of the industry at year *t*. These industry-, city-, and year-specific measures capture the extent to which foreign sales or innovation activities in an industry are clustered in a city.

To construct *industry diversity of foreign presence in a city (sales)*, we first used a standard Herfindahl measure to capture the extent to which foreign firms' sales were concentrated in some industries and then used one to minus the concentration measure (Raghunathan, 1995). Specifically, for city *j* with *n* industries at year *t*,

$$\textit{Industry diversity of foreign presence (sales)}_{jt} = 1 - \sum_{k=1}^{n} \left(\frac{\textit{sales of foreign firms}_{kjt}}{\sum_{k=1}^{n} \textit{sales of foreign firms}_{kjt}} \right)^2.$$

Similarly,

$$\textit{Industry diversity of foreign presence (innovation)}_{jt} = 1 - \sum_{k=1}^{n} \left(\frac{\textit{new product value of foreign firms}_{kjt}}{\sum_{k=1}^{n} \textit{new product value of foreign firms}_{kjt}} \right)^2.$$

The two measures for industry diversity of foreign presence in a city are city and year specific. For observations in cities with no foreign presence, we treated the diversity value as zero. As a robustness check, we dropped observations in cities with no foreign presence and found consistent results. In the robustness checks, we also constructed the four measures for FDI presence in a location at the provincial level and found consistent results.

Control variables. We included four firm-level control variables: *productivity gap*, *SOE*, *size*, and *age*. The first variable, *productivity gap*, partially captures Chinese firms' absorptive capacity (Zhang et al., 2010); Chinese firms with a lower productivity gap than foreign firms are likely to be more innovative. Productivity gap is measured as

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the average total factor productivity of foreign firms in an industry in a year, divided by the total factor productivity of a Chinese firm in the same industry and year. Here, total factor productivity is the residual derived from the Cobb–Douglas function of output (value-added) on input (labour and capital). We took a log transformation of the measure to correct its skewed distribution. The productivity gap measure is firm and year specific.

The second variable, *SOE*, is a dummy equal to 1 if the state equity share is higher than the share of any other types of ownership, including corporate, individual, collective, and foreign. SOEs might have more product innovation because they possess more financial and human resources for innovation than firms that are not state owned (Zhou & Li, 2008). However, SOEs might also have lower efficiency in developing new products (Jefferson, Bai, Guan, & Yu, 2006). In addition, we controlled 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 might 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 might suggest stronger capability to innovate, but older firms are more likely to inherit the legacies of the centrally planned economy in China and thus be less innovative.

We also used two industry-level variables to control for the effect of industry and market structure. First, we employed a standard Herfindahl measure for *market concentration* by utilizing firm-level information for local market sales (total sales minus export sales) contained in the Census data (Raghunathan, 1995). For a given firm i in an industry k with a total number of firms of n_k in year t, we calculated the Herfindahl measure as follows:

$$Market\ concentration_{kt} = \sum_{i=1}^{n_k} \left(\cdot sales_{ikt} \Big/ \sum_{i=1}^{n_k} sales_{ikt} \right)^2.$$

The market concentration measure is industry and year specific. The effect of market concentration is uncertain; firms in industries with a high concentration might possess more resources for innovation, but they also face less competitive pressure to improve product innovation. Second, *industry innovation* was measured as the ratio of new product value to total product value of an industry in a specific year. We expect industry innovation to have a positive effect on the product innovation of a firm.

In addition, we constructed a city-level control variable, *city innovation*, to capture the potential impact of the creative city as a source of innovation spillovers as emphasized by Jacobs (1969). This variable was computed as the total new product value of all firms in a city divided by the total product value of the city, and is therefore not restricted to foreign innovation.

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Finally, we included 30 industry dummy variables (according to two-digit SIC codes) to control for other possible cross-industry heterogeneity, five-year dummies for any temporal effects, and 30 provincial dummies for possible regional differences.

