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FDI SPILLOVERS IN AN EMERGING MARKET: THE ROLE OF FOREIGN FIRMS' COUNTRY ORIGIN DIVERSITY AND DOMESTIC FIRMS' ABSORPTIVE CAPACITY

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Prior literature on foreign direct investment (FDI) spillovers has mainly focused on how the presence of FDI affects the productivity of domestic firms. In this study, we advance the literature by examining the effect of the diversity of FDI country origins on the productivity of domestic firms. We propose that the diversity of FDI country origins can facilitate FDI spillovers by increasing the variety of technologies and management practices brought by foreign firms, to which domestic firms are exposed and that they can potentially utilize. Further, the extent to which domestic firms can utilize these technologies and practices depends upon their absorptive capacity. Using panel data on Chinese manufacturing firms during the period 1998–2003, our results support these propositions. We find that the diversity of FDI country origins in an industry has a positive relationship with the productivity of domestic firms in the industry. This positive relationship is stronger when domestic firms are larger, and when the technology gap between FDI and the domestic firms is intermediate. Copyright © 2010 John Wiley & Sons, Ltd.

INTRODUCTION

Research in the strategy, international business, and economics literatures has paid increasing attention to the role of foreign direct investment (FDI) in the productivity of domestic firms in emerging markets. A widely accepted argument in this line of research is that foreign firms from developed countries typically enjoy technological superiority and strong management capabilities and their technologies and management practices can be transferred to or imitated by domestic firms in emerging markets. These so-called 'spillovers' are defined as positive externalities that benefit domestic firms with the presence of FDI, which can result in productivity increases among domestic firms (Blomström, 1986; Caves, 1974; Spencer, 2008).

Despite this appealing argument, previous studies have produced mixed findings on FDI spillovers in emerging markets. Some studies have found evidence of positive spillover effects from FDI to emerging market firms (e.g., Blomström, 1986; Buckley, Clegg, and Wang, 2007; Tian, 2007; Wei and Liu, 2006). Others, however, have found that

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FDI may either have no spillover effects or even have negative effects on domestic firms' productivity in emerging markets (Aitken and Harrison, 1999; Feinberg and Majumdar, 2001).

Underlying the mixed results are two notable reasons. First, as Görg and Strobl have argued, the approach adopted in the existing empirical studies of FDI spillovers mainly 'focuses on the simpler issue of whether the presence of [FDI] affects productivity in domestic firms' (Görg and Strobl, 2001: 724). These studies have conceptualized FDI as homogenous flows of capital and have largely ignored the heterogeneous nature of FDI in terms of foreign firms' entry modes, the nature of the production techniques, and the country of origin (Fortanier, 2007). Second, FDI spillovers involve a process in which domestic firms learn from foreign firms. Thus, FDI spillover effects also depend upon the role of domestic firms as the recipients of spillovers. Although the importance of firm characteristics in organizational learning have been well studied in the management and strategy literature (e.g., Cohen and Levinthal, 1990; Zahra and George, 2002), prior research on FDI spillovers has consisted of econometric studies that have largely treated domestic firms as passive recipients of spillovers. Thus, to better understand how spillovers actually occur, it is important to take into account the characteristics of domestic firms (e.g., their capacity to learn).

To address these gaps, we go beyond the existing literature, which mainly focuses on the FDI presence in an industry, and examine how the diversity of FDI country origins in an industry is related to the productivity of domestic firms in the industry. We define the diversity of FDI country origins as the extent to which foreign firms in an industry are from different country origins.[1] From an organizational learning perspective (Ghoshal, 1987; Huber, 1991), we argue that for FDI spillovers to actually take place, two factors are crucial: *domestic firms' opportunity to learn from foreign firms* and *domestic firms' capacity to learn from foreign firms*. The diversity of FDI country origins can increase domestic firms' *opportunity to learn* through exposure to different systems of technologies, management practices, and cultural values brought by foreign firms from different country origins,[2] which will in turn lead to positive spillover effects. Further, the effect of the diversity of FDI country origins on the productivity of domestic firms depends upon the domestic firms' *capacity to learn* from FDI. This effect will be stronger when domestic firms are more able to absorb knowledge and techniques brought by foreign firms. We will test these arguments using a panel data of Chinese manufacturing firms during the period 1998–2003.

THEORY AND HYPOTHESIS DEVELOPMENT

Theoretical background on FDI spillovers

How do FDI spillovers occur? The literature generally suggests four major mechanisms (Blomström and Kokko, 1998; Spencer, 2008). The first mechanism is demonstration effect, in which domestic firms, through exposure to foreign firms' activities, can observe these firms' technologies and management practices and imitate them in their own operations, thus increasing the domestic firms' productivity (Blomström and Kokko, 1998). The second mechanism is building domestic linkages. When foreign firms build backward and forward linkages with domestic suppliers and distributors, knowledge from these firms can be transmitted to the suppliers and distributors, and ultimately to domestic firms using the same suppliers and distributors (Spencer, 2008). Third, spillovers can occur through employee turnover. When employees from foreign firms take jobs in domestic firms, details about the foreign firms' technologies and management practices can diffuse to domestic firms, creating positive spillover effects. The fourth mechanism is that the increased competition that accompanies FDI entry can force domestic firms to increase their productivity by updating manufacturing technologies and adopting advanced

[1] FDI can take the forms of wholly owned foreign firms and foreign-domestic joint ventures. Knowledge transfer in foreign-domestic joint ventures involves mechanisms that are different from those of spillovers, which are essentially unintended movements of knowledge without compensation between firms. To clearly examine FDI spillover effects, FDI in this study refers to foreign direct investment in the form of wholly owned foreign firms.

[2] Domestic firms with minority foreign ownership can benefit from knowledge flow from their foreign partners, in addition to possible spillovers from foreign firms, with which they have no ownership relationships. In order to clearly examine domestic firms' benefits from FDI spillovers, the term 'domestic firms' in this study refers to firms with 100 percent domestic ownership.

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management practices to meet this competitive challenge (Blomström and Kokko, 1998). This so-called 'competition effect' may also reduce the productivity of domestic firms—that is to say, have a crowding out effect. This occurs if foreign firms attract demand away from their domestic competitors (Aitken and Harrison, 1999) and/or if the entry of foreign firms increases the costs of various inputs including labor and raw materials.

One may argue that these FDI spillover mechanisms may be 'local' because any benefits from foreign firms via these mechanisms would be received first by the neighboring domestic firms before they diffuse to other, more distant domestic firms. While most previous empirical studies in the FDI spillover literature have been silent on this issue and have focused on FDI presence at the national level (e.g., Blomström, 1986; Buckley *et al*., 2007; Feinberg and Majumdar, 2001; Tian, 2007; Wei and Liu, 2006), there are two exceptions (Aitken and Harrison, 1999; Chang and Xu, 2008). Aitken and Harrison (1999) examined the effect of national FDI presence and regional FDI presence on the productivity of domestic firms in Venezuela and found little evidence for spillovers from local foreign investment. They concluded that 'there is no empirical support for the hypothesis that technology is transferred locally from [foreign owned firms] to domestically owned firms' (Aitken and Harrison, 1999: 614). Chang and Xu (2008: 499) argued that FDI spillover effects 'can go beyond narrowly defined local boundaries and become more pronounced at the country level (Keller, 2002).' They found that the share of foreign firms (not including those from Hong Kong, Macau, and Taiwan) at the national level increases the likelihood of domestic firm survival, but the share of foreign firms at the regional (province) level has no significant effect.

It seems that neither Aitken and Harrison (1999) nor Chang and Xu (2008) found empirical evidence to support that FDI spillover effects are just 'local,' which endorse other studies' focus on FDI presence at the national level. Therefore, in this study we focus on FDI spillover effects at the national level in China. In addition to testing our hypotheses at the national level, we conduct supplementary analyses to examine FDI spillover effects at the local (provincial) level to explore possible differences in such effects between the national and local levels.

The diversity of FDI country origins and FDI spillovers

Domestic firms in emerging markets typically are less resource endowed, and they desire to search and learn technologies and managerial practices from their counterparts from developed markets that are better resource endowed (Hitt, Li, and Worthington, 2005). As we noted earlier, one of the crucial factors that can affect FDI spillover effects is the extent to which domestic firms have the opportunity to learn from foreign firms. While the presence of FDI potentially opens up this opportunity, we go further to argue that at a given level of FDI presence, the diversity of FDI country origins can additionally contribute to the spillover effects.

When there is a greater diversity of FDI country origins in an industry, domestic firms get exposed to a greater variety of technologies and management practices brought by foreign firms because countries differ along important dimensions including geography, culture, administrative and institutional context, domestic market, and business system (Ghemawat, 2003; North, 1991). It has been noted that firms respond to the idiosyncratic opportunities and challenges that they face by creating unique search paths that can generate resource heterogeneity (Ahuja and Katila, 2004). Facing different opportunity sets in the environment, firms in different countries can create different technologies and management practices by exploiting traditional country arbitrage in capital and costs as well as arbitrage in more industry-specific inputs such as knowledge and the availability of complementary products, technologies, and infrastructures (Ghemawat, 2003). For example, responding to their unique country environments, Japanese auto makers such as Toyota and Honda developed technologies and management practices (e.g., fuel-efficient auto products and just-in-time supply management) that have been for a considerable time distinctive from their European and American rivals. Indeed, it has been widely recognized that firms' strategic and technological actions diverge across countries (North, 1991; Wan and Hoskisson, 2003: 28).

When foreign firms from different country origins enter an emerging market, they bring their

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heterogeneous technologies and management practices to the host market. Exposure to an environment with diverse technologies and management practices can facilitate domestic firms' openness and promote their learning from foreign firms (Kim, 1997; Zahra and George, 2002). As Cohen and Levinthal argued, knowledge diversity in the environment 'provides a more robust basis for learning because it increases the prospect that incoming information will relate to what is already known' (Cohen and Levinthal, 1990: 131). Empirically, Van Wijk, Van den Bosch, and Volberda (2001) found that the breadth of knowledge exposure positively influences a firm's propensity to explore new and related knowledge. Exposure to a greater variety of FDI technologies and management practices can also provide more opportunities for domestic firms to recombine these technologies and practices to create their own competitive advantage. The innovation and knowledge management literature has noted that new knowledge creation is often the result of recombining existing elements of knowledge into new syntheses (Henderson and Clark, 1990; Katila and Ahuja, 2002; Kogut and Zander, 1992; Zhang and Li, 2010). From this perspective, the greater the diversity of technologies and management practices brought by foreign firms, the greater the combination potentials. This is because there is a limit to the number of new combinations that can be created by using the same set of knowledge elements (Katila and Ahuja, 2002). As foreign firms from different country origins bring various technologies and management practices, the industry's knowledge pool develops enhanced economies of scale and scope, improving the possibility for domestic firms to find new useful combinations of these elements (Zhang and Li, 2010).

More specifically, a greater diversity of FDI country origins can enhance the effects of the FDI spillover mechanisms discussed above. First, the demonstration effect can be enhanced because domestic firms are able to observe and imitate a greater variety of technologies and management practices brought by foreign firms from a greater diversity of country origins. The demonstration effect can take place across regions within a nation because domestic firms can imitate foreign technologies and products introduced to the nation to develop their own goods for their home markets. Second, foreign firms in China tend to build backward and forward linkages with domestic suppliers and distributors. On the one hand, foreign firms can purchase raw materials and components locally at lower costs than imports; on the other hand, the Chinese government has continuously pressed foreign firms to 'produce more of their goods in China and to source their supplies domestically' (Osland and Björkman, 1998: 93). As foreign firms from diverse country origins build extensive domestic business linkages, a greater variety of FDI knowledge can be transmitted to the domestic suppliers and distributors, which can further diffuse to domestic competitors. Such knowledge spillovers can go beyond regional boundaries. As Tallman and Phene (2007: 257) noted, geographic 'proximity may not be as important in a domestic context' (for knowledge spillovers) and that 'the national innovation systems and the resulting common technological culture' can lead to a lack of significant difference between knowledge flow within regions and that between regions.

Third, when employees of foreign firms from a greater variety of country origins take jobs in domestic firms, they bring a greater variety of FDI technologies and management practices to the domestic firms. Employee turnover rate in China—18 percent in 2006—is one of the highest in Asia (Leininger, 2007), and the rate is even higher for managers and professionals (Dickel and Watkins, 2008; Leininger, 2007). Many Chinese domestic companies are transforming their businesses to compete on the global stage and their expectations of talents are beginning to match those of foreign firms (Leininger, 2007). They desire to hire talents from foreign firms, which typically have heavily invested in their employees. Employee migration may take place across regions in China. A national talent market, at least for management and professional positions, is forming as evidenced by the fact that the once significant salary differences among the four largest labor markets—Beijing, Shanghai, Guangzhou, and Shenzhen—have gradually disappeared (Leininger, 2007). According to a survey[3] conducted in March 2009, 30 percent of the 1,070 respondents had cross-region working experience and 47 percent of the respondents were willing to work cross-region if appropriate opportunities arose.

[3] The survey was conducted by Manpower, a human resource consultancy and the report is available on www.manpower.com.cn (accessed 15 August, 2009).

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Fourth, a greater diversity of FDI country origins may also increase FDI's crowding-out effects on domestic firms, which may offset the spillover effects associated with a greater diversity of FDI country origins. Since foreign firms from different country origins tend to use different technologies and management practices, they increase demand and prices of various types of raw materials and talents, and they can also meet demand of a broader spectrum of markets by offering different technologies and products. This makes it difficult for domestic firms to differentiate and to avoid head-to-head competition with foreign firms for both inputs and markets. However, foreign firms that use different inputs and offer different technologies and products also help to more fully develop local supply infrastructure (Spencer, 2008) and create domestic demand (Kosová, forthcoming), which can benefit domestic firms. Moreover, the coexistence of foreign firms from various country origins in a host country can direct their attention to their competition with each other, which may distract their attention to domestic competitors. Overall, we propose that,

Hypothesis 1: All else being equal, the diversity of FDI country origins in an industry is positively related to the productivity of domestic firms in the industry.

The moderating effects of domestic firms' absorptive capacity

Above, we have proposed that the diversity of FDI country origins in an industry can facilitate FDI spillovers by increasing opportunities for domestic firms in the industry to learn from foreign firms. We further argue that the extent to which individual domestic firms can benefit from such opportunities depends upon their capacity to learn from foreign firms.

While external knowledge such as competitors' knowledge can contribute to a focal firm's knowledge, the firm is unable to assimilate and utilize the external knowledge passively. Instead, as Cohen and Levinthal (1990: 128) argued, a firm's absorptive capacity—referring to the firm's 'ability to recognize the value of new information, assimilate it, and apply it to commercial ends'—determines the extent to which the firm can utilize spillovers of competitors' knowledge. Consistent with this argument, we expect that the relationship between the diversity of FDI country origins and the productivity of domestic firms is contingent upon the domestic firms' capacity to learn from foreign firms. The greater the domestic firms' capacity to learn from foreign firms, the stronger the positive relationship discussed above. Following this logic, in this section we examine the moderating effects of two characteristics of domestic firms—their size and the technology gap between FDI and the domestic firms, which have been highlighted in prior research on knowledge acquisition and spillovers (e.g., Gerschenkron, 1962; Henderson and Cockburn, 1996; Sjöholm, 1999).[4]

The moderating effect of domestic firm size

We propose that the positive relationship between the diversity of FDI country origins and the productivity of domestic firms in the industry is stronger when the size of the domestic firms is larger. There are two reasons for this positive interaction effect.