Analyses

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

RESULTS

Table 1 presents the correlation matrix and descriptive statistics for the key variables. During the period 2000–2006, the average new product ratio (product innovation) was 3 percent for Chinese firms. With the privatization of the Chinese state-owned sectors, only 10 percent of the firms in our sample were still controlled by the state from 2000 to 2006. Table 1 suggests moderate levels of correlation between the two measures for industry-specific foreign presence in China (0.40), those for industry-specific foreign presence in a city (0.38), and those for industry diversity of foreign presence in a city (0.48), which indicates that the measures based on sales and new product values are not fully substitutable and are therefore reasonable alternatives for testing our hypotheses. Table 1 shows that *industry innovation* is highly correlated with *industry-specific foreign presence in China (innovation)* at 0.71. We therefore dropped *industry innovation* in regressions that used innovation-based foreign presence measures.

Table 2 summarizes the regression results based on the fixed effects models. Models 1–4 report results using sales-based foreign presence measures, and Models 5–8 report results using innovation-based foreign presence measures. The results in Models 4 and 8 indicate that industry-specific foreign presence in China, based on sales or innovation measures, has a statistically significant and positive effect on product innovation by local firms ($p < 0.01$ in both models), which lends strong support to Hypothesis 1, that positive intra-industry FDI spillovers occur at the national level.

Model 4 indicates that industry-specific foreign presence in a city, based on the sales measure, has no significant effect on local firms' product innovation. Model 8

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Table 1. Descriptive statistics and correlation matrix

		1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*
1	Product innovation	1													
2	Industry-specific foreign presence in China (sales)	0.06*	1												
3	Industry-specific foreign presence in China (innovation)	0.12*	0.40*	1											
4	Industry-specific foreign presence in a city (sales)	0.03*	0.17*	0.09*	1										
5	Industry-specific foreign presence in a city (innovation)	0.06*	0.08*	0.08*	0.38*	1									
6	Industry diversity of foreign presence in a city (sales)	0.05*	0.25*	0.12*	0.14*	0.08*	1								
7	Industry diversity of foreign presence in a city (innovation)	0.11*	0.16*	0.12*	0.12*	0.13*	0.48*	1							
8	Productivity gap	−0.01*	0.02*	0.08*	−0.03*	−0.01*	−0.09*	−0.03*	1						
9	Industry innovation	0.16*	0.13*	0.71*	0.05*	0.04*	0.13*	0.13*	0.08*	1					
10	City innovation	0.18*	0.10*	0.11*	0.06*	0.10*	0.27*	0.40*	0.04*	0.14*	1				
11	Size	0.16*	−0.07*	0.11*	0.00*	0.01*	0.02*	0.04*	−0.05*	0.17*	0.07*	1			
12	Age	0.04*	−0.10*	−0.00	−0.05*	−0.02*	−0.06*	0.00	0.17*	0.05*	0.05*	0.22*	1		
13	SOE	0.02*	−0.09*	−0.00*	−0.05*	−0.02*	−0.14*	−0.06*	0.25*	0.01*	0.02*	0.11*	0.42*	1	
14	Market concentration	0.01*	−0.03*	0.02*	−0.02*	−0.00	−0.00	0.08*	0.01*	0.02*	0.01*	0.03*	−0.01*	−0.01*	1
	Mean	0.03	0.28	0.02	0.003	0.003	0.63	0.27	1.17	0.07	0.09	9.49	10.60	0.10	0.04
	S.D.	0.14	0.18	0.03	0.01	0.02	0.33	0.32	0.74	0.07	0.11	1.37	12.04	0.31	0.10

Notes: $n = 752{,}937$; *$p < 0.05$.

Table 2. Results of fixed effects models predicting the effect of inward FDI on product innovation of Chinese firms