First, large domestic firms tend to have stronger capacity than small ones to learn technologies and management practices brought by foreign firms from different country origins. The economics literature has suggested that relative to small ones, large firms are more able to spread the fixed costs of research and development (R&D) over a larger sales base and are more able to exploit economies of scale and scope in R&D activities (Cohen and Levin, 1989; Panzar and Willig, 1981). Also, because large firms are more able to mitigate problems of adverse selection and moral hazard in the financial markets, they are better positioned to raise capital for risky projects (Henderson and Cockburn, 1996). Empirically, Henderson and Cockburn (1996: 33) have shown that in pharmaceutical industries, larger firms are more able to sustain an adequately diverse portfolio of research projects and to capture internal and external spillovers of knowledge. Thus, relative to small firms, large domestic firms have greater absorptive capacity to recognize and understand the variety of technologies and management practices brought by foreign firms from different country origins and assimilate these new knowledge

[4] Other attributes of domestic firms—including their ownership type (e.g., state ownership vs. private ownership), their R&D investment, and their alliance ties with foreign firms may also proxy for their absorptive capacity (Li and Atuahene-Gima, 2002) and should be explored in future research.

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elements into their existing knowledge stock. In contrast, because small domestic firms tend to have relatively weaker absorptive capacity, the variety of technologies and management practices brought by foreign firms from different country origins may be so complex and heterogeneous that they may exceed domestic firms' knowledge search and processing capacities.

Second, relative to small firms, large domestic firms' greater stock of internal resources and knowledge can be used as complementary assets to utilize the variety of technologies and management practices brought by foreign firms from different country origins. As noted by Winter (1984: 293), the new knowledge that firms obtain from their external environment typically is a collection of fragments of possible useful knowledge and that the number and quality of these fragments tend to be less than what is needed. Therefore, further utilization and development of these external knowledge elements require complementary assets of the focal firms. Relative to small firms, large domestic firms have more internal complementary assets that can be used to exploit FDI spillovers. Relatedly, a variety of technologies and management practices brought by foreign firms from different country origins are potentially observable to all domestic firms in the industry and thus simple recombination of these FDI knowledge elements may be discovered by multiple domestic firms. Katila and Ahuja (2002: 1186) noted that by combining firm-specific knowledge elements with new solutions, firms are more likely to create new, unique combinations that can be commercialized. Similarly, we argue that relative to small firms, large domestic firms are more able to combine their firm-specific knowledge with new knowledge elements brought by foreign firms from different country origins to create new, unique technologies and products. Based on these arguments, we propose the following:

> *Hypothesis 2: The positive relationship between the diversity of FDI country origins and the productivity of domestic firms is stronger for large domestic firms than for small ones.*

The moderating effect of the technology gap

While foreign firms typically enjoy technological superiority and strong management capabilities in an emerging market, the technology gap between foreign firms and domestic firms varies. In this study, technology gap refers to the extent to which FDI in an industry is technologically advanced relative to a domestic firm in the industry (Gerschenkron, 1962). We propose that the positive relationship between the diversity of FDI country origins and the productivity of domestic firms is the strongest when the technology gap is intermediate, compared with when the gap is either too small or too large.

We propose this quadratic moderating effect because the technology gap between FDI and domestic firms affects both the potential of FDI spillovers and the domestic firms' capacity to absorb FDI spillovers. When the technology gap between FDI and domestic firms is too small (or in some cases, the domestic firms are even more advanced than FDI), the potential of FDI spillovers is limited because the domestic firms can learn little from FDI (Gerschenkron, 1962; Sjöholm, 1999). In this situation, although foreign firms from different country origins bring a variety of technologies and management practices, these knowledge elements have little value to the domestic firms. Therefore, when the technology gap is too small, the diversity of FDI country origins has a relatively weak impact on the productivity of the domestic firms.

We expect that when the technology gap is too large, the diversity of FDI country origins may also have a relatively weak impact on the productivity of the domestic firms. When the technology gap is too large, technologies and management practices brought by foreign firms from different country origins certainly represent advanced, external knowledge for the domestic firms to learn, thus increasing the potential of FDI spillovers. However, when the gap is too large, the domestic firms may not have the capacity to absorb the advanced technologies and management practices brought by foreign firms. The absorptive capacity literature has suggested that a certain level of knowledge overlap is necessary for a focal firm to draw upon the knowledge stock of another firm because a firm's ability to use new knowledge elements depends largely upon the firm's existing knowledge stock (Cohen and Levinthal, 1990; Rosenkopf and Almeida, 2003; Tallman *et al*., 2004). When the technology gap is too large, the domestic firms do not have internal knowledge resources to recognize the value and contents of a variety of knowledge elements brought by foreign firms from different country origins. It is even more difficult

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for the domestic firms to integrate various FDI knowledge elements with their own knowledge stock to create competitive advantage. Indeed, a great diversity of FDI country origins combined with a too-large technology gap may signal a situation in which spillovers are not likely to occur at all. In this situation, foreign firms from different country origins take over the bulk of the market by offering different and superior technologies and products and thus force domestic firms into narrow niches that are negligible for foreign firms. As a result, because domestic firms may not have direct competition with foreign firms, there is not much reason to expect spillover effects (Kokko, 1994).

In contrast, we expect that when the technology gap between FDI and domestic firms is intermediate, the diversity of FDI country origins has the strongest positive impact on the productivity of the domestic firms. When the technology gap is intermediate, foreign firms are still advanced relative to the domestic firms, and thus the technologies and management practices brought by foreign firms from different country origins represent desirable external knowledge elements, creating the potential for FDI spillovers. Also, when the technology gap is intermediate, there are some overlaps between the domestic firms' internal knowledge stock and the technologies and management practices brought by foreign firms from different country origins. Thus, the domestic firms have the capacity to understand the value and contents of FDI technologies and practices. In summary, when the technology gap is at the intermediate level, there is a potential for FDI spillovers, and the domestic firms also have the capacity to learn and utilize the variety of technologies and management practices brought by foreign firms from different country origins. Therefore, we propose the following hypothesis.

Hypothesis 3: The positive relationship between the diversity of FDI country origins and the productivity of domestic firms is the strongest when the technology gap between FDI and the domestic firms is intermediate.

METHODOLOGY

Data sources and sample

We tested our arguments in the context of China's emerging market, the largest FDI recipient country in the world. The major data source of this study is the Annual Industrial Survey Database (1998–2003) of the Chinese National Bureau of Statistics (CNBS). While this database includes domestic firms and foreign firms (as well as foreign-domestic joint ventures), it does not contain information about country origins of foreign firms. We identified country origins of foreign firms from the Foreign Direct Investment Enterprise Database, which was also collected by the CNBS.

The CNBS' Annual Industrial Survey Database contains the most comprehensive information about domestic and foreign firms in China (Tian, 2007). By law, all firms in China are required to cooperate with the CNBS and submit their basic and financial information to the CNBS (Chang and Xu, 2008). The aggregation of firm-level information collected by the CNBS is published in the official *China Statistics Yearbooks*. The CNBS statistics are largely accurate and internally consistent (Chow, 1993), and they have been used by previous studies in the strategy and international business areas (e.g., Buckley *et al*., 2007; Chang and Xu, 2008; Tian, 2007).

Every year, each firm listed has its key financial information such as sales, capital, and employment as well as demographic information such as the year when the firm was founded and ownership included in the database. Starting from 1998, this database covers all state-owned firms, and those non-state-owned firms (including foreign invested firms) that have annual sales of renminbi (RMB) 5 million (about US$620,000 based upon the official exchange rate of 2005) or above. Hence, data prior to 1998 were not included in the study because some firms in China (for example, private firms) were not included in the database. Also, consistent with previous studies (e.g., Blomström and Persson, 1983; Javorcik, 2004; Tian, 2007), this study focused on firms in manufacturing industries.

As noted earlier, in order to avoid the potential of mixing the joint venture effect and the spillover effect, we define foreign firms as 100 percent foreign-owned firms and domestic firms as 100 percent domestic-owned firms. Our sample consisted of 567,462 domestic firm-year observations, covering 158,746 domestic firms (unevenly distributed across years) during the period 1998–2003. These domestic firms cover 509 four-digit

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standard industrial classification (SIC) code manufacturing industries, accounting for more than 91 percent of manufacturing industries in China (a small number of industries were not included because the lack of FDI in these industries made it impossible to calculate the diversity of FDI country origins). Further, data on 81,054 foreign firm-year observations from 29,067 foreign firms were used to calculate FDI-related variables such as the diversity of FDI country origins, the technology gap between FDI and domestic firms, the share of foreign firms in the industry, and the number of foreign firms in the industry.