	Model 1	*Model 2*	*Model 3*	*Model 4*	*Model 5*	*Model 6*	*Model 7*	*Model 8*
Productivity gap	−0.14*** (0.03)	−0.14*** (0.03)	−0.14*** (0.03)	−0.15*** (0.03)	−0.13*** (0.03)	−0.13*** (0.03)	−0.13*** (0.03)	−0.15*** (0.03)
Size	0.72*** (0.03)	0.72*** (0.03)	0.72*** (0.03)	0.71*** (0.04)	0.73*** (0.03)	0.73*** (0.03)	0.73*** (0.03)	0.65*** (0.04)
Age	0.26 (0.31)	0.26 (0.31)	0.27 (0.31)	0.18 (0.31)	0.30 (0.31)	0.28 (0.31)	0.28 (0.31)	−0.01 (0.31)
SOE	0.19* (0.10)	0.19* (0.10)	0.19* (0.10)	0.20* (0.10)	0.18* (0.10)	0.18* (0.10)	0.18* (0.10)	0.23** (0.10)
Market concentration	−0.34** (0.16)	−0.33** (0.16)	−0.34** (0.16)	−0.35** (0.16)	−0.38** (0.16)	−0.36** (0.16)	−0.36** (0.16)	−0.46*** (0.16)
City innovation	23.93*** (0.33)	23.93*** (0.33)	23.94*** (0.33)	23.88*** (0.33)	24.01*** (0.33)	23.91*** (0.33)	23.84*** (0.33)	23.10*** (0.33)
Industry innovation	4.94*** (0.50)	4.94*** (0.50)	4.95*** (0.50)	4.95*** (0.50)				
H1: Industry-specific foreign presence in China (sales)	0.80*** (0.20)	0.79*** (0.20)	0.79*** (0.20)	0.79*** (0.20)				
H2: Industry-specific foreign presence in a city (sales)		1.78 (2.06)	−0.77 (3.32)	−0.66 (3.34)				
H2: Industry-specific foreign presence in a city squared (sales)			10.44 (10.67)	10.22 (10.70)				
H3: Industry diversity of foreign presence in a city (sales)				0.40*** (0.12)				
H1: Industry-specific foreign presence in China (innovation)					3.25*** (0.84)	2.94*** (0.84)	2.96*** (0.84)	2.72*** (0.85)
H2: Industry-specific foreign presence in a city (innovation)						6.03*** (0.85)	14.36*** (1.60)	13.24*** (1.61)
H2: Industry-specific foreign presence in a city squared (innovation)							−19.85*** (3.24)	−18.44*** (3.25)
H3: Industry diversity of foreign presence in a city (innovation)								2.54*** (0.10)
Constant	−11.31*** (1.15)	−11.31*** (1.15)	−11.31*** (1.15)	−11.37*** (1.15)	−11.06*** (1.15)	−11.00*** (1.15)	−10.99*** (1.15)	−10.81*** (1.16)
Number of firms	346,111	346,111	346,111	346,111	346,111	346,111	346,111	346,111
Observations	752,937	752,937	752,937	752,937	752,937	752,937	752,937	752,937
R^2	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
F statistics	98.79	97.43	96.11	93.91	98.76	97.76	96.93	104.3

Notes: Robust standard errors in parentheses; year, industry, and province dummies were included; ***p < 0.01, **p < 0.05, *p < 0.10 (two-tailed tests).

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shows that industry-specific foreign presence in a city, based on the innovation measure, has a positive effect on the product innovation of local firms in the same industry and city ($p < 0.01$), whereas the square term of this variable has a negative effect on local firms' product innovation ($p < 0.01$). These results suggest that concentration of industry-specific foreign innovative activities in a city has an inverted U-shaped effect on product innovation by Chinese firms in the same industry and city. We thus find some evidence to support Hypothesis 2, that intra-industry spillover benefits at the subnational level are curvilinear. In addition, the contrasting results based on sales and innovation measures also suggest that innovation-based measures might be better able to capture the availability of foreign knowledge directly related to product innovation activities.

Figure 1 illustrates the intra-industry spillover benefits at city level. Based on the results in Model 8 (with all variables kept at the mean level except the measures on industry-specific foreign presence in a city), Figure 1 shows that, at the city level, the presence of industry-specific foreign innovation has a curvilinear effect on product innovation by Chinese firms. Specifically, as the ratio of new product value of foreign firms in an industry and city increases from 10 percent to 35 percent, the ratio of new product value of a Chinese firm in the same industry and city increases from 4.4 percent to 5.7 percent; however, as the ratio of new product value of foreign firms in an industry and city continues to increase from 35 percent to 90 percent, the ratio of new product value of a Chinese firm decreases from 5.7 percent to 0.3 percent.

The results in Models 4 and 8 also suggest that industry diversity of foreign presence in a city, based on either sales or innovation measures, significantly and positively affects product innovation by Chinese firms ($p < 0.01$ in both models), which supports Hypothesis 3, that positive inter-industry FDI spillovers occur at the subnational level.