Model specification

In the FDI spillover literature (e.g., Aitken and Harrison, 1999; Blalock and Gertler, 2005; Tian, 2007), domestic firm productivity is estimated by using a log-linear Cobb–Douglas production function. Following this standard procedure, we estimated domestic firm productivity as follows.

$$\begin{aligned} \mathrm{Y}_{ijt} = {} & \beta_1 \text{ Log } \mathrm{K}_{ijt} \\ & + \beta_2 \text{Log } \mathrm{L}_{ijt} \\ & + \beta_3 \text{ FDI country origin diversity}_{jt} \\ & + \beta_4 \text{ FDI country origin diversity}_{jt} \\ & \quad \times \log \ \mathrm{K}_{ijt} \text{ (or log } \mathrm{L}_{ijt}) \\ & + \beta_5 \text{ Technology gap}_{ijt} + \beta_6 \text{ Squared} \\ & \quad \text{term of technology gap}_{ijt} \\ & + \beta_6 \text{ FDI country origin diversity}_{jt} \\ & \quad \times \text{technology gap}_{ijt} \\ & + \beta_7 \text{ FDI country origin diversity}_{jt} \\ & \quad \times \text{squared term of technology gap}_{ijt} \\ & + \beta_8 \text{ Controls} \\ & + \alpha_{ij} + \varepsilon_{ijt.} \end{aligned} \quad (1)$$

Log output Y_{ijt} for firm i in industry sector j at time t was regressed on firm inputs (log K and log L), the diversity of FDI country origins in sector j at time t, the technology gap between FDI and domestic firm i in sector j at time t, and their interaction terms. A vector of controls was also included in the model specification. We used firm annual sales for firm output (Chung, Mitchell, and Yeung, 2003). To remove the effects of deflation or inflation due to price change over time, we deflated firm sales using 1990's constant price (Aitken and Harrison, 1999; Tian, 2007). Firm inputs include the log of the firm's capital input (K_{ijt}, its capital stock) and the log of its labor input (L_{ijt}, its number of employees). We deflated the capital stock by the gross domestic product deflator on the basis of 1990's constant price (Aitken and Harrison, 1999; Tian, 2007). The vector of controls included the number of foreign firms in sector j at time t, the share of foreign firms in sector j at time t, and its squared term. In addition, the vector of controls also included region dummies at the provincial level, industry dummies, and year dummies. The rationale of including these controls and their measurements is discussed later. Further, α_{ij} is an unobserved effect for domestic firm i in sector j, and ε_{ijt} is the error term.

Measurement

To measure the *diversity of FDI country origins* in an industry sector, we adapted previous studies' measurements of the diversification of a firm's business portfolio (e.g., Bowen and Wiersema, 2005) to create the entropy of the diversity of FDI country origins as follows:

$$\text{Diversity} = \sum_{i=1}^{N} \mathrm{S}_i \ \ln \ (1/\mathrm{S}_i)$$

where S_i is the number of foreign firms with country origin_i as a percentage of the total number of foreign firms in a four-digit SIC code manufacturing industry sector in a year, and N is the total number of country origins of foreign firms that are present in the sector in a specific year. We used the number of foreign firms across country origins to measure this variable because the number of potential source firms is important to knowledge spillovers (Stuart and Sorenson, 2003). Entropy equals zero if all foreign firms in an industry sector in a year have the same country origin and it rises with the extent of the diversity in FDI country origins in an industry sector. This variable was calculated for each of the four-digit SIC code manufacturing industries in the sample and was updated yearly.

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As an alternative measurement, we calculated the Herfindahl index of the diversity of FDI country origins as follows.

$$\text{Herfindahl index} = \sum_{i=1}^{N} (S_i)^2$$

Because a lower value of the Herfindahl index (H) indicates a higher level of diversity, we used the inverse measure ($1/H - 1$) (Bowen and Wiersema, 2005) such that a higher value indicates a greater diversity of FDI country origins. The entropy and the inverse Herfindahl index ($1/H - 1$) have a correlation of 0.84 ($p < 0.001$) and produced fundamentally the same results. For simplicity of presentation, we only reported results using the entropy of the diversity of FDI country origins in this study. In supplementary analyses, we also used the shares of FDI sales, assets, and employment across country origins to measure the entropy and the inverse Herfindahl index and produced consistent results.

Technology gap was measured by the difference of the average productivity (firm annual value added (RMB10 million)/the number of employees, weighted by firm asset size) of foreign firms in a four-digit SIC code manufacturing industry sector and the productivity of a domestic firm in the same sector. The higher the value of this variable, the more technologically advanced FDI is relative to the focal domestic firm. We used the weighted average of firm productivity to calculate the technology gap because productivity may vary significantly across firms of different sizes. The measure of the technology gap was calculated for each domestic firm in the sample and was updated yearly. As an alternative measurement, we measured the technology gap as the difference of the (unweighted) average productivity of foreign firms in an industry sector and that of a domestic firm in the same sector. This alternative measure produced results consistent with those reported in this study.

As noted by Sjöholm (1999: 61), the difference in productivity captures the observed differences (rather than the expected differences) in technology between foreign firms and domestic firms. Although this measure of technology gap has its limitations (which is discussed in the limitation section), our use of this widely adopted measure (e.g., Kokko, 1994; Kokko, Tansini, and Zejan, 1996; Liu *et al.*, 2000; Sjöholm, 1999; Tian, 2007) enables us to compare our results with, and build upon, previous studies.

In our models, we controlled for *the number of foreign firms* in the industry (log transformation). If there is only one foreign firm, the 'diversity' measure is necessarily zero; as the number of foreign firms increases, these foreign firms are likely to come from different country origins. Therefore, the diversity of FDI country origins in an industry tends to relate to the number of foreign firms in the industry. In order to accurately examine the effect of the diversity of FDI country origins, it is necessary to control for the number of foreign firms in the industry to rule out this alternative explanation.

We also controlled for the *share of foreign firms* in an industry. This is because most prior research on FDI spillovers has focused on the effect of FDI share in an industry (Görg and Strobl, 2001). Because our measurement of the diversity of FDI country origins only included wholly owned foreign firms, to be consistent, the share of foreign firms in an industry was measured as the share of wholly owned foreign firms' sales in the total sales of the industry.[5] This variable was calculated for each of the four-digit SIC code manufacturing industries in the sample and was updated yearly. Further, because it is possible that the share of foreign firms in an industry may have a curvilinear effect on the productivity of domestic firms (Buckley *et al.*, 2007), we controlled for the *squared term of the share of foreign firms*. In supplementary analyses, we measured the share of foreign firms as the share of their employment (assets) in the total employment (assets) of the industry. These alternative measures produced fundamentally the same results as those reported here.

In addition, because China's economy has grown dramatically in the past decades, it is possible that the productivity of domestic firms in China changes over time. To capture this possible effect, we included five *year dummies* (1999, 2000, 2001, 2002, and 2003) using the year of 1998 as the base group for comparison. We also controlled for

[5] Previous studies have typically measured FDI share as the share of FDI sales/assets/employment (including those of both wholly owned foreign firms and foreign-domestic joint ventures) in the total sales/assets/employment of an industry sector (Djankov and Hoekman, 2000; Kathuria, 2000; Javorcik, 2004; Tian, 2007). In supplementary analyses, we used these alternative measures, and the results remained the same.

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*region dummie*s at the provincial level and *industry dummies*.[6]

Endogeneity check

The primary purpose of this study is to examine the effect of the diversity of FDI country origins on the productivity of domestic firms. A possible reversed causal relationship is that when the productivity of a given industry in a host country is high, many foreign firms in that industry will find the country an attractive investment location. Thus, a greater number of foreign firms (relatedly, a greater diversity of FDI country origins) may choose to invest in the country. Therefore, the number of foreign firms in an industry (relatedly, the diversity of FDI country origins) may be partially determined by the productivity of the industry in the host country.