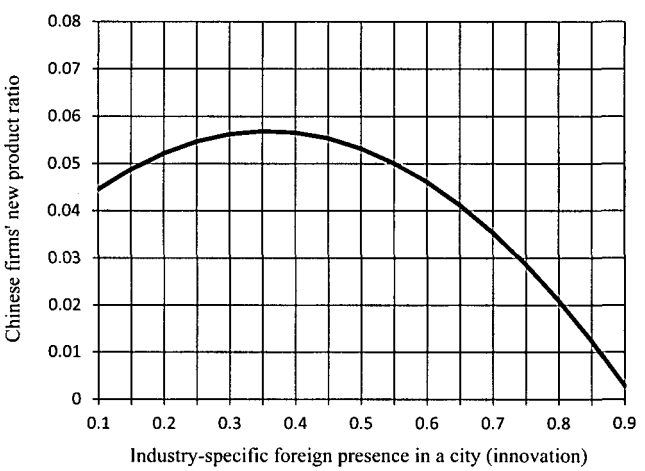

Figure 1. Intra-industry FDI spillover benefits at the city level in China

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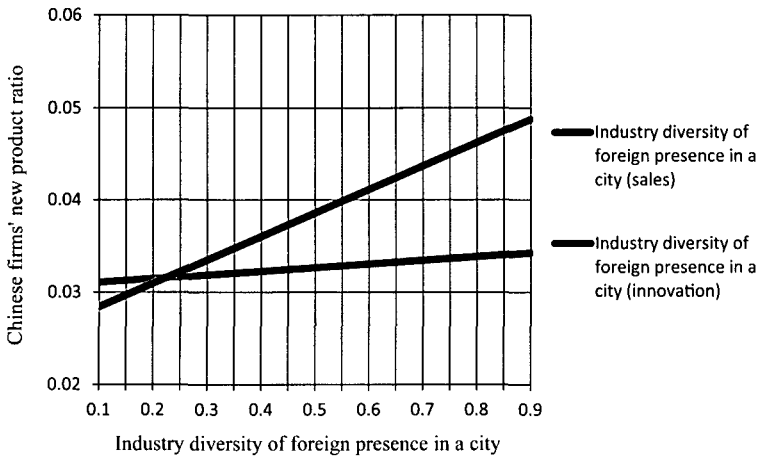

Figure 2. Inter-industry FDI spillover benefits at the city level in China

We drew Figure 2 based on Models 4 and 8 (with all variables kept at the mean level except the measure for industry diversity of foreign presence in a city) to illustrate the positive inter-industry FDI spillover benefits at city level. It shows that as the industry diversity of foreign sales activities in a city increases from 0.1 to 0.9, the ratio of new product value of a Chinese firm increases from 3.1 percent to 3.4 percent, and as the industry diversity of foreign innovation activities increases from 0.1 to 0.9, the ratio of new product value of a Chinese firm increases from 2.8 percent to 4.9 percent.

Figure 2 also shows that, in most cases (when the industry diversity level is greater than 0.2), innovation-based industry diversity measures are associated with higher spillover benefits for local firms than are sales-based industry diversity measures, which suggests again that innovation-based measures might better capture the availability of foreign knowledge directly related to product innovation.

The results of some control variables in Model 4 are worth noting. City innovation has a positive effect on local firms' product innovation ($p < 0.01$), suggesting that local firms can benefit from locating in creative cities with high levels of innovation, regardless of industry or ownership. Market concentration has a negative effect on local innovation ($p < 0.05$), indicating that a competitive market contributes more to local innovation. State-owned enterprises have more product innovation than non-SOEs ($p < 0.10$), suggesting that although SOEs have lower efficiency in utilizing resources for innovation purposes than non-SOEs, their superior access to resources helps them innovate more than non-SOEs.

Robustness Checks

To check the robustness of our results based on city-level foreign presence measures, we adopted provincial-level foreign presence measures (results are available

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on request) because of possible changes in the administrative boundaries of some cities (Lu & Tao, 2009). We found that industry-specific foreign presence in a province, based on sales or innovation measures, has an inverted U-shaped effect on product innovation by local firms in the same industry and province, which lends more support to Hyothesis 2 regarding intra-industry FDI spillover effects at the subnational level. We also found that the diversity of industries in which foreign firms are engaged in a province, based on sales or innovation measures, has a statistically significant and positive effect on product innovation by local firms in the same province, which gives more support to Hypothesis 3 regarding positive inter-industry FDI spillovers at the subnational level.

To deal with the potential endogeneity problems related to the foreign presence measures, market concentration, and productivity gap, and to control for the impact of a firm's past product innovation on its current product innovation, we included the one-year lag values of these variables in a robustness check. We found results largely consistent with those reported in Table 2. Because taking the one-year lags of these variables leads to a significant reduction of the sample size (53 percent fewer observations), we treated this test as a robustness check only.

Finally, we tested whether, at the national level, foreign presence in an industry (based on sales or innovation measures) has an inverted U-shaped effect on product innovation by local firms. We did not find statistically significant results to support a curvilinear relationship.

DISCUSSION

Theoretical Implications

Our study examines how FDI spillovers affect product innovation by local firms in an emerging market. Our study makes two important contributions to the FDI spillover literature. First, while previous studies focused primarily on FDI spillover benefits in terms of productivity improvement of local firms (Meyer & Sinani, 2009), our study is among the first to examine FDI spillover benefits in terms of product innovation by local firms. As a related contribution, we also measure foreign presence in a manner that better captures the ability of local firms to access the product innovation capabilities of foreign firms. Second, in addition to industry-level FDI spillovers at the national level, we also examine the spatial dimensions of FDI spillovers (i.e., location-level FDI spillovers at the subnational level) by combining insights from both the FDI spillover and cluster literatures. Using a large data sample of Chinese firms from 2000 to 2006, we find evidence of strong national and subnational FDI spillovers that benefit the product innovation of local firms.

Specifically, we find strong evidence of intra-industry spillover benefits for local firms at the national level; that is, foreign presence in an industry positively affects

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the product innovation of local firms in the same industry. This finding lends support to our arguments that the presence of foreign firms in an industry generates positive spillovers through demonstration effects, development of local supporting and related industries, employee turnover, and competition.

We also find evidence of intra-industry spillover benefits at the subnational level. Specifically, local firms will engage in more product innovation when they are in cities or provinces with a higher concentration of innovation activities by foreign firms in the same industry. However, we also observe that the benefits of co-location with innovative foreign firms start to decline as foreign innovation activities become too concentrated in a location (see Fig. 1), which indicates that the negative crowding-out effect associated with foreign competition dominates the positive effect associated with foreign knowledge spillovers after the locational concentration of innovation activities by foreign firms reaches its optimal level. Thus, geographic concentration of foreign innovation activities generates both positive and negative spillover effects on local firms in the same industry and location. Our findings, therefore, only partially support the existence of MAR externalities; that is, locating close to firms in the same industry always generates positive intra-industry spillovers that contribute to firm performance (Glaeser et al., 1992). Our findings are more in line with recent developments in the cluster literature that recognizes the congestion costs associated with geographic concentration of firm activities (Pouder & St. John, 1996), and in the FDI spillover literature that highlights the crowding-out effect as a result of intensified foreign competition (Chang & Xu, 2008; Spencer, 2008).

We find that intra-industry FDI spillover benefits at the national level are linear rather than curvilinear, indicating that the positive knowledge spillover effect dominates any negative competition effect at the national level. This finding is consistent with the arguments that competition effects associated with FDI spillovers are more salient at the subnational level than at the national level in China because firms in China typically engage in regional rather than national competition (Chang & Xu, 2008).

We also find evidence of inter-industry FDI spillovers at the subnational level (see Fig. 2). In cities or provinces with a greater diversity of industry sectors involving foreign firms, local firms tend to have more product innovation. This finding supports the existence of strong inter-industry spillovers in a common geographic unit, that is, Jacobian externalities (Jacobs, 1969).

We also find that, for the most part, our estimates of the spillover benefits from access to foreign knowledge are higher when we measure foreign presence by the product innovation activities of foreign firms rather than the more traditional measure based on sales. This suggests that future studies of spillover effects should be more nuanced in their choice of how to measure foreign presence. In particular, future research should better match the measure of foreign presence to the nature of the spillovers being analyzed.