To rule out this possible reversed causal relationship, we conducted the following endogeneity check. We regressed the number of foreign firms in the industry in year t (or the change of the number of foreign firms from year $t-1$ to year t) on the average productivity of all firms (or all domestic firms) in the industry in year $t-1$. We also regressed the diversity of FDI country origins in the industry in year t (or the change of the diversity of FDI country origins from year $t-1$ to year t) on the average productivity of all firms (or all domestic firms) in the industry in year $t-1$. If any one of the predictors had been significant, it would have provided some evidence of the endogeneity concern. Our results showed that none of these predictors was significant. Thus, we concluded that this reversed causal relationship is unlikely to occur in our data.

Data analyses

Our sample consisted of an unbalanced panel of domestic firms over six years (1998–2003). Based upon Wooldridge (2002), we used the following procedure to choose models for data analyses. First, we needed to decide whether to use the panel data method or the pooled ordinary least squares (OLS) approach. Generally speaking, the panel data method is used when the data consists of repeated observations on the same units (e.g., firms) over time and these repeated observations are correlated. The basic objective of the panel data method is to model the unobserved individual effects associated with these units. In comparison, the pooled OLS approach is used when the data has both cross-section and time-series features but no within-groups autocorrelation. We used the Breusch-Pagan Lagrange multiplier test for this choice.[7] Results of the test suggested that unobserved individual effects exist in the data and thus the panel data method should be used.

Second, for the panel data method, we needed to decide to use fixed effects or random effects. The key issue distinguishing between fixed effects and random effects is whether the unobserved individual effects are correlated with the observed explanatory variables in the model. If there is zero correlation between the unobserved effects and the regressors, random effects should be used. Otherwise, the fixed-effects model is more appropriate. We used the Hausman test for this choice, and the results of the test revealed that explanatory variables are correlated with the unobserved effects, and thus a fixed-effects model is appropriate for our analyses. We followed Wooldridge (2002) to conduct fixed-effects transformation (also called the within transformation)[8] to eliminate unobservable firm effects for Equation 1. To facilitate the statement, we rewrote Equation 1 as follows

$$y_{ijt} = x_{ijt}\beta + a_{ij} + \varepsilon_{ijt} \qquad (2)$$

where x_{ijt} represents all regressors in equation (1). We first averaged Equation 2 over t=1,. . .,T to get

[6] The age of domestic firms was not controlled for because when firm-fixed effects and year dummies are included jointly, the effects of firm age are entirely accounted for (Bothner, 2005: 626). In supplementary analyses, we controlled for domestic firm age and its squared term and our results did not change.

[7] The Breusch-Pagan Lagrange multiplier (LM) test is to check the presence of unobserved individual effects. The null hypothesis of this test is that variances of individuals' unobserved effects are zero. If the null hypothesis is rejected, unobserved effects exist and thus the panel data method should be applied. Otherwise, the pooled OLS approach is more appropriate.

[8] The basic idea of fixed effects in panel data analysis is to transform regression equations to eliminate the unobservable firm effects. When more than two time periods are available, there are different transformations that can accomplish this purpose (Wooldridge, 2002: 267). In addition to the approach used here, another method of transformation is time differencing (e.g., Haskel *et al*., 2007; Javorcik, 2004). The disadvantage of the time differencing method is that it reduces the length of panel data. Particularly, in order to eliminate persistent change in the variables of interest and reduce the impact of noise, longer time difference should be used, which will further reduce the length of panel data (Javorcik, 2004). Our panel, which is from 1998 to 2003, would have been significantly shortened if this method had been used.

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Table 1. Means, standard deviations, and correlations of variables[a,b,c]

Variables	Mean	S.D.	1	2	3	4	5	6
1. Log Y	8.693	1.505	—					
2. Log K	8.796	1.468	0.656	—				
3. Log L	4.871	1.159	0.597	0.732	—			
4. Number of foreign firms in the industry (log)	3.301	1.492	0.030	−0.117	−0.044	—		
5. Share of foreign firms in the industry	0.114	0.118	−0.040	−0.137	−0.089	0.556	—	
6. Diversity of FDI country origins	1.724	0.387	0.029	−0.024	−0.064	0.383	0.136	—
7. Technology gap	0.017	0.114	0.038	0.084	0.067	−0.019	−0.050	0.001

[a] N=567,462 firm years.
[b] Year dummies, region dummies, and industry dummies are not included in the correlation matrix but are included in model estimations.
[c] Correlations with absolute values equal to or greater than 0.019 are significant at the level of $p < 0.001$.

the cross-section equation

$$\overline{y}_{ij} = \overline{x}_{ij} + a_{ij} + \overline{\varepsilon}_{ij} \tag{3}$$

where $\overline{y}_{ij} = T^{-1}\sum_{t=1}^{T} y_{ijt}$, $\overline{x}_{ij} = T^{-1}\sum_{t=1}^{T} x_{ijt}$, and $\overline{\varepsilon}_{ij} = T^{-1}\sum_{t=1}^{T} \varepsilon_{ijt}$. Subtracting Equation 3 from Equation 2 for each t gives the fixed-effect transformed equation

$$y_{ijt} - \overline{y}_{ij} = (x_{ijt} - \overline{x}_{ij})\beta + \varepsilon_{ijt} - \overline{\varepsilon}_{ij} \tag{4}$$

or

$$\ddot{y}_{ijt} = \ddot{x}_{ijt}\beta + \ddot{\varepsilon}_{ijt}, \mathrm{t} = 1, \ldots, \mathrm{T} \tag{5}$$

where $\ddot{y}_{ijt} = y_{ijt} - \overline{y}_{ij}$, $\ddot{x}_{ijt} = x_{ijt} - \overline{x}_{ij}$, and $\ddot{\varepsilon}_{ijt} = \varepsilon_{ijt} - \overline{\varepsilon}_{ij}$. The time demeaning of Equation 2 has removed the unobserved effects a_{ij}.

After the firm-fixed effect transformation, following Haskel, Pereira, and Slaughter (2007) and Javorcik (2004), we added a full set of fixed effects for year, industry, and region into Equation 5. The common logic here is that firm-fixed effects transformation only eliminates the unobserved effects that do not change over time (including fixed regional and industrial effects), but it does not remove time-varying unobserved effects. By adding dummies for year, region, and industry into the after-transformation model (Equation 5), we can control for time-varying unobservable region and industry effects, which may drive changes in attractiveness of a particular region or industry (Javorcik, 2004: 616).

Finally, heteroskedasticity is always a potential problem in panel data analysis (Wooldridge, 2002: 274). We used the modified Wald test to check for heteroskedasticity, and the results suggested that there is heteroskedasticity in the data. Therefore, we used an REG model to estimate Equation 5 (with year, region, and industry dummies included) with the standard errors clustered at the firm level to adjust for heteroskedasticity.[9]

RESULTS

Table 1 presents descriptive statistics and correlations for the variables (except year dummies, region dummies, and industry dummies) used in this study. Table 2 presents the firm-fixed effect models of domestic firms' production function. Model 1 includes controls only. Results of Model 1 suggest that the number of foreign firms in the industry is positively related to the productivity of domestic firms in the industry ($b = 0.028$, $p < 0.001$). Further, the share of foreign firms in the industry is negative and significant ($b = -0.175$, $p < 0.001$) and its squared term is negative and significant ($b = -0.213$, $p < 0.01$).

Model 2 adds the main effect of the diversity of FDI country origins. It is positive and significant ($b = 0.014$, $p < 0.001$). This result supports Hypothesis 1, which proposes that the diversity of FDI country origins in an industry has a positive relationship with the productivity of domestic firms in the industry. To show the practical implication of this significant effect, we calculated its marginal effect. If the diversity of FDI country origins increases by one standard deviation (standard deviation = 0.387) from its mean value

[9] Alternatively, we used XTGEE models and obtained similar results.

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Table 2. Firm-fixed effect models of domestic firm production function[a,b,c,d]

Variables	Model 1	Model 2	Model 3a	Model 3b	Model 4	Model 5	Model 6
Controls							
Log K	0.388***	0.388***	0.387***	0.387***	0.387***	0.387***	0.387***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Log L	0.354***	0.354***	0.354***	0.354***	0.355***	0.355***	0.356***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Number of foreign firms in the industry	0.028***	0.026***	0.025***	0.026***	0.026***	0.026***	0.026***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Share of foreign firms in the industry	−0.175***	−0.170***	−0.170***	−0.170***	−0.167***	−0.166***	−0.148***
	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)
Share of foreign firms squared	−0.213**	−0.214**	−0.219**	−0.213**	−0.227***	−0.227***	−0.237***
	(0.071)	(0.071)	(0.071)	(0.071)	(0.071)	(0.071)	(0.071)
Region dummies	Included	Included	Included	Included	Included	Included	Included
Industry dummies	Included	Included	Included	Included	Included	Included	Included
Year dummies	Included	Included	Included	Included	Included	Included	Included
Predictors							
Diversity of FDI country origins		0.014***	0.014***	0.014***	0.016***	0.016***	0.014**
		(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Diversity of FDI country origins × log K			0.025***		0.027***	0.027***	0.029***
			(0.003)		(0.003)	(0.003)	(0.003)
Diversity of FDI country origins × log L				0.013***			
				(0.002)			
Technology gap					−0.088***	−0.088***	−0.089***
					(0.014)	(0.017)	(0.008)
Technology gap squared						−0.001	−0.001
						(0.002)	(0.001)
Diversity of FDI country origin × technology gap						−0.140	−0.143**
						(0.190)	(0.047)
Diversity of FDI country origins × technology gap squared							−0.101***
							(0.009)
R-squared	0.1819***	0.1820***	0.1822***	0.1821***	0.1824***	0.1824***	0.1831***

[a] N = 567,462 firm years.
[b] Significance levels: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$ (two-tailed tests).
[c] Estimated coefficients and associated robust standard errors (in parentheses) are reported.
[d] The models do not have constants because the fixed transformation has removed the intercept term (see Equation 5).

(mean = 1.724[10]) to 2.111,[11] domestic firm productivity would increase by 0.52 percent.

Hypothesis 2 proposes that the positive relationship between the diversity of FDI country origins and the productivity of domestic firms is stronger for large domestic firms than for small ones. Model 3a includes the interaction term[12] of the diversity of FDI country origins and domestic firm size in terms of the size of capital stock (log K) and it is positive and significant ($b = 0.025$, $p < 0.001$). Model 3b includes the interaction term of the diversity of FDI country origins and domestic firm size in terms of the size of employment (log L) and it is also positive and significant ($b = 0.013$, $p < 0.001$).

To facilitate interpretation, we plotted the significant interaction effect of the diversity of FDI country origins and log K in Model 3a in Figure 1 (the plot of the significant interaction effect of the diversity of FDI country origins and log L in Model 3b is fundamentally the same). In order to create this figure, all variables in Model 3a except the diversity of FDI country origins and log K were constrained to means. The diversity

[10] If an industry has foreign firms from five country origins and the number of foreign firms is equally distributed among the five country origins, the diversity of FDI country origins would be 1.792—close to the mean value of 1.724.
[11] If an industry has foreign firms from eight country origins and the number of foreign firms is equally distributed among the eight country origins, the value of the diversity of FDI country origins would be 2.079—close to the value of the mean plus one standard deviation (2.111).
[12] Variables were mean-centered prior to the creation of their interaction terms (Aiken and West, 1991).

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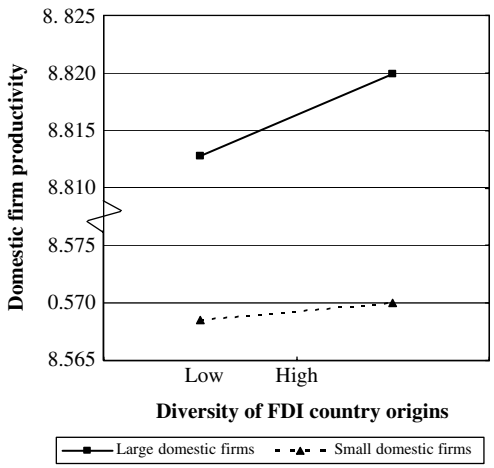

Figure 1. Diversity of FDI country origins and domestic firm productivity: the moderating role of domestic firm size

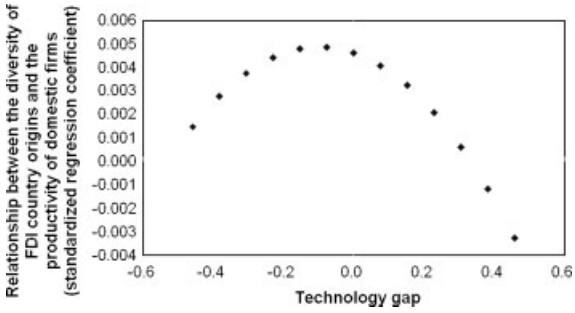

Figure 2. The relationship between the diversity of FDI country origins and the productivity of domestic firms as a function of technology gap

of FDI country origins and log K took the values of one standard deviation below and above the mean. As shown in Figure 1, the positive relationship between the diversity of FDI country origins and domestic firm productivity is stronger when domestic firm size is large (one standard deviation above the mean) than when it is small (one standard deviation below the mean). These results thus support Hypothesis 2.

Hypothesis 3 proposes that the positive relationship between the diversity of FDI country origins and the productivity of domestic firms is the strongest when the technology gap between FDI and the domestic firms is intermediate. Models 4–6 are used to test this hypothesis (if the diversity of FDI country origins' interaction term with log L instead of its interaction term with log K is included in these models, the results are virtually the same). Model 4 adds the main effect of the technology gap, which is negative and significant ($b = -0.088$, $p < 0.001$). Model 5 adds the squared term of the technology gap ($b = -0.001$, n.s.) as well as the interaction of the diversity of FDI country origins and the technology gap ($b = -0.140$, n.s.). Finally, Model 6 adds the interaction of the diversity of FDI country origins and the squared term of the technology gap, which is negative and significant ($b = -0.101$, $p < 0.001$). This result suggests that the relationship between the diversity of FDI country origins and the productivity of domestic firms varies across different levels of the technology gap in a quadratic manner.

Following the approach used by Suvak *et al.* (2002), we plotted this significant interaction effect in Figure 2. The plot shows how the relationship between the diversity of FDI country origins and the productivity of domestic firms varies across different levels of the technology gap. To create this plot, the regression equation predicting the productivity of domestic firms was examined at different levels of the technology gap. The vertical axis of the graph represents values for the standardized regression coefficient for the diversity of FDI country origins predicting the productivity of domestic firms, and the horizontal axis represents values for the technology gap. As shown in the figure, there is an inverted U-shaped relationship between the diversity of FDI country origins and the productivity of domestic firms across increasing levels of the technology gap. The coefficient is the highest when the technology gap is at the intermediate level compared with when the technology gap is either too small or too large. These results thus support Hypothesis 3.

Supplementary analyses

We have found that the diversity of FDI country origins at the national level has a positive and significant relationship with the productivity of domestic firms in the same industry. In supplementary analyses, we also examined how geographic proximity may affect the effect of the diversity of FDI country origins. Consistent with Chang and Xu (2008), we define geographically proximate foreign firms as those located in the focal domestic firm's province. Accordingly, we created a subsample composed only of domestic

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firms whose province has at least one 100 percent foreign-owned firm in the focal domestic firm's industry. We created this subsample because only if a focal domestic firm's province has at least one 100 percent foreign-owned firm in the focal domestic firm's industry, the local-level measures of the diversity of FDI country origins and the technology gap can be calculated for the focal domestic firm. Otherwise, these variables would have a missing value for the focal domestic firm.