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Practical Implications

Our study has important implications for the knowledge acquisition strategies of local firms in emerging markets. Co-location with innovative foreign firms can result in increased product innovation activity by local firms but only up to a point. Local firms should pay attention to both intra-industry and inter-industry spillover benefits that foreign firms generate in a location. A location with greater diversity of industries that foreign firms are involved in can provide local firms with diversified industry knowledge that is critical for product innovation. A location with concentrated innovative foreign firms in the same industry can also generate significant spillover benefits for local firms. Geographic proximity to foreign firms allows for the establishment of networks with foreign companies or employees, which, in turn, facilitate intensive knowledge transfer from foreign knowledge holders to local firms. Local firms, however, should avoid locations with very high concentrations of innovative foreign firms in their industry because local firms are likely to have limited access to financial or human resources for product innovation as a result of intense competition from foreign firms.

Given our findings that innovation-based measures for foreign presence in a location can better capture the availability of foreign knowledge related to product innovation activities than sales-based measures, we suggest that local firms, in choosing to co-locate with foreign firms, should also value the activities of foreign firms. Locating close to a cluster of foreign firms that are active in product innovation provides more learning opportunities and spillover benefits for local firms.

We also find some evidence that not all spillovers originate with foreign firms. Our results point to the possibility that locating in cities with high levels of innovation, whether foreign or domestic, can benefit local firms. These types of spillover benefits are likely to be more important in the future as local firms develop their innovative capabilities.

Our study also has important implications for government policy in emerging markets. When attracting foreign direct investments into a local market, local governments should understand that the presence of innovative foreign firms can have both positive and negative impacts on local firms. On one hand, foreign presence can enhance the innovative capabilities of local firms through knowledge spillovers. On the other hand, a sufficiently large presence of foreign firms might increase input costs (ranging from energy and water to highly skilled labour) for local firms and might therefore squeeze them out of the market. Policies can be designed to reduce these congestion costs, for example by improving basic local infrastructure and attracting talent from other parts of the market or overseas. Our study also suggests that local governments should focus on creating a diversified foreign presence because knowledge spillovers can come from diverse sources.

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Limitations and Future Research Directions

This study has several important limitations, which also provide opportunities for future research. First, we focus exclusively on product innovation. While product innovation is certainly important, they do not cover the full range of innovative activities that firms undertake, and future research should study a broader range of innovative activities, particularly process innovation. Second, our definition of a new product innovation might be too broad in that it does not indicate whether new products are simply incremental improvements. Thus, future studies should attempt to develop broader and more sophisticated measures of innovative activity (Garcia & Calantone, 2002). Third, as appropriate measures of absorptive capacity (e.g., R&D expenditure) become available, future studies might examine how the absorptive capacity of a local firm moderates the benefits from industry-level and location-level FDI spillovers. Finally, future research might explore other sources of spillover benefits, such as those associated with locating activities in foreign markets characterized by high levels of knowledge (Griffith, Harrison, & Van Reenen, 2006; Li, Li, & Shapiro, 2012).

CONCLUSION

Our study provides evidence of FDI knowledge spillovers that create significant innovation benefits for local firms at both national and subnational levels. Specifically, at the subnational level, local firms benefit from the presence of foreign firms in the same or diverse industries, but only up to the point where foreign firms drive up the costs of innovation resources. Our study suggests the importance of examining FDI spillover effects at the subnational level because knowledge is often geographically clustered. Such clustering facilitates knowledge transfer but also increases congestion costs and competitive pressures. Future research should examine in more depth the tradeoffs of locating close to FDI clusters and the conditions under which the benefits exceed the costs. Such research will have important implications for both firm strategy and government policy in emerging markets.

NOTES

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[1] The 2004 data lacked a set of key variables such as total product value and new product value, so we did not use them to construct the sample. To minimize bias as a result of dropping the information in 2004, in the robustness tests we used linear predictions to fill out the missing values in 2004 and found similar regression results in the new sample.

[2] We deleted 25,606 observations because of missing values for the key variables. Another 21,017 observations were deleted for overtly dubious values, for example, those reporting negative total product value or negative total equity.

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[3] We included firms from Hong Kong, Macau, and Taiwan (HMT) in the 'foreign' category.
[4] Chinese industry codes changed in 2003 (Brandt, Van Biesebroeck, & Zhang, 2012). We developed a concordance table at the four-digit industry code level to convert the old codes to the new ones. The main changes were in medical and pharmaceutical products, rubber products, ordinary machinery, special-purpose equipment, transport equipment, electrical equipment and machinery, electronics and telecommunications, and instruments, metres, and office equipment.

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