With this subsample, we recalculated all FDI-related variables (the diversity of FDI country origins, number of foreign firms in the industry, and share of foreign firms in the industry) at three levels: the national level, the local level (i.e., using foreign firms within the focal domestic firm's province), and the nonlocal level (i.e., using foreign firms outside the focal domestic firm's province) and estimated their impact on the productivity of the domestic firms, respectively. Results are reported in the Appendix.

The results of Model 1 in the Appendix show that at the national level, the diversity of FDI country origins is positive and significant ($b = 0.043$, $p < 0.001$). Its interaction with domestic firm size (log K) is positive and significant ($b = 0.035$, $p < 0.001$). Its interaction with the squared term of the technology gap is negative and significant ($b = -0.142$, $p < 0.001$). These results are consistent with those reported in Table 2.

The results of Model 2 in the Appendix show that at the local level, the diversity of FDI country origins is not significant ($b = -0.007$, n.s.). However, it is positive and significant ($b = 0.015$, $p < 0.001$—results available from the authors upon requests) when the number of foreign firms in the industry is dropped from the model. Its interaction with domestic firm size (log K) is positive and significant ($b = 0.024$, $p < 0.001$). But its interaction with the squared term of the technology gap is not significant.

Moreover, the results of Model 3 in the Appendix show that at the nonlocal level, the diversity of FDI country origin is positive and significant ($b = 0.022$, $p < 0.001$). Its interaction with domestic firm size (log K) is positive and significant ($b = 0.020$, $p < 0.001$). Its interaction with the squared term of the technology gap is negative and significant ($b = -0.061$, $p < 0.001$).

DISCUSSION AND CONCLUSIONS

Main findings

In this study, we examined how the diversity of FDI country origins in an industry is related to the productivity of domestic firms in the industry and how the domestic firms' absorptive capacity can moderate this relationship. Using panel data on Chinese manufacturing firms during the period 1998–2003, we found that the diversity of FDI country origins is positively related to the productivity of domestic firms. We also found that this positive relationship is stronger for large domestic firms than for small ones, and that this positive relationship is the strongest when the technology gap between FDI and the domestic firms is at the intermediate level.

This study makes both theoretical and empirical contributions to the FDI spillover literature. First, our focus on the diversity of FDI country origins in an industry is significantly different from prior spillover research, which has largely treated FDI in an industry as a united party and has aggregated foreign firms into an overall share of FDI in the industry. As Fortanier (2007: 46) argued, 'FDI is not a uniform flow of capital across borders' and it differs in many dimensions. Aggregating foreign firms into FDI share at the industry level, as was done in prior research, can cause one to miss important information regarding how FDI spillovers actually take place. Our study extends prior research by showing how the diversity of FDI country origins can have a distinct effect on FDI spillovers. These findings are both theoretically and empirically important because they highlight the need to examine the heterogeneous nature of FDI and how such heterogeneity may affect FDI spillovers.

Second, we have integrated the FDI spillover literature with the learning and knowledge management literature and have theoretically explicated how the diversity of FDI country origins may affect FDI spillovers to domestic firms. Prior research on FDI spillovers has consisted of econometric studies that have assumed that the presence of FDI *per se* can create positive externalities to domestic firms (Görg and Strobl, 2001). In contrast, we argue that FDI spillovers in essence involve a process in which domestic firms learn

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technologies and management practices from foreign firms. Drawing upon the learning and knowledge management literature (Ahuja and Katila, 2004; Cohen and Levinthal, 1990; Henderson and Clark, 1990; Kogut and Zander, 1992; Zhang and Li, 2010), we propose that a greater diversity of FDI country origins can enhance the economies of scale and scope of the industry's knowledge pool by bringing different technologies and management skills to a host country. When domestic firms are exposed to a greater variety of foreign technologies and management practices, they can have a broader scope for knowledge search and thus are more likely to find new, useful combinations of these knowledge elements and create their own technologies and practices (Zhang and Li, 2010). Our findings support these arguments and highlight the important role of foreign firms' country origin diversity in enhancing domestic firms' learning opportunities in the FDI spillover process.

Third, rather than viewing domestic firms as passive recipients of FDI spillovers, our study contributes to the FDI spillover literature by examining the role of domestic firms in FDI spillovers. We argue that the heterogeneity in domestic firms' absorptive capacity can affect their benefits from FDI spillovers. Our findings show that domestic firms are more likely to benefit from the diversity of FDI country origins when they are larger and/or have an intermediate technology gap relative to foreign firms. The quadratic moderating effect of the technology gap is particularly interesting. Essentially, our results suggest that it is at the intermediate level of the technology gap that domestic firms have both the opportunity and the ability to learn from foreign firms and thus benefit the most from the diversity of FDI country origins. These findings highlight the complexity of the question of how (and under what conditions) FDI spillovers occur.

Although not formally hypothesized, we found that the number of foreign firms in an industry has a positive and significant relationship with the productivity of domestic firms in the industry. It appears that individual foreign firms represent distinct sources of FDI spillovers and thus the number of foreign firms in an industry can facilitate FDI spillovers by increasing the number of spillover sources. This finding further endorses our fundamental standpoint in this study. Namely, FDI in an industry is not a homogeneous and unified party. Instead, foreign firms from different country origins can bring different technologies and management skills to a host country. Each individual foreign firm may also bring some unique knowledge to the industry's knowledge pool in the host country. Therefore, it is crucial to go beyond the existing FDI literature's focus on the simpler issue of FDI presence and broaden our understanding of how FDI spillovers actually take place.

We found that the share of foreign firms in an industry and its squared term are both negatively related to the productivity of domestic firms in the industry. Plot (not reported in the paper but available from the authors upon request) shows that the overall effect of the share of foreign firms is negative and this negative effect is stronger when the share of foreign firms is higher. These findings suggest that the effect of FDI share in an industry is curvilinear rather than linear, consistent with the results reported by Buckley *et al*. (2007). Moreover, we found that FDI share at the national level has an overall negative effect on the productivity of domestic firms in China, while Chang and Xu (2008) found that FDI share (not including that from Hong Kong, Macau, and Taiwan) at the national level has a positive effect on the survival of domestic firms in China. This difference suggests that FDI spillovers may have differential impact on different performance consequences of domestic firms—for example, productivity versus survival.

FDI spillovers at the national level versus the local level

As shown in Models 1–3 in the Appendix, the number of foreign firms, the share of foreign firms, and its squared term are significant at the national, local, and nonlocal levels—with the exception of the main effect of the share of foreign firms at the nonlocal level. The diversity of FDI country origins is significant at the national and nonlocal levels. At the local level, the diversity of FDI country origins is not significant when the number of foreign firms is controlled for, and is significant otherwise. There are two possible explanations for the inconsistent effects of the diversity of FDI country origins at the national versus local level.

One explanation is that the diversity of FDI country origins has no significant effect at the local level because FDI spillover effects and crowding-out effects offset each other. As argued by Chang

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and Xu (2008), FDI spillover effects are more pronounced at the national level while FDI crowding-out effects are more evident at the local level. Therefore, at the local level, the crowding-out effects associated with the diversity of FDI country origins are strong enough to totally offset the spillover effects associated with the diversity of FDI country origins. In comparison, at the national and nonlocal levels, the crowding-out effects are not sufficient to totally offset the spillover effects. However, this explanation does not explain why the effects of the number of foreign firms and the share of foreign firms persist across the national, local, and nonlocal levels.

The other explanation is that the insignificant effect of the diversity of FDI country origins at the local level is simply a statistical artifact. At the local (provincial) level, there tends to be a smaller number of 100 percent foreign-owned firms in an industry. Previous studies (e.g., Chang and Park, 2005; Head, Ries, and Swenson, 1995) have shown that FDI tends to cluster by national origin as well as by industry. Thus at the local (provincial) level, the number of foreign firms tends to (1) be highly correlated with the diversity of FDI country origins and (2) has a greater variance across region-industry combinations. Therefore, the number of foreign firms absorbs the effect of the diversity of FDI country origins at the local level, but not at the national and nonlocal levels.

Overall, our results support the argument that FDI spillovers can go beyond regional boundaries and take place at the national level. However, different from Aitken and Harrison (1999) and Chang and Xu (2008), who found FDI spillover effects at the national level but not at the local level, our results show that FDI spillovers take place at both the national and local levels (at least for the number of foreign firms and the share of foreign firms).

Practical implications

Our study provides important guidelines and practical implications for policy makers and business managers. It has long been noted that FDI can be an important source for emerging market firms to learn advanced technologies and management practices. Findings of this study suggest that after controlling for the number of foreign firms and the share of foreign firms, the diversity of FDI country origins can additionally boost domestic firms' productivity. These findings suggest that policy makers in emerging markets need to develop policies that attract not only a large amount of FDI but also FDI from different country origins. For domestic firms' managers, our findings suggest that the extent to which domestic firms can benefit from FDI spillovers depends upon their capacity to learn from foreign firms. It appears that large firms and those with an intermediate technology gap with foreign firms are in a better position to benefit from the diversity of FDI country origins.

Limitations and future research directions

Our study has several limitations that offer significant opportunities for future research on this important topic. First, we examined the heterogeneous nature of FDI in terms of the diversity of FDI country origins and focused on how this diversity may affect domestic firms' productivity. Future research can investigate other aspects of FDI heterogeneity. For example, foreign firms may differ along dimensions such as their entry mode, market overlap, resource interdependence, or alliance networks. Future research may examine how FDI heterogeneity in these dimensions can affect FDI spillovers. Also, future research should investigate FDI spillover effects by going beyond domestic firms' productivity. For example, it will be interesting to examine how FDI can affect strategic entrepreneurship in emerging markets, including the formation of new ventures, the development of domestic firms' capabilities, and domestic firms' strategic renewal and innovation.

Second, we examined the moderating effects of the size of domestic firms and the technology gap between FDI and domestic firms. As noted earlier, other attributes of domestic firms may also proxy for their absorptive capacity, including their ownership type, R&D investment, and alliance ties with foreign firms (Li and Atuahene-Gima, 2002). It will be fruitful for future research to examine the moderating effects of these variables. Future studies may also examine how external contexts may moderate the relationship between the diversity of FDI country origins and the productivity of domestic firms. For example, Zhang *et al*. (2007) argue that foreign firms in emerging markets face various types of appropriability hazards of their technologies. Appropriation concerns can vary significantly across industry sectors with different appropriability regimes (Gulati and Singh, 1998) and across

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foreign firms with different strategies (Spencer, 2008; Zhang *et al*., 2007). Therefore, an important research question that should be examined in the future is: how do the appropriation concerns affect the relationship between the diversity of FDI country origins and the productivity of domestic firms?

Third, in this study we have focused on 100 percent domestic-owned firms in order to clearly examine the effect of FDI spillovers. Domestic firms with foreign ownership—that is, domestic-foreign joint ventures—may benefit from FDI spillovers. They can also learn and acquire knowledge from their foreign partners (Lane, Salk, and Lyles, 2001). Thus, it would be interesting for future research to compare FDI spillover effects between 100 percent domestic-owned firms and domestic-foreign joint ventures.

Fourth, as noted above, our measure of the technology gap has limitations. Technology gap in terms of the difference in labor productivity may be attributed to differences in capital intensities or scale of production rather than the difference in technologies (Sjöholm, 1999: 61). In the particular context of China, this difference may be caused by politically inspired excess labor in domestic firms, which foreign firms can partially resist. Although this measure has limitations, we believe that this does not necessarily negate our spillover arguments. When the difference between FDI and domestic firms is too small (regardless the reasons for the difference), there would be limited opportunity for the domestic firms to learn from FDI. When the difference is too large, the domestic firms are too different from the foreign firms to absorb a variety of technologies and management skills brought by these foreign firms from different country origins. We would still expect that the positive relationship between the diversity of FDI country origin and the productivity of domestic firms will be the strongest when the difference is intermediate. Nevertheless, it is important for future research to verify our results using more refined measures of the technology gap.

CONCLUSION

To the best of our knowledge, this is the first study that examined how the heterogeneous nature of FDI in terms of their country origin diversity affects the productivity of domestic firms in an emerging market. Our focus on the diversity of FDI country origins deviates significantly from the extant literature that has mainly focused on the simple presence of FDI in an industry. Also, we advance the FDI spillover literature by drawing upon the learning and knowledge management literature and by testing the moderating role of domestic firms' absorptive capacity. We believe that our study can contribute to a better understanding on how FDI spillovers actually take place and provide insights into mechanisms that facilitate knowledge spillovers across organizational boundaries and across national borders. We hope that this study will inspire future research to investigate this important issue in management, international business, and economics disciplines.

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APPENDIX

Results of Supplementary Analyses[a,b,c,d]

Variables	Model 1 (national level)	Model 2 (local level)	Model 3 (nonlocal level)
Controls			
Log K	0.381***	0.380***	0.380***
	(0.004)	(0.004)	(0.004)
Log L	0.345***	0.341***	0.341***
	(0.004)	(0.004)	(0.004)
Number of foreign firms in the industry (national)	0.025***		
	(0.002)		
Number of foreign firms in the industry (local)		0.027*	
		(0.002)	
Number of foreign firms in the industry (nonlocal)			0.018***
			(0.002)
Share of foreign firms in the industry (national)	−0.088***		
	(0.022)		
Share of foreign firms squared (national)	−0.245*		
	(0.096)		
Share of foreign firms in the industry (local)		−0.084***	
		(0.022)	
Share of foreign firms squared (local)		−0.104*	
		(0.045)	
Share of foreign firms in the industry (nonlocal)			0.014
			(0.029)
Share of foreign firms squared (nonlocal)			−0.213*
			(0.084)
Region dummies	Included	Included	Included
Industry dummies	Included	Included	Included
Year dummies	Included	Included	Included
Predictors			
Diversity of FDI country origins (national)	0.043***		
	(0.008)		
Diversity of FDI country origins (local)		−0.007	
		(0.004)	
Diversity of FDI country origins (nonlocal)			0.022***
			(0.005)
Diversity of FDI country origins (national) × log K^e	0.035***		
	(0.005)		
Diversity of FDI country origins (local) × log K^e		0.024***	
		(0.003)	
Diversity of FDI country origins (nonlocal) × log K^e			0.020***
			(0.004)
Technology gap (national)	−0.128***		
	(0.012)		
Technology gap squared (national)	−0.007***		
	(0.001)		
Technology gap (local)		−0.130***	
		(0.023)	
Technology gap squared (local)		−3.17E-03***	
		(9.14E-04)	
Technology gap (nonlocal)			−0.105***
			(0.012)
Technology gap squared (nonlocal)			−0.006***
			(0.001)
Diversity of FDI country origin (national) × technology gap (national)	0.065		
	(0.039)		

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APPENDIX (*Continued*)

Variables	Model 1 (national level)	Model 2 (local level)	Model 3 (nonlocal level)
Diversity of FDI country origin (local) × technology gap (local)		−0.687* (0.082)	
Diversity of FDI country origin (nonlocal) × technology gap (nonlocal)			−0.050 (0.048)
Diversity of FDI country origins (national) × technology gap squared (national)	−0.142*** (0.018)		
Diversity of FDI country origins (local) × Technology gap squared (local)		0.065 (0.047)	
Diversity of FDI country origins (nonlocal) × technology gap squared (nonlocal)			−0.061*** (0.006)
R-squared	0.2113***	0.2078***	0.2068***

[a] N = 277,294 firm years. This sample is composed of domestic firms whose province has at least one 100% foreign-owned firm in the focal domestic firm's industry.
[b] Significance levels: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$ (two-tailed tests).
[c] Estimated coefficients and associated robust standard errors (in parentheses) are reported.
[d] The models do not have constants because the fixed transformation has removed the intercept term.
[e] For the sake of presentation simplicity, only the interaction of the diversity of FDI country origins and log K is reported here. The interaction of the diversity of FDI country origins and log L is also positive and significant.

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